FINDING A WAY: AIDS TO SUPPORT CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD)

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Abstract

Autism Spectrum Disorder (ASD) is a developmental disorder affecting around 1:68 children. Among other characteristics, children with ASD can be unduly sensitive to the elements in the environment, such as noise or light. Those affected have also described childhood difficulties finding their way around school. Despite the increasing numbers of children diagnosed with ASD, to date there has been little evidence-based research investigating how the environment affects them.

The purpose of this exploratory experimental study was to determine whether wayfinding aids, (colored doors, colored shapes on the floor, and signage), applied in an elementary school corridor could help children with ASD find their way to a given destination with minimal assistance. This could improve their wayfinding skills and promote independence. Person-environment Fit Theory guided the research. This states that if a person is well-matched to their environment it can have a positive effect on them.

A convenience sample of participants with ASD aged 8-11 ($n=9$) were randomly assigned to control or treatment groups. A study route was set up along part of the school corridor unfamiliar to participants. Each participant was given wayfinding instruction and shown the way to a destination before being asked to find the way on his/her own. Participants in the control group used existing cues in the environment. Participants in the treatment group used wayfinding aids applied along the route. A mixed methods approach to data collection included observation, behavioral mapping, and a post-study interview/questionnaire to find out what participants felt about their wayfinding experience and what they remembered about the route.

The study found that all participants were able to find their way to the destination. This suggests that wayfinding could be used as an educational intervention to teach children with ASD how to find their way around school. Participants in the treatment group remembered more colors, shapes, and signs along the route compared to the control group. Some participants demonstrated a hypersensitivity to the environment, adversely affected by noise, light, and smell. Some participants demonstrated Weak Central Coherence, focusing on small details to help them find their way around rather than perceiving the larger environment. With further testing, it may be possible for clinicians who treat children with ASD to use wayfinding as a diagnostic tool to help them find out how children with ASD perceive their environment and what they are sensitive to in it.

This is believed to be the first research study to test children with ASD in wayfinding. By documenting an evidence-based research process with children with ASD as participants, this study could act as a model for other designers and researchers to follow. It could also be replicated to determine whether the results are applicable to wayfinding in other school corridors, or other environments, used by children with ASD.

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CHAPTER 1: INTRODUCTION

Background

"Why do you get lost so often? 'I think it's this: we don't really know where we ought to be' " (Higashida, 2013, p. 93). So writes a 13-year-old boy diagnosed with Autism Spectrum Disorder (ASD) explaining the difficulty he has finding his way around (Higashida, 2013). A number of adults with ASD have also written about their experiences becoming lost in the environment (Baumers & Heylighen, 2010). Difficulty finding their way around is just one potential issue that individuals with ASD can experience in a condition that has been described by the United States government as "an important public health concern" (Centers for Disease Control and Prevention [CDC], 2015a).

The reason the CDC expresses such concern about ASD is because of the increasing numbers of children in the United States being diagnosed with the condition. Current estimates by the CDC are that 1:68 children have ASD (Baio, 2014). This is an increase from previous data released by the CDC which estimated that 1:88 children had ASD (Baio, 2012), and an increase from data previous to that indicating 1:110 children had ASD (Rice, 2009). Furthermore, there may be greater numbers of children with ASD in certain areas: researchers estimated that the number of children with ASD in one urban city is 1:48 (Hewitt et al, 2013). The rise in the number of children diagnosed with ASD has led to public concern that there is an autism epidemic which the CDC does not dismiss (CDC, 2015a). However, they are unable to state the reasons for the increase in numbers (CDC, 2015a). From a different methodology, researchers Oller and Oller

(2010) examined a number of sources of current research and formed the opinion that there is an "undeniable autism epidemic" (p. 1).

The main characteristics of ASD are that it particularly affects a person's ability to interact socially with other people, to converse in a typical manner, and to act in generally accepted ways of behavior (American Psychiatric Association [APA], 2013). Many children with ASD are also adversely affected by their environment so that noisy or brightly lit surroundings or strong smells can disturb them (APA, 2013). Although all humans are affected by their environment to different extents (Kopec, 2012) children with ASD can be particularly affected (APA, 2013; Dunn, 2008). There are also many factors in the environment that can influence human behavior including the effect of noise or crowding levels, the presence of wayfinding cues, or personal preferences (Kopec, 2012; APA Division 34, 2015). Since children spend thousands of hours in school during their educational years (Hull & Newport, 2011) this is a particular environment where sensitive design could support children with ASD.

The design of schools that are appropriate to meet children's needs is essential to maximize their learning potential (National Institute of Building Sciences [NIBS], 2011). This includes children with ASD, many of whom are taught with their peers, children without ASD, in the same school environment (Simpson, Myles, & LaCava, 2008). Indeed, legislation dictates that children with disabilities should be educated in the same school environment as children without disabilities as far as possible if it meets the needs of the child with a disability (Individuals with Disabilities Act [IDEA], 2004). Environmental factors that affect design include space and form, materials and finishes, textures and patterns, acoustics, thermal comfort, light, wayfinding, and color (Jones, 2014; Slotkis, 2013).

In recent years, led by healthcare design, there have been efforts to ensure that design practitioners create environments based on knowledge gained from research into human behavior in the built environment with the aim of improving human well-being and comfort (Center for Healthcare Design, 2008; Hamilton, 2004; Hamilton & Watkins, 2009; Martin, 2009). To date, however, research into the design of schools that are appropriate for children with ASD is lacking (Henry, 2011b; Henry 2011c; Khare, 2010; Martin, 2014; Shabha & Gaines, 2011). Wayfinding is a particular topic that has not been studied in relation to schools and their use by children with ASD yet we know that it can be a particular issue affecting children with ASD (Higashadi, 2013; Baumers & Heylighen, 2010). Gerland (1997) also reported about the difficult time she had at school as a child with ASD finding her way to the classrooms, to the lunch room, and to the restrooms. Her difficulties made her feel inadequate compared to her peers and highlighted how different she was from them (Gerland, 1997).

This study examines ASD and the challenges it represents for children with the condition. A child is defined as anyone between 7-17 years of age, the compulsory age at which children must receive education in the state in which the study took place (Minnesota Statutes, 2014). It also considers how the built environment can adversely affect children with ASD, focusing on schools as the center of learning and development in childhood. The study will specifically consider wayfinding and its impact on children with ASD for whom "the built environment can be a frightening and confusing place, difficult to negotiate and tolerate" (McAllister & Maguire, 2012, p. 201).

Autism Spectrum Disorder (ASD)

ASD is defined by the APA (2013) as a neurodevelopmental disorder having two distinct elements, the inability to interact socially in a generally accepted manner and the focus on a narrow and repetitive field of behavior. ASD has been noted as affecting a child's ability to communicate, to relate to other people, and to use their imagination (Deudney, 2006; Mesibov & Shea, 1998; Wilkes, 2004). For reasons that have not been established, more boys are diagnosed with ASD than girls at a ratio of 5:1 (Baio, 2014). While there are commonalities, each child differs in the manifestation of their condition, their abilities, and the individual characteristics they exhibit (Edelson, 2011; Martin, 2014). Due to this wide range in characteristics, the disorder is defined as a spectrum (APA, 2013).

Children with a less severe form of ASD are generally able to function at the higher level of the spectrum (APA, 2013; Wilkes, 2004). A minority of high functioning people with ASD, about 1:10, have savant traits, i.e., extraordinary talents (Edelson, 2011; Mackintosh, 2011). A notable savant with ASD is depicted in the film *Rainman* (Johnson & Levinson, 1988). This stars Dustin Hoffman as a savant who can recall and memorize large amounts of information, such as listings in a telephone book, but finds it otherwise difficult to complete everyday tasks. Children with ASD at the lower functioning level of the spectrum generally have little to no form of verbal communication and often have additional intellectual disabilities (APA, 2013).

Intellectual disability is defined as a lack of mental skill relating to problem solving, socialization, and life skills (APA, 2013). Research from the Centers for Disease Control and Prevention (CDC) indicates that as many as 51% of children with ASD have a lower than average intelligence quotient (IQ) with 31% of these children having an intellectual disability (Baio, 2014). Another study in the United Kingdom suggests that 50% of children with ASD have a mild to moderate intellectual disability while nearly 20% of children with ASD have a severe intellectual disability (Chakrabarti & Fombonne, 2001).

The characteristics of ASD can also be described in terms of hyper- and hyposensitivity to the environment (APA, 2013). Children with ASD who are hypersensitive may react to external stimuli that a child without ASD may not notice (Dunn, 2008). For example, the texture of a particular item of clothing, or a strong smell, or a loud noise may unduly disturb hypersensitive children (National Institute of Mental Health [NIMH], 2008). Children with ASD who are hyposensitive are likely to have a high tolerance level and may not react to external stimuli that children without ASD would notice or react to (Dunn, 2008). For example, such children may be unaware of smell or immune to pain when they injure themselves (NIMH, 2008). Conversely, some may feel the need to stimulate themselves by making loud noises or handling pungent substances (Wilkes, 2004). Some children may be hypersensitive to some stimuli but hyposensitive to other stimuli (Dunn, 2008). Many children with ASD also exhibit challenging behaviors, often because they cannot understand or process what is going on around them, which can manifest as violence or aggression towards others, or injury to themselves (Edelson, 2011; Emerson, 2001; NIMH, 2008).

Prevalence

As discussed earlier, the latest research published by the CDC, based on data collected from a study of 8-year-olds across 11 states in 2010, estimates that as many as 1:68 children in the United States has ASD (Baio, 2014). This is an alarming increase from data collected and published by the CDC based on a similar study in 2006 which estimated that 1:110 children had the condition (Rice, 2009). At that time the CDC described the numbers of children diagnosed with the condition as “an urgent public health crisis” (Rice, 2006, p.1).

Other states have also reported high numbers of children diagnosed with ASD. In Minnesota, a study collecting data from the health and special education records of 12,329 children aged 7-9 found that 1:48 has ASD (Hewitt et al., 2013). In California, a report by the Health and Human Services Agency estimated that between 1987 and 2007 there was a 1,148% growth rate in the number of individuals diagnosed with ASD (Cavagnaro, 2009). ASD has now become the fastest growing developmental disability in the United States (Gaines, Curry, Shroyer, & Amor, 2010). In comparison, in 2006 the National Institute of Health reported that the rate of children born with Down syndrome, a different type of developmental disability, was estimated at 1:700 (Parker et al., 2010).

Causes

While the characteristics of ASD and the increased prevalence are well documented, there is an ongoing debate about its causes. Researchers are undecided whether the increased numbers of children found to have ASD are a result of better diagnosis, better gathering and dissemination of data, or whether some environmental factors have led to the increase (Oller & Oller, 2010). Whatever the cause, it is widely accepted that the numbers of children being diagnosed with ASD in the United States is increasing (Baio, 2014; Oller & Oller, 2010).

Prognosis

ASD is a lifelong condition for which most experts believe there is no cure (Frith, 2003; Oller & Oller, 2010; Simpson, Myles, & LaCava, 2008). In 1980, the APA predicted a bleak outlook: only 1:6 adults with ASD would be likely to be able to live and work independently; 1:6 adults with ASD may be able to make some adjustments to allow them to live independently; but 2:3 adults with ASD were unlikely to be able to live independently and would always be severely impaired (Oller & Oller, 2010; Simpson, Myles, & LaCava, 2008). According to Oller and Oller (2010) APA's 1980 predictions did not fully come to be and most experts now believe that children with ASD can be helped through training and education (CDC, 2015; NIMH, 2008; Simpson, Myles, & LaCava, 2008).

Financial Impact

In addition to the human costs of ASD, the condition represents a substantial financial cost to society in increased medical, supportive care, and educational costs. Various estimates have been put forward regarding the costs of ASD. Costs can reflect the severity of ASD, described in terms of three levels (APA, 2013). Children with Level 1 ASD are able to function at the highest level of the spectrum; children with Level 2 ASD function at the mid-range of the spectrum, and children with Level 3 ASD function at the lowest level of the spectrum (APA, 2013). For children at the lower levels of the spectrum, there are financial costs of employing caregivers. Also at stake is the loss of income by parents who frequently become fulltime caregivers but receive little or no compensation (Buescher et al., 2014; CDC, 2010).

The lifetime costs of supporting a person with ASD without an intellectual disability have been estimated at $1.4 million rising to $2.4 million for a person with ASD with an intellectual disability (Buescher, Cidav, Knapp, & Mandell, 2014). The CDC (2010) states that some individuals with ASD receive specialist medical support, estimated at up to six times the cost of an individual without ASD. Some children with ASD also receive special education services, estimated at three times the cost of children attending school who do not need special education services (Autism Society, 2013). Other estimates are that a typically developing child costs around $12,600 per year to educate (National Center for Education Statistics, 2015). Lavelle et al. (2014) collected national data relating to educational costs from which they estimated that each child with ASD costs around an additional $8,600 per year to educate. There is data to suggest that some of these lifetime costs could be reduced if children with ASD were provided with early diagnosis and treatment interventions (Autism Society, 2013). With funding for school budgets constrained and limited resources available these additional costs are a burden on school districts facing increased numbers of children with ASD needing specialized support. Schools are required to make educational provision for children with ASD.

Education for Children with ASD

In 1990, the Americans with Disabilities Act (ADA) passed into legislation a landmark civil rights law that made it unlawful for, among other provisions, a place of education to discriminate against a student because of their disability (ADA, 1990). The act states that a student “cannot be excluded from participation in or be denied the benefits of services, programs, or activities of a public entity” (Sec 202, ADA, 1990). In the same year, the Individuals with Disabilities Education Act (IDEA) passed into law (IDEA, 1990). This act was based on previous legislation and has been amended twice since then, the latest version passed in 2004 (Driscoll & Nagel, 2004). IDEA (2004) contains many important principles relating to the education of children with disabilities. One of these principles is that of Free Appropriate Public Education (FAPE), originally conceived under Section 504 of the Rehabilitation Act of 1973 (Department of Education [DOE], 2007). This act mandates that every school district in every state provide an education free of charge to students with disabilities (DOE, 2007).

Another important principle is that of Least Restrictive Environment (LRE) which requires that each school district must ensure “to the maximum extent appropriate, children with disabilities…are educated with children who are nondisabled” (300.114, IDEA, 2004). Many children with ASD are therefore educated in a general school setting, with support as required. Children functioning at the lower level of the spectrum may be educated in a special school if their needs are better met there (Myler, Fantacone, & Merritt, 2003). Many supports and interventions are provided in schools to assist children with ASD, including support staff.

Support Staff

In the school setting teachers are assisted in their work by paraprofessionals. Paraprofessionals is the generic name for a variety of teacher support staff who are employed to provide a range of duties in the school environment, including lunch room assistance, playground assistance, and special education assistance (Minnesota Department of Education [MNDOE], 2015). Typical duties of special education paraprofessionals could also include helping children in the classroom, taking students to the restroom, and escorting them between classrooms (SPENSE, 2002; Finch, 2015).

Interventions

For the purposes of this study, an intervention can be defined as any practice designed to improve the education, behavior, or development of a child with ASD (Wong et al., 2014). Despite the lifelong effects of ASD, most clinicians and educationalists agree that early interventions, including supportive teaching and learning strategies, are essential to improving the outcome for children with ASD (Agency for Healthcare Research & Quality [AHRQ], 2014; Chakrabarti & Fombonne, 2001; National Professional Development Center, 2014; Simpson, Myles, & LaCava, 2008). One of the common goals in training and treatment approaches for children with ASD is for them to achieve greater independence (Earles-Vollrath, Cook, Robbins, & Ben-Arieh, 2008).

To date, interventions have focused on medical and educational treatments that could assist children with ASD and not on physical environmental interventions that could help. Since the APA (2013) states that children with ASD are affected by factors in their environment, including sound, texture, and light, the implication is that environmental interventions could offer a potential source of support. Despite this, there has been limited research so far into how school environments could be designed to assist children with ASD (Henry, 2011c, Kabot & Reeve, 2010; McAllister, 2010; McAllister & Maguire, 2012).

Design and Human Behavior

Humans are affected by the environment and they interact with it (Kopec, 2012). As British Prime Minister Winston Churchill said to Parliament in 1943, "We shape our buildings, and afterwards our buildings shape us" (International Centre for Facilities, 2006). This view is echoed by Kopec (2012) writing in more recent times, "The human-environment relationship is symbiotic in that the environment influences our behaviors and we in turn influence the environment" (p.1).

Many researchers have examined this interaction between the environment and humans, some through the development of design and human behavior theories. Brown and Guay (2011) describe the person-environment (P-E) fit theory as, "The compatibility that occurs when [the] individual and work environments are well matched" (p. 1). Kopec (2012) describes how environmental design can affect human behavior by causing over- or under-stimulation, a phenomenon known as stimulation theory. Humans gather information about their environment through the five senses of sight, sound, touch, taste, and smell and are stimulated by the information perceived by those senses (Kopec, 2012).

Children with ASD face challenges in the environment that affects their behavior (APA, 2013, Whitaker, 2008). They interact with the environment in unique ways due to their sensory challenges and they can be disengaged or challenged by their environment

(Dunn, 2008). According to the APA, the hyper- or hyposensitivity that children with ASD experience is due “to sensory input or unusual interests in sensory aspects of the environment” (2013, p. 50). Given these significant challenges, it is surprising that little research is available to inform designers how to create supportive environments for children with ASD (Henry, 2011b; Henry, 2011c; Khare, 2010; Martin, 2014; Shabha & Gaines, 2011; Vázquez & Torres, 2013).

Evidence-Based Design (EBD)

Designers who engage in evidence-based design (EBD) create design solutions in part based on empirical research findings to produce environments that support and benefit the humans who use them (Center for Health Design, 2008; Martin, 2009). There are several reasons why EBD is important in the design of the built environment. Design criteria based on empirical research in concert with knowledge gained from education and experience can help designers make informed design decisions (Hamilton & Watkins, 2009; Martin, 2009).

There is currently a lack of scientific literature relating to the design of the school environment for children with ASD which is criticized by many authors (Henry, 2011b; Henry 2011c; Khare, 2010; Martin, 2014; Shabha & Gaines, 2011). The research that currently exists regarding the design of educational environments for children with ASD is also sometimes flawed in methodology, lacking rigor, or is anecdotal in origin (Henry, 2011; Martin, 2014). Moreover, the knowledge that does exist is not easy for designers to find (Scott, 2009) and is often “fragmented and inconclusive” (Shabha & Gaines, 2011, p. 228). In an interview, Mostafa, an architect and researcher into environments for children with ASD, stated that a lack of funding plays a large part in the paucity of research (Quick, 2013). If more rigorous research about designing schools for children with ASD is conducted, published, and made available to designers in a format that they can easily use, it could guide them to create supportive educational environments based on empirical evidence (Martin, 2014). It is therefore possible that environmental design interventions might emerge as a strategy to support children with ASD alongside medical and educational interventions.

School Design

In the literature, existing studies concerning the design of schools for children with ASD have taken a number of research approaches. Several researchers adopted a design criteria/checklist approach, sending a questionnaire to caregivers and special education teachers to establish their requirements for an environment that supports children with ASD, and evaluating the responses via a hierarchy of importance (Khare & Mullick, 2008; McAllister, 2010; Mostafa, 2008). Both Khare and Mullick (2008) and McAllister (2010) also undertook observation in existing schools. Others have taken a case study approach (Pauli, 2004; Scott, 2009). Pauli (2004) investigated the effect of color on the behavior of children with ASD and Scott (2009) investigated whether existing school environments in the United Kingdom met the needs of children with ASD.

There have been few experimental approaches, although Mostafa (2008) undertook detailed experiments on classroom layout and acoustics and their effects on children with ASD. More research experiments could provide design professionals with research findings about how to design schools suitable for children with ASD. Some researchers also concluded that the design of the learning environment could promote an increase in independence of children with ASD (Khare & Mullick, 2008). One aspect of research that has not yet been considered is how school corridors could be designed to help children with ASD find their way around.

Wayfinding

An early definition of wayfinding was provided by Lynch (1960). Lynch (1960) describes the concept of wayfinding as the way in which humans use sensory clues from the environment to find their way around. Wayfinding has become an increasingly important skill for people to learn, particularly over the last century with the expansion in city development and building (Gibson, 2009). Moreover, "Getting people from place to place and orientating them in complex spaces is increasingly complicated" (Gibson, 2009, p. 16). The need for orientation and wayfinding is particularly necessary in a school since many are large with a complex arrangement of corridors. They can also be especially challenging during transition times when children have to move quickly between classrooms in a crowded environment. Willey, a woman with ASD, writes about her college campus experience:

> (It was) difficult for me to find my way – literally and figuratively…I remember leaving a class totally unable to discern which way I needed to go in order to follow the most direct path to my next class. The crowds of students would fill the doorways and the halls, giving me little time to grab hold of my thoughts so that usually I would just follow the wave of students out of the building, as if I

knew where I was going" (Willey, 1999, p. 48).

Tammett, a man with ASD who has savant skills, describes how, despite his prodigious skills in mathematics and linguistics, he frequently got lost at school and resorted to following other students between classes to avoid this (Tammett, 2006). Baumers and Heylighen, in a 2010 study reviewing autobiographies written by individuals with ASD, reported finding similar difficulties. Several adults with ASD described their childhood experiences finding their way around the school (Baumers & Heylighen, 2010). Some reported a hopeless reliance on trial and error to find their way around and some felt keenly their lack of ability to wayfind compared to their peers who did not have ASD (Baumers & Heylighen, 2010). The way humans behave in the environment and whether they feel safe and supported there provides important information that designers need to understand and address to create appropriate environments.

Statement of the Problem

To date, research has focused on medical and educational interventions to support children with ASD, but there has been limited research into how the design of the physical school environment could support them (Henry, 2011b; Henry 2011c; Khare, 2010; Martin, 2014; Shabha & Gaines, 2011). Since it is known that environmental stimuli affects children with ASD (APA, 2013; Dunn, 2008; NIMH, 2008), it is an important yet overlooked area of study. Furthermore, children with ASD often have difficulty at school navigating between classrooms which can cause upset and emphasize their differences compared to their classmates (Baumers & Heylighen, 2010; Tammett, 1999; Willey, 1999). Additional costs are incurred by school districts in relation to providing special education support staff to assist children with ASD, including assistance that may be needed to support the child during transitions between classes. In the literature no studies could be found that have investigated how the design of school corridors could help children with ASD to wayfind around the building.

Purpose of the Study

The purpose of this research is to conduct an exploratory study to determine if a supportive physical school environment could improve the wayfinding ability of children with ASD. Specifically, this research will investigate the use of assistive wayfinding aids as a means to improve the wayfinding abilities and thereby promote the independence of children with ASD. This is important, not only because a more supportive environment could enable children with ASD to find their way around the school more easily and allow them to become more independent, but also because it could potentially free up some of the time that support staff spend escorting children with ASD around the school. This research will also document the process of conducting an experiment with children with ASD that could act as a model for use by other researchers to conduct future experiments, particularly relevant in an area that is currently lacking much research.

Research Questions

This research study is intended to answer the following research questions:

Q1. Can assistive wayfinding aids increase the ability of children with ASD to wayfind along the corridors in the school environment independently?

Q2. Can assistive wayfinding aids increase the ability of children with ASD to wayfind along the corridors in the school environment with *minimal assistance*, thereby increasing their independence? The term "minimal assistance" is used in recognition that some children with ASD will always need some assistance with wayfinding, particularly children with a Level 2 or Level 3 diagnosis of ASD. Children with ASD may also need a member of support staff close at hand to ensure they do not endanger themselves or others, or simply wander off (Nguyen, 2009). This is highlighted by the tragic case of Avonte Oquendo, a teenage boy with ASD from New York, who ran out of his school unnoticed by staff and whose remains were discovered several months later (Baker, 2014).

Q3. What do children with ASD think about their experience wayfinding along the corridors in the school environment? There is less value in providing an environmental intervention if children with ASD do not like or enjoy the experience. Their feedback could also provide valuable information about how they perceive the environment when wayfinding. If children with ASD identify that wayfinding aids help them to navigate, this information would be useful for designers who are considering their implementation in schools. Also, this is a population who is not often asked their opinion; no similar research could be found asking children with ASD for their opinion.

Importance of the Study

Research into the design of the school environment for children with ASD is important for a number of reasons. First, there is a lack of research concerning the design of the school environment in general and none that focuses on wayfinding as it relates to children with ASD. The findings from this exploratory study could contribute to the interior design body of knowledge regarding the design of educational environments and its effect on children with ASD. By application of an evidence-based approach to wayfinding, designers may be able to improve the school environment for children with ASD.

Second, by documenting the process of conducting an experiment with children with ASD, this research could provide a model and an impetus for other researchers to investigate how the environment could be designed to support children with ASD. The study could also be replicated to determine if the results are applicable to wayfinding in corridors in other school buildings. By extension, it could be applied to different types of environments used by children with ASD, such as clinics or childcare facilities, to test wayfinding and expand knowledge about the influence of the designed environment on children with ASD.

Third, this research is important because it could be used by special education teachers and school administrators. At the school district board level, this knowledge could help in allocating scarce funds for design solutions to benefit children with ASD, based on empirical evidence. It may also reduce the amount of time caregivers spend escorting children with ASD around the school. The findings could also be useful for ASD advocacy groups and parents and caregivers as they seek to influence designers and educators to provide interventions that support children with ASD in school.

Summary

With the rising incidence of children diagnosed with ASD and the associated personal, financial, and social costs it is important to consider all strategies that could support these children, including the design of the built environment. Chapter 2 reviews the literature relating to the human, education, and design aspects of ASD and the theories that could be used to support the study. Chapter 3 describes in detail the method for carrying out the study. Chapter 4 discusses the findings and Chapter 5 ends with the conclusions drawn from the study.

CHAPTER 2: REVIEW OF LITERATURE

The purpose of the study is to find out whether assistive wayfinding aids can help children with ASD to navigate along a school corridor. The literature review begins by outlining the characteristics of ASD and continues with a discussion of the literature relating to education for children with ASD, the influence of design on human behavior, and environmental design factors in the school. The design perspective focuses on wayfinding as it relates to schools and specific wayfinding cues such as color, legibility, imageability, landmarks, pictograms, and tactility that could contribute and influence how children with ASD find their way in the school environment. Details of previous interior environmental studies and their findings related to children with ASD are included. Lastly, a discussion of theories relative to framing the research questions of interest are presented for context as the theoretical framework for the study is described.

ASD

Definition

Prior to 2013, ASD was defined in the *Diagnostic and Statistical Manual of Mental Disorders (DSM)* (*DSM-IV;* American Psychiatric Association [APA], 2000) as one of a number of Pervasive Development Disorders which included Autistic Disorder, Rett's Disorder, Childhood Disintegrative Disorder, Asperger's Disorder (AD), and Pervasive Development Disorder Not Otherwise Specified (PDDNOS). The *DSM* is the manual used by clinicians to diagnose patients with mental disorders (APA, 2013c). Under *DSM-IV,* Autistic Disorder was described in terms of impairments in three areas, the inability to interact socially in a generally accepted manner, a delay or lack of communication skills, and a focus on a narrow and repetitive field of behavior (APA, 2000).

In 2013, the APA amended the definition of ASD and it is now termed a neurodevelopmental disorder (*DSM-5;* APA, 2013). Individuals who were previously diagnosed under *DSM-IV* as having Autistic Disorder, Childhood Disintegrative Disorder, AD, or PDDNOS are now included under the umbrella diagnosis of ASD (APA, 2013c). *DSM-5* classifies the characteristics of ASD into two main categories, 1) impairments in social communication and interaction and 2) restricted, repetitive behaviors (RRB) (APA, 2013). To meet the diagnosis of ASD, individuals must display impairments in both of these categories (APA, 2013).

The international community as represented by the World Health Organization (WHO) provides another major diagnostic definition of ASD (Frith, 2003). The WHO was set up as part of the United Nations in 1948 with responsibility for global public health issues and interests among its member countries (WHO, 1993); it currently has 194 member countries (WHO, 2015). *The International Classification of Diseases-10 Classification of Mental and Behavioural Disorders (ICD-10)* provides the current WHO classifications for both physical and mental disorders (WHO, 1993). *ICD-10* defines autism as impairments in social communication, social interaction, and RRBs. This classification system is scheduled to be used in the United States from the beginning of October 2015 for the purposes of billing medical insurance companies (Nordal, 2014). Characteristics of ASD described in *DSM-5* and *ICD-10* are provided in the following sections. The WHO supports the Social Model of Disability (Oliver, 1990; WHO, 2002).

The tenet of the Social Model of Disability is that it is society that disables people by not providing them with proper access to services (Oliver, 1990; WHO, 2002). This is in contrast to the outdated Medical Model of Disability which viewed people with a disability as needing to be cured and who must change to fit into the environment like everyone else, that is, non-disabled people (WHO, 2002).

Terminology

Social science research supports the use of "people first" language, hence "child with ASD" rather than "autistic child" (American Psychological Association, 2010). However, many people with ASD dislike people first language and opt for "autistic person" because they see their autism as part of themselves (Autism Network International, 2008; Larsen, 2011; Sinclair, 1999). Furthermore, some people prefer to use the term autism spectrum or autism spectrum condition because "disorder" has negative implications (National Autistic Society [NAS], 2015). For clarity, this study will use the conventional term "child/ren with ASD."

The NAS (2015) suggests that the term "typically developing children" be used to describe children without ASD and that term will be used in this study. However, the term "neurotypical" can also be found in the literature, coined by Attwood in 1988, to differentiate people who do not have ASD (Cashin, 2006). This term tends to be used by people with ASD to talk about people who do not have ASD (Larsen, 2011) and the NAS (2015) therefore suggests its use is not fully appropriate. Another term found in the literature is "neurodiversity," a concept and social movement advocating for people with ASD and other neurological disorders; that they be able to live and be accepted for who they are, with support, without society trying to cure them (Neurodiversity Symposium, 2014). This study will use the terms “typically developing child/ren” or “child/ren without ASD.”

Characteristics of ASD

The characteristics of ASD are described in this study in terms of the categories commonly found in evaluation reports used by school districts, including the district where the research took place (North Metro School District, 2014a [note the school district name has been change to protect confidentiality]). It is important to remember that these characteristics vary greatly on an individual basis and it is often quoted, “If you know one person with autism; you know one person with autism” (Autism Speaks, 2012, p. 5).

Level of ASD. *DSM-5* lists three severity levels of ASD:

- Level 1: requiring support
- Level 2: requiring substantial support
- Level 3: requiring very substantial support (2013, p. 52)

The implications of the APA’s definition (2013) is that everyone diagnosed with ASD needs some level of support, with all that implies in terms of human and financial costs. Another common diagnostic tool, the Childhood Autism Rating Scale (CARS) developed by Eric Schopler, classifies ASD into four levels from “not autistic,” through “mildly,” to “moderately autistic,” to “severely autistic” (Schopler, Reichler, Vellis, & Daly, 1980, p. 98). The recognition that there are varying levels of ASD on a continuum has led to it being described as covering a spectrum (APA, 2013b).

Gender. There is a significant gender imbalance in the numbers of boys and girls diagnosed with ASD. The latest estimates released by the Centers for Disease Control and Prevention (CDC) are that boys are nearly five times as likely to be diagnosed with ASD than girls, 1:42 boys and 1:189 girls (Baio, 2014). The CDC base their current estimates on data collected from12 sites in the United States but they have monitored up to 14 sites for ASD prevalence since 2002 (CDC, 2015b). Although there are various hypotheses of why more boys are identified with ASD than girls, such as normal differences between the sexes exaggerated in individuals because of the characteristics of ASD, or genetic causes that may be inheritable by more males, the reason for this gender imbalance is not currently understood (National Autistic Society, 2014).

Ethnicity. There is an ongoing discussion about whether ASD is linked to ethnicity. In 2008, members of the Somali community in Minneapolis, Minnesota, expressed concern to the Minnesota Department of Health that there seemed to be a disproportionate number of children from their community who had been diagnosed with ASD (Hewitt et al., 2013). This led to an investigative research project designed to find out the number and characteristics of Somali children diagnosed with ASD living in Minneapolis (Hewitt et al., 2013). The findings, made public in 2013, reported that Somali and White children were about equally likely to be diagnosed with ASD (1:32 and 1:36 respectively), but Black (non-Somali) and Hispanic children were less likely to be diagnosed with ASD (1:62 and 1:80 respectively) (Hewitt et al., 2013). The reasons for the greater prevalence of ASD in Somali and White children are not known and further research in this area needs to be carried out (Hewitt et al., 2013).

Comorbid conditions. There are a number of other comorbid conditions that are seen in individuals diagnosed with ASD affecting between 10-37% (Simpson, Myles, & LaCava, 2008). Comorbidity is defined as the diagnosis of two or more medical conditions in an individual (Mosby, 2009). ASD and intellectual disability, discussed below, are frequently diagnosed together, but there are also other conditions (APA, 2013). In a review of recent literature, Jeste (2011) found that sleep impairments, particularly insomnia, were widely reported in individuals with ASD although differences in methodology meant the percentages could not be assimilated and so estimates varied from between 44%-83%. Jeste (2011) also reviewed another reported comorbid condition, epilepsy, i.e., a brain disorder caused by abnormal electrical patterns in the brain which provokes mild or severe seizures, from moments of imperceptible staring to full blackouts and convulsions (U.S. National Library of Medicine [NLM], 2015). Jeste (2011) found that 30% of children with ASD have epilepsy. Ludlow, Wilkins, and Heaton (2006) reported that one-third of individuals with ASD experienced seizures from an early age; Simpson, Myles, & LaCava (2008) cited reports of ASD and epilepsy varying from 7%-42%.

Intellectual/cognitive functioning. The assessment of intellectual functioning or ability is traditionally based on a definition of intelligence quotient (IQ) calculated by the combination of an individual's mental age divided by their chronological age multiplied by 100 (Mackintosh, 2011). *DSM-5* defines an intellectual disability as a score of two or more standard deviations below the general population, i.e., 70 or below (APA, 2013c). In their research, the CDC defines an IQ of over 85 as average or above average, an IQ of

71-85 as borderline, and an IQ of 70 or below as having an intellectual disability (Baio, 2014). Of 3,604 children with ASD 8 years of age surveyed in 2010, the CDC reported that more than half had an accompanying intellectual disability, 23% with a borderline IQ and 31% with an intellectual disability (Baio, 2014). In addition, the CDC found that there was a difference in ethnicity; more non-Hispanic Black children (48%) were diagnosed with an intellectual disability than Hispanic children (38%) and non-Hispanic White children (25%) (Baio, 2014).

APA (2013b) describes difficulties in three domains of intellectual functioning, conceptual (e.g., difficulty in reading, writing, and math), social (e.g., difficulty in empathy and communication skills), and practical (e.g., difficulties in personal care and money management) (APA, 2013b). Jordan (2001) likens having an intellectual disability along with ASD to having a delay in mental development accompanied by the unusual behaviors typical of ASD.

Another common problem in the cognitive functioning of children with ASD is their inability to generalize, that is, to take what they have learned in one situation and apply it to another (Simpson, Myles, & LaCava, 2008). This challenge has implications for the learning environment in that children may not be able to generalize their experience and what they have learned in one environment to another, for example, from the classroom to the home. Also, many children with ASD do not have the same perception of danger as a typically developing child so have to be watched more closely (Nguyen, 2009).

Social, emotional, and behavioral functioning. As stated earlier, individuals with ASD can have a variety of difficulties in their social communication, interaction, and emotional functioning (APA, 2013; National Institute of Mental Health [NIMH], 2008). Difficulties with social interaction include an inability to perceive that someone else has a point of view (Baron-Cohen, 2008; Frith, 2003) and a general lack of empathy towards others (Frith, 2003). This lack of reciprocity also means that children with ASD often have problems with turn-taking during playtime which can manifest in issues making friends and understanding relationships, including an inability to experience imaginative play (APA, 2013; Baron-Cohen, 2008; NIMH, 2008). Many individuals also have problems understanding the subtleties of language or the use of metaphors and take meanings literally (Jordan, 2001; NIMH, 2008). The journalist Ron Suskind, the parent of a son with ASD, gives an example of a conversation with his son, "You and her in the car. Who knows where it'll end?" and his son's emphatic reply, "Home!" (Suskind, 2014, p. 296). Individuals with ASD also tend to avoid eye contact (Frith, 2003). This puts other challenges in motion such as understanding typical nonverbal communication and is often combined with an inability to perceive non-verbal gestures, to understand body language, to interpret facial expression, or to follow eye gaze (Baron-Cohen, 2008; Jordan, 2001; NIMH, 2008).

Another characteristic of social and emotional behavior of individuals with ASD is a dislike of physical contact (Frith, 2003). Grandin, a well-known scholar with ASD, describes herself as a child hating to be touched or hugged by other people but craving physical pressure (2006). This need led her to design a "squeeze machine" for herself which she used to apply pressure to her body to help her relax and relieve stress (Grandin, 2006, p.58).

Regarding difficulties in behavioral functioning, APA (2013) describes a number of restrictive, repetitive behaviors (RRBs), as discussed earlier, as one of the two categories of impairments noted in the *DSM-5* (APA, 2013). RRBs include actions such as arm flapping or body spinning or an obsession with moving parts on toys or machinery (APA, 2013). Baron-Cohen (2008) describes a child who would spend hours spinning the wheel of his toy car. Grandin (2006) describes spending hours at the seaside watching sand running through her fingers. RRBs can also include repetitive verbal behaviors such as echolalia, (i.e. repeating someone's words). For example, "Do you want a drink?" is responded to with, "Do you want a drink" (Baron-Cohen, 2008; Frith, 2003). This characteristic of RRB can manifest as an obsessive interest in a particular item or activity to the exclusion of all else (APA, 2013). Behaviorally, people with ASD often need everything to be the same and can exhibit tantrums or difficult behavior if things are changed from their usual routine (APA, 2013; Baron-Cohen, 2008). *DSM-5* also stresses that the behavioral examples they give are typical ways that individuals diagnosed with ASD might behave, but that the list they provide is not exhaustive (APA, 2013).

Communication skills. Communication skills are defined for the purposes of this research as the level of verbal speech. Individuals may have different levels of communication depending on their level of ASD. Individuals with a Level 1 diagnosis are likely to be verbal and to speak in full sentences; individuals with a Level 2 diagnosis are likely to be verbal and use simple sentences; and individuals with a Level 3 diagnosis are likely to have few words of understandable speech or no speech at all (APA, 2013). Not only can delays in verbal communication occur, but in some children with ASD speech could be lacking altogether (WHO, 1993). The CDC (2010) cites information provided by the National Center on Birth Defects and Development Disabilities (NCBDDD) noting 40% of children with ASD do not talk, between 25%-30% have a few words between 12-18 months but lose them, and that some children may talk when they are older (NCBDDD, 2010).

Motor ability. Some individuals with ASD have difficulty controlling motor movements of their body. *DSM-5* refers to a condition called catatonia which is not considered as a separate diagnosis but is associated with ASD and other disorders (APA, 2013). It is characterized by abnormalities in physical motor activity, either decreased physical activity or excessive physical activity (APA, 2013). In a review of literature, Jeste (2011) found that impairments in motor ability were prevalent in individuals with ASD in both gross (large bodily) and fine (small bodily) movements. Impairments included dyspraxia, i.e., a lack of coordination in both gross and fine bodily movements, and difficulties in gait, i.e., in walking (Dyspraxia Foundation, 2015). Individuals with ASD can also have sensory integration dysfunction, i.e., a difficulty processing their movements and understanding how their body moves in space (Woronko & Killoran, 2011). Woronko & Killoran (2011) indicate this may affect between 42%-88% of individuals with ASD. Physical motor behaviors can also include echopraxia (copying someone else's movements) (APA, 2013).

Sensitivity to the environment. A common characteristic described by *DSM -5* under the category of RRBs is a hyper- or hyposensitivity to stimulation in the physical environment (APA, 2013). *DSM-5* directly links hyper- and hyposensitive behavior to the sensory aspects contained in the environment (APA, 2013). Many authors report that because children with ASD have difficulty processing, tolerating, or understanding what is going on around them in the environment this can lead to challenging behaviors or even violence or aggression towards others or themselves (Edelson, 2011; Emerson, 2011; Harrison & Hare, 2004).

Individuals with ASD who are hypersensitive have a low tolerance level and react to external sensory stimuli. Sounds, smells, and sights, tolerable or unnoticeable by typically developing children can be challenging for those with these heightened sensitivities. At the other extreme, hyposensitive children have a high tolerance level and a low reaction to sensory stimulation so, for example, they may not react to pain or changes in temperature (APA, 2013). *DSM-5* provides a non-exhaustive list of examples of hyper- and hyposensitivity including a lack of sensitivity to pain or temperature, adverse reaction to sounds or textures, fixations with smelling or touching objects, or obsessions with light from light fixtures (APA, 2013). Individuals with ASD can also fluctuate between hypo- and hypersensitivity (Harrison & Hare, 2004). Dunn (2008a), a researcher in sensory processing, reports that this is not a phenomenon seen only in individuals with ASD, but in the general population to some degree. There may be elements in the environment that most people are insensitive to or elements that most enjoy and seek, or conversely, elements that most people do not enjoy and try to avoid

(Dunn, 2008a).

From her experience with individuals with ASD, Grandin (2013) estimates that 9:10 people with ASD also have sensory disorders. Higashida (2013) wrote a book about his experience with ASD when he was 13. He describes issues with light, "'unfiltered' direct light sort of 'needles' its way into the eyeballs of people with autism in sharp straight lines, so we see too many points of light. This actually makes our eyes hurt" (p. 69). Williams (1996), a writer with ASD, describes her hypersensitivity as her brain taking on more information than it can keep up with, a term she calls "hyper saturation" (p.202). This sensitivity is not confined to the physical environment but can also apply to clothing.

Grandin (2006) describes an aversion to clothes as a child, "scratchy petticoats were like sandpaper scraping away at raw nerve endings" (p. 62). Conversely, some individuals may be insensitive to pain or induce self-harm (APA, 2013). Some may feel the need to stimulate themselves by making loud noises, some are unaware of smells, and some may feel the need for olfactory stimulation leading to inappropriate handling of pungent substances (Wilkes, 2007).

Several researchers have also described the tendency of children with ASD to fail to see the big picture and instead to focus on small, irrelevant details (Baron-Cohen, 2008; Frith, 2003). This phenomenon is known as Weak Central Coherence Theory. Baron-Cohen (2008) links this to "sensory hypersensitivity," that people with ASD are sensitive to and notice small details that others do not (p. 56). He goes on to say, "The sensory hypersensitivity theory clearly has major implications for creating autism- and

Asperger-friendly environments (at school, at home or at work), to minimize the stress from unpleasant sensory distractions (such as neon lights flickering, clocks ticking, and radios playing even at a distance)" (p. 56).

Hearing and vision. Several studies discuss the increased prevalence of hearing impairment in individuals with ASD (Kancherla, Braun, & Yeargin-Allsopp, 2013). The most recent report examined the population records of 230,000 8-year-olds with ASD in a metropolitan area of the United States over five years (Geggel, 2013). The investigators found that approximately 6%-7% of children with ASD had a hearing impairment or vision impairment, higher than in the general population of children diagnosed with a hearing or vision impairment (Geggel, 2013). Myles, Cook, Miller, Rinner, & Robbins (2000), in a book about children with AD, reported that Myler and other colleagues had conducted research that found that 85% of children with AD had auditory problems, though not necessarily hearing problems but problems with processing auditory information. This research will be discussed further in the theory section.

Other characteristics. Beyond intellectual, cognitive, social, emotional, and behavioral functioning; difficulties in communication and motor ability; sensitivity to the environment; and hearing and vision there are other well documented behaviors. The literature is punctuated with examples of distinct behavior, from individuals with ASD said to have homotrophic minds, i.e., who can only focus on one thing at a time, particularly when under duress (McAllister & Li, 2012); to hyperlaxia, i.e., children who have precocious reading skills but difficulty with language and social skills (Friedlander, 2009). A minority of high functioning people with ASD have savant traits, about 1:10, far more than in the general population where savant traits occur in less than 1:100 (Edelson, 2011). Savant traits describe individuals with phenomenal skills beyond the ability of average people (Edelson, 2011). Savant skills have been found in the domains of music, mathematics, and art (Pring, Ryder, Crane, and Hermelin, 2012).

Diagnosis

There is currently no physical examination or blood test that can diagnose ASD; it is diagnosed by behavioral observation of the individual, by surveying parents via questionnaire or interview, or by a combination of these (Baron-Cohen, 2008; Frith, 2003; NIMH, 2008). Clinicians often use what are known as standardized measurement instruments, diagnostic forms for trained medical practitioners to complete, to diagnose the condition, e.g., CARS (Baron-Cohen, 2008), mentioned previously. The Checklist of Autism in Toddlers (CHAT) and the Social Communication Questionnaire (SCQ) for 4-year-olds and upward are two other common diagnostic screening tools (NIMH, 2008).

New diagnostic techniques include research into eye-tracking (Jones & Klin, 2013). Jones and Klin (2013) carried out a longitudinal study on 110 infants, 59 at a high risk of developing ASD since they had a sibling with ASD, and 51 at a low risk of developing ASD since they had no close relatives with ASD. They showed the infants a video of caregivers under normal social interaction and measured the infants 10 times between 2 and 24 months to see whether they made eye contact with the images (Jones & Klin, 2013). Their findings were that in the high risk group over 20% of infants who showed a decline in eye contact were later diagnosed with ASD whereas, in the low risk group, only one infant was diagnosed with ASD (Jones & Klin, 2013). Jones and Klin (2013) suggest that decline in eye contact could provide an early diagnostic tool for ASD.

The current age at which diagnosis is made varies. *DSM-5* reports that symptoms usually manifest between 12-24 months (APA, 2013). Indeed, to gain a diagnosis of ASD individuals must show symptoms from early childhood (APA, 2013). However, APA also recognizes that some symptoms may not manifest until individuals experience socially demanding situations when they are older (APA, 2013). Baron-Cohen (2008) reports that diagnosis is frequently made between 18 months and 3 years of age. The CDC (2015a) reports that children with ASD are not usually diagnosed until four years of age. This implies that many children with ASD have been diagnosed before they start elementary school education, although individuals with the milder form of AD are not usually diagnosed until six years of age (CDC, 2015a).

Causes

While the symptoms and condition of ASD are well documented, opinion is divided on its causes. Some researchers believe it is related to genetics, some to a neurological disorder, some that it is caused by environmental factors, and some believe it is a combination of these (Edelson, 2011). The CDC (2015a) reports that parents who have a child diagnosed with ASD have a 2-18% chance of having a second child diagnosed with ASD. The CDC (2015a) also cites several studies investigating a link between identical twins and ASD concluding that if one twin has ASD the other twin has a 36%-95% chance of having ASD. In non-identical twins this chance is reduced to 0%-

31% (CDC, 2015). Approximately 10% of children diagnosed with ASD also have a genetic chromosomal condition such as Down syndrome (a syndrome in which individuals have an extra chromosome which can cause mental and physical impairment) (CDC, 2015c) or fragile X syndrome (a syndrome in which changes in a particular gene can cause mental impairment and social and behavioral problems) (CDC, 2015d).

Some theories on the causes of ASD have provoked controversy. For example, the "refrigerator mother" theory of ASD formulated by Kanner in the 1940s blamed the lack of the mother's maternal instincts for the child's problems (Laidler, 2004). In fact, Kanner did not use that phrase in his book but he was reported in *Time* (1960) as saying the parents of a child with ASD just happened "to defrost enough to produce a child" (p. 80). Another theory is the Mumps, Measles, and Rubella (MMR) theory which posited the MMR vaccination as the cause of ASD as published in the respected British medical journal *The Lancet* (Wakefield et al., 1998). The article caused widespread panic and an 80% drop in childhood MMR vaccinations in the United Kingdom (Deer, 2006). The article was later retracted and the lead author discredited (The Editors of *The Lancet*, 2010), but the myth around the single MMR vaccination as a cause of ASD persists, most recently in the U.S. press, fuelled by an outbreak of measles in California (Haberman, 2015). Haberman reported in the *New York Times* (2015) that measles had reputedly been eradicated in 2000 but that in 2014 the CDC reported 644 cases. In a rebuttal to concerns about the link between ASD and vaccinations, the CDC (2015e) published information about various studies that they had conducted or sponsored on the topic. Their findings are emphatic, "vaccines do not cause ASD" (CDC, 2015e, p.1).

Prognosis of ASD

One other facet of ASD to discuss is that most experts believe that there is no cure for the condition of ASD (Frith, 2003; Simpson Myles, & LaCava, 2008). Back in 1980, the APA predicted that only 1:6 adults with ASD were likely to live independently and find work, 1:6 may be able to do so with minimal adjustments, but 2:3 were unlikely to live independently (Oller & Oller, 2010; Simpson, Myles, & LaCava, 2008). Despite this early prognosis, most professionals and advocacy groups now agree that early interventions, including supportive teaching and learning strategies, are essential and can be successful in improving learning and life skills for children with ASD, with the outcome dependent on the child's level of ASD (Autism Science Foundation, 2015; National Autism Association, n.d.; NIMH, 2008; Ogletree, 2008; Simpson, Myles, & LaCava, 2008). To illustrate, some examples of successful outcomes are available. A case study by Ogletree (2008) describes how a range of measures implemented by a speech-language pathologist increased the communication abilities of a child with ASD. Grandin (2006) describes how, with the supportive teaching of family and educationalists, she became a university professor and a successful designer of livestock handling facilities.

Financial Impact

In addition to the impact of ASD on the individual and their families associated with the characteristics of ASD, there are also financial costs associated with caring for someone with ASD. This is a further motivation in trying to improve the outcome for children with ASD. A number of researchers have attempted the difficult task of putting a monetary value on these costs. In 2007, Ganz estimated these overall costs using direct medical, direct non-medical, and indirect data obtained from a variety of sources (Ganz, 2008). Direct medical costs included medical and dental treatment, prescription medicines, and specialist equipment; direct non-medical costs included special education facilities, school transport costs, respite care, and home care modifications; indirect costs included both the loss in income of an adult with ASD unable to work, based on the average working life of an adult, and loss of income of parents as caregivers unable to work (M. L. Ganz, 2007). With this data, M. L. Ganz (2007) used an age-range approach to hypothesize the costs incurred at each stage of life to arrive at a total lifetime cost. He also used a discount approach to obtain current costs per person with ASD in conjunction with a sensitivity analysis. The results of M. L. Ganz's (2007) work indicate that the average lifetime cost to society of a person with ASD is nearly $3.2 million. The estimated childhood cost covering the age range 3-17 is just over $1 million, which includes calculations for special education. M. L. Ganz (2007) calculated the costs for the total birth cohort of people with ASD as $35 billion. While there are potential flaws in the study concerning non-complete, non-current data, M. L. Ganz's study (2007) provides a baseline understanding of the overall categories of costs to society of a person with ASD over their lifetime.

Buescher, Cidav, Knapp, and Mandell (2014) also compiled lifetime costs of people with ASD, specifically comparing the United Kingdom to the United States and also considering the difference in costs between those with ASD with an intellectual disability (ID) and those with ASD with no ID. Their estimates, which contain similar flaws to that reported by M. L. Ganz (2007), such as incomplete and outmoded data, predicted a cost of $61 billion per annum to the United States for children with ASD from birth to age 17 (Buescher et al., 2014). In terms of the cost of special education, Buescher et al. (2014) estimate the costs per child with ASD with an ID and without an ID were just under $28,000 and just under $14,000, respectively (Buescher et al., 2014). The lifetime costs of a child from birth to 17 ranged from just over $115,000 per year to just over $1.9 million per year per child depending on the level of their ID (Buescher et al., 2014).

An informal report by Maltby (2000) included some interesting estimates on the educational costs of children with ASD. Using data from the U.S. population census of 1996, he calculated that the cost of mainstreaming 35% of children with ASD was $192 million over and above regular school costs. An ancillary cost included was an extra $34 million in special transportation (Maltby, 2003). In addition, a human cost of ASD that is rarely mentioned in the literature is that people with developmental disabilities are generally on the lowest income level compared to other members of society (Maltby, 2003). Maltby (2003) explains this dichotomy, “They might receive services that cost a great deal of money, but remain personally impoverished and dependent” (p. 406).

Other sources such as the CDC (2010) estimate that the specialist medical support required for a person with ASD is up to six times greater than the costs for a person without ASD. Despite the fact that the studies mentioned report flaws and that the authors had to make certain assumptions, it is clear that ASD is a cost burden to society of many millions of dollars per year.

Education for Children with ASD

Rehabilitation Act of 1973: Section 504

In the United States, protection of rights to education for all people with special circumstances has existed since the early 20th-century. A law dating back to 1917, the Smith-Hughes Act, provided federal money to help states fund vocational education programs (Indiana Government, 2015). This Act was followed over the years by various other acts passed by the federal government, many focusing on funding and rehabilitation programs for war veterans who had been disabled. These efforts culminated in the 1973 Rehabilitation Act (Indiana Government, 2015). This Act moved away from the vocational emphasis of the original law to focus federal funding on people with a disability (Indiana Government, 2015). The section of the Act that is particularly relevant to education is Section 504.

Section 504 made the provision that no "individual with a disability in the United States . . . shall, solely by reason of her or his disability, be excluded from the participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance" (Department of Education [DOE], 2007, p. 1). The DOE is responsible for applying the Section 504 regulations in its domain, which includes the funding it provides to school districts (Department of Justice, 2009).

Free Appropriate Public Education (FAPE)

One of the keystones of Section 504 is that each child with a disability must be provided with an education free of charge, "a free appropriate public education regardless of the nature or severity of the person's disability" (DOE, 2007, p. 1.). Under FAPE, a disability is defined as any physical or mental impairment which adversely affects a person's ability to carry out their daily activities. Appropriate education includes education in a general classroom with appropriate assistance or education in a separate classroom for all or part of the day in addition to related therapies and medical diagnostics to support their education (DOE, 2007). Appropriate assistance provided to the student could include physical aids, equipment, and human help, such as interpreters for students with a hearing impairment or readers for students with a vision impairment (DOE, 2007). Regarding education in the classroom, FAPE states that students with disabilities must be educated in the same classroom as students without disabilities wherever possible. Guidance issued by DOE (2007) reiterates, "Students with disabilities and students without disabilities must be placed in the same setting, to the maximum extent appropriate to the education needs of the students with disabilities" (p. 5). FAPE also makes the provision that a student with a disability must have her/his educational needs met to the same extent as a student without a disability and that each student must be appropriately evaluated by the school district (DOE, 2007). The principles of FAPE have been strengthened by their inclusion in another piece of legislation, the Individuals with Disabilities Education Act (IDEA), discussed below.

Individuals with Disabilities Education Act (IDEA)

The origins of the IDEA date back to the Education of the Handicapped Act (EHA) of 1970 which was later amended to the Education for All Handicapped Children Act (EAHCA) of 1975 (Driscoll & Nagel, 2008). The principles of FAPE were incorporated into IDEA in 1990, but the latter emphasized the education of children as individuals with disabilities rather than as handicapped children and that they should be educated in the least restricted environment (Driscoll & Nagel, 2008). IDEA was amended in 1997 to further strengthen the legislation, particularly focusing on how individual education plans (IEPs) could help evaluate teaching and learning (Driscoll & Nagel, 2008).

The 2004 Individuals with Disabilities Education Improvement Act (also known as IDEA) strengthened previous legislative acts, including incorporating FAPE with additional details. Now, one of the ways of complying with Section 504 is by complying with IDEA (2004) (DOE, 2007). IDEA (2004) extended the provision of FAPE, which must be provided to all children from the ages of 3 to 21, including children with disabilities (DOE, 2006). Some of the key elements of IDEA (2004) as they relate to this study are discussed below.

Least Restrictive Environment (LRE). The LRE principle states that children with a disability must be educated to the greatest degree possible and in the least restrictive setting with children who do not have a disability (IDEA, 2004). Separate classes or separate schools are only acceptable if the child's disability prevents him/her from achieving his/her educational potential, even with the availability of assistance (IDEA, 2004). Supplementary aids must also be provided to the student as appropriate to support him/her, including physical aids, equipment, and school staff (DOE, 2007).

Definition of a child with ASD. IDEA (2004) defines a child with autism as having a disability (300.8, IDEA, 2004). ASD is described by IDEA (300.111, 2004) as "a developmental disability significantly affecting verbal or nonverbal communication and social intervention, generally evident before age three that adversely affects a child's educational performance." IDEA (300.111, 2004) also describes other characteristics associated with ASD such as RRBs "resistance to environmental change or change in daily routines, and unusual responses to sensory experiences."

Individualized Education Program (IEP). The concept of individual education programs (often called plans) is included in IDEA 2004 which mandates that each state must provide every student with a disability with an IEP (IDEA, 2004). An IEP is a written statement detailing the child's disability and how it affects his/her learning as well as providing annual, measurable goals and outcomes to monitor how the student is progressing academically (300.320, IDEA, 2004). In determining whether a child is eligible for an IEP, the educational establishment has to assemble information about the child, including his/her performance in aptitude and achievement tests, the views of their teachers and parents, and information on the child's physical, social, and adaptive behavior (300.306, IDEA, 2004). A medical diagnosis is not required under IDEA 2004 (DOE, 2011) and a medical diagnosis provided by a practitioner outside of the school does not automatically entitle a child to an IEP (Mahler, 2015). However, as part of the information assembled about the child, a diagnosis from a medical practitioner could be included as part of the documentation to assess the child's eligibility for an IEP (DOE, 2011). An IEP must be reevaluated at least every three years (300.303, IDEA, 2004).

Related services. In addition to educational services, IDEA (2004) lists a range of related services that must be provided to a child with a disability if it will help him/her to access education. The list includes speech-language pathology, audiology, and psychology services; physical and occupational therapy; and school health and nurse services (300.34 IDEA, 2004). These services could be provided to students with ASD depending on their level of need and ability.

Staffing. A highly qualified special education teacher is required to teach in a special education class (300.156, IDEA, 2004). In addition, paraprofessionals working in special education may also be required to be appropriately educated (Minnesota Department of Education [MNDOE], 2012). A paraprofessional is defined as a helper who is trained to assist a teacher (Merriam-Webster, 2012). The ratio of teachers to students in a special education classroom varies depending on the needs of the students in the class, but a typical arrangement could be 12 students in a class with one special education teacher and one paraprofessional for students with minimal needs, and a ratio of 12 students with one special education teacher and four paraprofessionals for students with greater needs (United Federation of Teachers, 2015).

Paraprofessionals can carry out a variety of duties and be known by a variety of titles (MNDOE, 2015). Duties could include providing physical assistance, assisting with personal care, helping to manage behavior, and supporting learning (MNDOE, 2015). Paraprofessionals are typically referred to as special education paraprofessionals, pupil support assistants, or instructional assistants (MNDOE, 2015). For the purposes of this study, the term paraprofessionals will be used, abbreviated to "para/s."

The Americans with Disabilities Act (ADA)

The Americans with Disabilities Act (ADA, 1990) is an overarching civil rights law that makes it an offence to discriminate against a person because of his/her disability in access to employment, public services, public transportation, telecommunications, and various other provisions. Under the provisions of public services, the ADA states that a person with a disability "cannot be excluded from participation in or be denied the benefits of services, programs, or activities of a public entity" (ADA, 1990, Sec. 202). A public entity is defined as any state, local government, department, or agency (ADA, 1990, Sec. 201). This provision, among other things, made it a civil rights offense for a place of education to discriminate against a student because of their disability and requires providers of public education to provide equal access to their services for students with a disability (Department of Justice, 2009). The legislation specifically refers to disability, not ability level (ADA, 1990).

Another relevant section of the ADA was the provision that within nine months of the legislation, architectural guidelines meeting a minimum expected standard would be issued to ensure that buildings and facilities were accessible for people with disabilities in terms of their architecture and design (Sec. 504, ADA, 1990). The latest guidelines published under this provision are the 2010 ADA Standards for Accessible Design (Department of Justice, 2010).

No Child Left Behind Act (NCLB)

The No Child Left Behind Act (NCLB, 2001) is a federal law which built on previous legislation and was designed to ensure that all students attained measurable goals and graduated from high school (Yell, 2005). The legislation was in response to concerns that there were gaps in the achievement levels of students particularly in terms of race, ethnicity, or disability (Yell, 2005). NCLB also made it a requirement that highly qualified teachers be employed to teach all students, including students with a disability (Yell, 2005). This requirement, among others, was subsequently incorporated into IDEA (2004) (DOE, 2007).

Instructional Setting

The legislation that has been outlined states that children should be educated together regardless of their ability level wherever possible. The practice of including students with a disability in a regular classroom is known as "mainstreaming" (Merriam-Webster, 2012). Mainstreaming is defined as the education of a student with a disability with peers of the same age who do not have a disability in a general education classroom (United Federation of Teachers, 2015). However, federal regulations also recognize that it is not always appropriate for a child with a disability to be mainstreamed all the time and a range of settings may therefore be appropriate to meet the needs and ability of the child (MNDOE, 2014). A setting is defined as the location and amount of time that the student with an IEP receives educational services; settings range from 1 to 8 (MNDOE, 2014). The subjects in this research are likely to be educated in Settings 1, 2, and 3. Each setting is described below.

Setting 1. This setting refers to students with disabilities who receive special education outside the regular classroom for less than 21% of the school day, which may include education in the regular classroom, education outside the regular classroom, or education in a resource room (MNDOE, 2014). A regular classroom is defined as a general education class within a public school (Mastropieri & Scruggs, 2007). A resource room is defined as a separate room where a student with an IEP receives specialized educational instruction (Mastropieri & Scruggs, 2007).

Setting 2. This setting includes students with disabilities who receive special education outside the regular classroom between 21-60% of the school day, including in a resource room or a combination of a resource room and a regular classroom (MNDOE, 2014).

Setting 3. This setting includes students with disabilities who receive special education outside the regular classroom over 60% of the day, which may include education in a self-contained special classroom, or a combination of education in a special classroom and a regular classroom (MNDOE, 2014). A special classroom is defined as a class of students with disabilities who are taught together because they have similar needs (United Federation of Teachers, 2015). Special classrooms could have students with the same disability or a variety of disabilities (United Federation of Teachers, 2015).

Settings 4 and 5. These settings include students with disabilities who receive special education in a separate public or private facility over 50% of the day (MNDOE, 2014). Students may be educated exclusively in that facility or in a regular school building for the remaining percent of the day (MNDOE, 2014).

Settings 6 and 7. These settings include students with disabilities who receive special education in a separate public residential or private residential facility over 50% of the day (MNDOE, 2014). Students may be educated exclusively in that facility or in a separate non-residential school or in a regular school building for the remaining percent of the day (MNDOE, 2014).

Setting 8. This setting refers to students with disabilities who receive special education in hospital or at home.

Despite legislation to the contrary, however, Kluth (2003) states that it is the practice of some educational bodies to provide separate classrooms and programs for students with disabilities, thereby, not educating them with their peers in a general classroom. Referring to students with ASD specifically, she states that many are educated in the same special educational setting because they are labelled as having ASD and not because they have similar educational needs and goals (Kluth, 2003).

Interventions

Definition. An intervention is a treatment or therapy for individuals with ASD designed to promote social communication, reduce RRBs, and improve quality of life (Agency for Healthcare Research & Quality [AHRQ], 2014). The literature is inconsistent about the categories of interventions. For example, the AHRQ (2014) classifies interventions into behavioral, educational, and medical; the National Professional Development Center (NPDC, 2014) classifies interventions as behavioral covering cognitive, augmentative, and instructional interventions; the National Academy of Sciences (2001) classifies interventions as instructional and augmentative; the What Works Clearinghouse™ (WWC) (WWC, 2013) classifies interventions as educational programs, policies, and practices; and authors Simpson, Myles, & Ganz (2008) classify interventions as behavioral, educational, and biological. For the purposes of this review, interventions will be classified as medical and educational, covering behavioral, cognitive, and augmentative interventions. A discussion of environmental interventions is also provided, i.e., adaptations to the built environment to improve behavior and cognition.

Evidence-based (E-B) interventions. Interventions can also be defined as whether they are E-B practices shown to provide an effective method of treatment (NPDC, 2014). The WWC, part of the U.S. DOE, was set up in recognition that, to teach effectively, educators must have access to the latest scientifically supported educational interventions (WWC, 2013). The WWC was set up with the purpose of using "rigorous and relevant research, education, and statistics to improve our nation's education system" (WWC, 2013, p.1).

Another source citing evidence-based interventions is the NPDC, a body set up by three leading universities that have specialist centers for ASD treatment and research (NPDC, 2014). To be accepted as an evidence-based intervention by this body, studies are put through a rigorous review process to determine if 1) the research has appeared in a peer-reviewed scientific journal; 2) it is a high quality research design of two randomized or quasi-experimental studies; 3) it is a high quality research design of five single subject studies; or 4) it is a high quality research design of one randomized or quasi-experimental group study and three single subject studies (NDPC, 2014). The NPDC also provides both training modules for educators and briefing papers on the interventions that meet their standards (NPDC, 2014). With limited funds available, agencies such as NPDC and WWC recognize that authorities need to use interventions that demonstrate improvements for students with ASD.

Benefits of interventions. A few interventions are discussed here but there are numerous available, some respected and well-established, some recognized as evidence-based practices by national bodies, and some controversial and their benefits unfounded (Simpson, Myles, & Ganz, 2008). Despite the number and range of interventions available "to date, no single intervention has been identified that is appropriate for all children with ASD" (Schilling & Schwartz, 2004, p. 431). What does seem to be established is that the earlier the intervention is started the better the long term outcome for the child (CDC, 2015a; NIMH, 2008; Simpson, Myles, & LaCava, 2008).

Medical Interventions

Medical interventions do not cure ASD but they may alleviate some of the effects for some people (CDC, 2015a). Medical interventions include administering drugs such as aripiprazole and risperidone, both classed as types of atypical antipsychotic drugs that work by altering brain activity (U.S. National Library of Medicine, 2015). Both drugs have been shown to reduce RRBs and challenging behaviors (AHRQ, 2014). However, these drugs have also been shown to cause weight gain and drowsiness (AHRQ, 2014). Serotonin reuptake inhibitors (SRIs), anti-depressants that help balance the body's chemical systems (National Institute of Child Health & Human Development, 2015), are used to treat RRBs and challenging behaviors, but AHRQ (2012) found insufficient evidence to support their use as an intervention and also reported side effects of the drugs, such as nausea and insomnia.

Educational Interventions

According to the NPDC there are two types of interventions available to children with ASD, “comprehensive treatment models” and “focused intervention practices” (Wong et al., 2014). Comprehensive treatment models provide a broad range of educational objectives in a comprehensive training package. Examples include applied behavior analysis (ABA) and the Treatment and Education of Autistic and related Communication-handicapped CHildren (sic) (TEACCH) (Wong et al., 2014). Focused intervention practices describe a training program focusing on a specific skill set. Examples include the Picture Exchange Communication System (PECS) and visual supports (Wong et al., 2014). These interventions are considered to be evidence-based practices by the NPDC (Wong et al., 2014). Each is described in more detail below.

ABA. ABA as a technique was popularized by Ivar Lovaas working at the University of California Los Angeles, although it dates back to the work of behavioral therapists in the 1920s (Simpson, Myles, & Ganz, 2008). It is an intensive therapy undertaken on a one-to-one basis involving an instructor manipulating an antecedent event to change the individual’s behavior and improve his/her skills, i.e., a cause and effect approach (Simpson, Myles, & Ganz, 2008). Lovaas’ original experiment required 19 subjects with ASD in the treatment group to undergo 40 hours of therapy over 2 years and 19 subjects with ASD in the control group to undergo 10 hours of therapy over 2 years (Lovaas, 1987). Parents were also trained in the therapy and Lovaas (1987) reported that subjects in the control group could have received therapy 365 days a year so they may have received more than 40 hours of therapy each week. Lovaas (1987) reported that nearly 50% of the treatment group achieved typical intellectual and educational functioning after therapy compared to just 2% of the control group.

Many other research studies have found improvements in the functioning level of children with ASD following intensive ABA instruction, as reported by Simpson, Myles, and Ganz (2008) and the NPDC (2014) regards it as an E-B intervention. However, the WWC (2010) reviewed 58 studies using Lovaas' intervention method and reported that only two studies met WWC research standards. The results of both studies showed some improvement in cognition, but neither showed improvements in other domains (WWC, 2010). AHRQ (2014) is also cautious about ABA as an intervention, rating it as moderately successful in improving cognition and language in some children.

Programs offering the ABA method can be found around the United States, including one at the Minnesota Autism Center that provides ABA intervention in the home, at school, or at their center (Minnesota Autism Center, 2015). A drawback is that it is recommended to be applied over a sustained period of time, making it costly. Although, Lovaas, writing in 1987, stated that the cost of a trained therapist for two years would be $40,000, a small amount compared to the nearly $2 million estimated for the lifetime costs of institutionalizing a child.

TEACCH. The TEACCH program was developed by Eric Schopler in the 1960s working at the University of North Carolina (Mesibov et al., 2004). Schopler believed in the theory of the Culture of Autism; that the deficiencies in relationships, communication, learning, and the senses experienced by people with ASD created a particular "culture of autism" that could be helped by working to their individual strengths and by adapting the interior to suit them (Mesibov et al., 2004). TEACCH is termed a structured teaching approach because of the way the course materials, the teaching method, and the physical classroom space are set up in a regular, organized manner comprehensible to a child with ASD (Mesibov et al., 2004). The TEACCH method of teaching emphasizes the individuality of the child with ASD and utilizes teaching methods and practices suitable for that particular child so that they learn as much as they can within their own limitations (Association for Science in Autism Treatment, 2011; Mesibov et al., 2004; Texas Statewide Leadership of Autism, 2010). The program focuses on predictability so that the child with ASD knows what to expect and when to expect it, both in school and in the home environment (Mesibov et al., 2004).

Visual schedules as shown in Figure 1 are also used to support learning. They are particularly important as some individuals do not understand verbal commands or can forget verbal information, but they often remember visual information (Mesibov et al., 2004). Visual supports include labelling furniture in the classroom, providing pictorial images of daily activities, or organizing tasks in a work schedule (Earles-Volrath, Cook, Robbins, & Ben-Arieh, 2008; Mesibov et al., 2004). Visual information can later be combined with the written word to promote higher functioning skills as shown in Figure 2 (Earles-Volrath et al., 2008). For example, a child might start by learning a visual image, such as a black and white line drawing, then the written word is added in conjunction with the image which could promote the higher skill of the written word, eventually using the written word without the image (Earles-Volrath et al., 2008).

Figure 1. Typical visual schedule. (Retrieved from https://s-mediacacheak0.

pinimg.com/originals/c4/1b/45/c41b45032d224d5621f2b59f4d754e57. jpg, 3/17/2015).

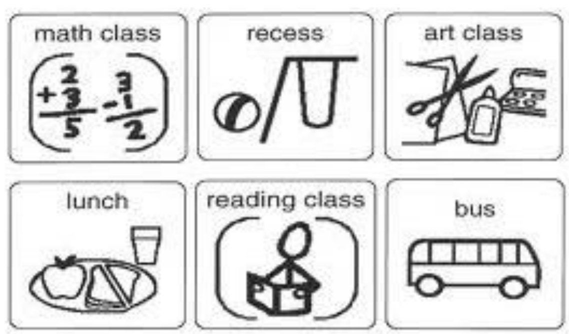

Figure 2. Typical pictorial images with text. (Retrieved from http://2.bp.blogspot.com/-z28QiNvZpIs/UDkQwL0NCOI/AAAAAAAACkc/ZLzyzGohrkc/s1600/ visual+ schedule.jpg 3/17/2015).

PECS. PECS was developed by Bondy and Frost in 1985 working at the Delaware Autism Program (PECS, 2015). The basis of the intervention is that the child exchanges a picture of an item or an activity that they want to do with the teacher in exchange for the specific item or activity (Simpson, Myles, & Ganz, 2008). PECS begins with teaching a student to request an item by exchanging a picture of the item for the actual item, e.g. a cookie (Bondy & Frost, 1998). Gradually more pictures of items are added to a communication binder that the student keeps and uses to request items or activities as shown in Figure 3 (Bondy & Frost, 1998).

Figure 3. Typical PECS communication binder. (Retrieved from http://www.pecsproducts.com/catalog/images/small-book-blue-detail.gif).

Later phases involve the student being taught to use the picture in a phrase with the final phase focusing on teaching the student to answer questions (Bondy & Frost, 1998). For some children who are non-verbal or who have very limited speech, PECS can be a suitable communication system (Simpson, Myles, & Ganz, 2008). Simpson, Myles, and Ganz (2008) report that research has shown that PECS can help children to communicate and the NPDC considers PECS an E-B practice for children aged between 5 and 12 (Colett-Klingenberg, 2008). Visual systems such as PECS can also help in wayfinding strategies. These will be described in the next section.

Environmental Interventions

Given the focus of this study, interventions were explored to determine if any addressed the needs of children with ASD, particularly in relation to the design of the educational space, namely the school building or classroom. One specific topic considered by the WWC is the evidence of successful interventions for students with disabilities between the ages of 5 and 18. As of November 2014, no studies were found that had been reviewed by the WWC concerning specific interventions in the built environment for students with ASD. In addition, no studies were found that provided E-B interventions for the design of schools and the built environment for children with ASD by the NPDC. There was reference to a future training module entitled “Structure and Management” (NPDC, 2014), but the focus of the module was not described and might refer to school operations rather than the physical environment. In summary, two leading bodies, WWC and NPDC, that review research literature to find evidence-based interventions have not identified any studies relating to the design of the physical school relative to learning outcomes for children with ASD. It seems that there is an opportunity for more research to be conducted about how the design of the environment could benefit children with ASD and findings put forward which could complement established medical and educational interventions.

Design and Human Behavior

We know that the built environment influences our behavior and that we influence the design of the built environment (Kopec, 2012). This concept was first put into words in 1924 by Winston Churchill, an English politician who later became Prime Minister of Great Britain, at a speech he gave to the English Architectural Association, “There is no doubt whatever about the influence of architecture and structure upon human character and action. We make our buildings and afterwards they make us. They regulate the course of our lives" (The Churchill Centre, 2015; International Centre for Facilities, 2006). Tversky (2003), a professor of psychology, describes our relationship with buildings as, "The space we explore, the space we inhabit as we move from place to place" (p. 72). Architects Malnar and Vodvarka (2004) consider that spaces have general characteristics that can be perceived by everyone but also that spaces take on personal meaning depending on the individual. The relationship between design and human behavior will be discussed below. Two other design concepts that affect human behavior, particularly in the area of wayfinding for people with ASD, are place blindness and neurotypical design, also discussed. This is followed by a discussion on evidence-based design (EBD) and how this approach can enhance the environment for people.

The Relationship between Design and Human Behavior

The field of environmental psychology tries to explain how humans influence, and are influenced by, the built environment (Kopec, 2012). Malnar and Vodvarka (2004) liken designed space to a story that can be read by humans "with a beginning, middle, and end" (p. 281). They have identified various senses that humans use to interact with their environment, including, auditory, haptic (touch), taste, smell, orientation, temperature, and visual (Malnar & Vodvarka, 2004). The quality of the building stock, the crowding levels, and physical elements such as acoustics, temperature, color, and lighting can each have a positive or negative effect on human behavior and mood (Kopec, 2012). In addition, sources of human discomfort can often be traced back to the environment but sometimes this information is not acted upon (Kopec, 2012). Kopec (2012) provides an example of a child who experiences stress caused by a crowded environment who is given medication or therapy by a clinician to combat stress whereas an environmental psychologist would seek to modify the environment by eliminating the stimulation that caused the stress. This approach relates to children with ASD who are often adversely affected by overstimulation caused by the environment.

Hunter (2010) particularly emphasizes the importance of wayfinding on human well-being stating, "Given the impact of wayfinding on human psychology, occupant satisfaction, health, long-term performance, and the financial bottom line, inattention to wayfinding reduces the inclusiveness of buildings for everyone" (p. 1). Kopec (2012) discusses schools and their effect on students with regard to wayfinding. He states that clear wayfinding can reduce students' feelings of confusion and vulnerability, especially when they are new to the space, but that all students would benefit from legible wayfinding, particularly as transition times between classes are often short and hurried (Kopec, 2012). Kopec (2012) suggests wayfinding cues such as shapes in the floor as many students walk with their eyes down, pictograms (pictures) for visual learners, and color to enhance features that can provide landmarks.

Place Blindness (Topographical Agnosia)

The concept of place blindness, correctly termed topographical agnosia, posits that some people with ASD, an unknown percent, have difficulty recognizing places and routes even though they may have travelled the same route many times before (Copley, 2009: Copley, 2011; Lawton, 2013). It is suggested that the use of notable landmarks could help a person with ASD with place blindness to navigate more easily (Copley, 2009: Copley, 2011; Lawton, 2013). Topographical agnosia has parallels with face blindness (prosopagnosia) another condition which many people with ASD have whereby they cannot recognize people's faces (Lawton, 2013).

However, while the concept of topographical agnosia is interesting, it does not have a body of scholarly work around it. No research articles alluding to the condition could be found either in the fields of ASD or design. There are a few articles that investigate topographical amnesia, the inability to selectively find one's way, often after a head or brain injury (Aguirre & D'Esposito, 1999), but that was the extent of the literature found. However, there is much description of the phenomena of place blindness on websites for those with ASD and several blogs where people with ASD describe their topographical agnosia (Inner Aspie, 2012; My Asperger's Child, 2012). It supports the body of literature that memorable features can be useful cues for wayfinding for people with ASD.

Neurotypical (NT) Design

Neurotypical (NT) design relates to design for children with ASD (Henry, 2011c).

Henry reports that advocates of the NT design approach believe that interiors should not be designed with the sensory sensitivities of the child with ASD in mind, but should be designed as near to the typical environment as possible because it is within typical environments that children with ASD will have to function (Henry, 2011c). Henry (2011c) describes one school where the corridors are set up as a typical main street scene, not the low key, bland, non-stimulating environment often associated with interiors designed for children with ASD. Schools that have been designed using the NT approach include the Celebrate the Children school in Denville, New Jersey (DMR

Architects, 2013) and the Developmental Learning Center in Warren, New Jersey (USA Architects, 2008).

Henry (2011c) puts forward arguments both for and against the NT design approach. Exponents of the approach believe it will help children to better generalize what they learn into the real world since some do not believe that children with ASD are best served by an environment which does not contain sensory stimulation as they will not be able to generalize their learning outside (Henry, 2011c). Those against the NT design approach argue that these environments may not be well-designed in general so we should not advocate teaching children with ASD in them (Henry, 2011c). Also, this type of designed environment could cause over-stimulation so opponents to NT design believe that children should be taught first in a calm, supportive environment, tailored to their needs, and that once they have learned a particular skill they will be able to generalize it to other environments (Henry, 2011c; 2011b). Henry (2011c) concludes that there is not enough research into either type of design, and no direct research comparison between those for and against the NT design approach to advocate one over the other.

Evidence-Based Design (EBD)

EBD can be defined as “the process of basing decisions about the built environment on credible research to achieve the best possible outcome” (Center for Health Design, 2008). EBD originated in the healthcare industry, but it is an innovation that has diffused from that area of expertise into the healthcare design industry (Kopec, Sinclair, & Matthes, 2012; Martin, 2009). The impetus of EBD in the design profession can be traced back to 2002 when researchers Guerin and Martin at the University of

Minnesota created a website, InformeDesign®, sponsored by the American Society of Interior Designers (Martin, 2009). The website features a searchable database of findings from design and human behavior research transformed into evidence-based design criteria as a resource primarily for designers of the built environment (i.e., interior designers and architects) (Martin, 2009). This enables designers to access peer-reviewed evidence to influence their design solutions (see http://www.informedesign.org/).

The level of expertise of users of EBD has been likened to a four step process (Hamilton, 2004; Hamilton & Watkins, 2009). Level 1 design practitioners have minimal knowledge of how to implement EBD. For a Level 1 practitioner to incorporate EBD practices into their designs they could read journal articles relating to environmental designs and consider how the findings could be incorporated into their own designs (Hamilton & Watkins, 2009). A Level 2 practitioner might implement design features based on a hypothesis that they have and measure how successful the design is (Hamilton & Watkins, 2009). Level 3 practitioners build on Level 1 and 2 experience but actually report their findings to other designers outside their own firm (Hamilton & Watkins, 2009). At the top, Level 4 practitioners are expert at implementing EBD research, measuring the success of their design, and publicizing the results in peer-reviewed journals (Hamilton, 2004; Hamilton & Watkins, 2009). Most researchers would say that interior designers are at the first stage of EBD practice, conducting a search of the literature and applying what they learn to a project. Few practitioners have reached the pinnacle of actually posing a research question, conducting the research, applying findings to the design of their project, and publishing the findings in a peer-reviewed journal, i.e., Level 4 practitioners (Hamilton & Watkins, 2009). As yet, few designers (both interior designers and architects) have adopted EBD practices (Martin, 2009).

There are several reasons why EBD is important to the design of the built environment. First, this approach can ensure that designers apply solutions that enhance quality of life and protect environmental resources (Martin, 2009). Second, EBD has been a persuasive factor in funding projects in the healthcare industry where expenditure has to be justified to hospital administrators and healthcare providers (Hamilton, 2004; Martin, 2009). Like healthcare, education is an area with limited resources so it is imperative that the funds that are allocated go to the design of a learning environment that supports proven educational strategies. It is crucial in the light of financial and time pressures facing clients and designers to integrate EBD practices into the design process to create environments that are more suitable for users (Martin, 2009). Children with ASD could benefit from this approach.

EBD for Learning Environments for Children with ASD

Currently, there is a lack of scientific literature relating to the design of environments for individuals with ASD that is of concern to many researchers and authors (Henry, 2011b; Henry 2011c; Khare, 2010; Martin, 2014; Shabha & Gaines, 2011; Vázquez & Torres, 2013). As Martin (2014b), in a presentation to fellow interior design educators states, “Research rigor is critical, as stakeholders want to apply these findings about classroom design as so little evidence is available” (p. 465). Martin (2014) conducted an extensive literature review to identify research about the design of classrooms for young children with ASD. She found limited research with empirical findings concluding that a move towards an EBD research agenda was critical to enhance the learning of young children with ASD (Martin, 2014).

Henry, a researcher and writer focusing on design for children and adults with ASD, echoes this point (2011b) and expresses concern that many designers and architects create design solutions the benefits of which are “mired in anecdote and conjecture” and, worse, could actually do harm to students with ASD because they are not verified (2012a, p. 1). Unfortunately, many of the design precedents followed by architects when designing for children with ASD rely on “anecdotal or methodically flawed studies” (Henry, 2011c, p.1).

The relationship between the environment and human behavior has been studied and discussed across many research fields, from politicians to environmental psychologists, interior designers to architects. The relationship between the design of schools as the learning environment and the children who learn in them is one such important relationship.

Environmental Design Factors in the School

In addition to considering the demographic variables related to children with ASD, the design of the learning environment as a variable needs to be explored.

School Design

Lippman (2010) defines schools as bases for education where diverse learners can come together to gain knowledge. Elementary and secondary school design in the 1980s was often based on economies of scale, with architects establishing typical space standards for required rooms or areas in the school and producing prototypical designs that could be applied to various schools (Lippman, 2010). School buildings must meet federal, state, and local building regulations to ensure they are of safe and suitable construction, especially in the design of safe egress in an emergency (Jones, 2014; Harmon & Kennor, 2011).

Stakeholders in the design of the school include school administrators, facilities managers, teachers, students, and parents, as well as design professionals (Lippman, 2010). Design professionals involved in the building of schools include architects, landscape architects, and interior designers; structural, mechanical, electrical, and civil engineers; and other specialists for components such as security, acoustics, elevators, and commercial kitchens (InformeDesign, 2003; Lippman, 2009).

Benefits of a Well-Designed School

According to the WHO (2014), the physical design of the school environment including the design elements of heat, light, and ventilation are essential to the well-being of students. The benefits of a safe school building are that they can protect students from environmental and physical threats, which is especially important because the physical environment is known to affect children's health (WHO, 2014). The National Institute of Building Sciences (NIBS) endorses that secondary schools should be safe and comfortable environments (Vaughan, 2011). NIBS advocate, among other things, that well-designed schools should feature good daylighting, natural ventilation, improved air quality, appropriate thermal comfort, and quality acoustic performance that all help to maximize the productivity of students (Vaughan, 2011). Vaughan (2011) also stresses that the aesthetics of a secondary school are important to create a sense of pride and ownership amongst students and staff and, in relation to wayfinding, that the addition of color and pattern can provide a functional way to connect spaces. These design elements improve students' well-being and are important to the delivery of the school program (Vaughan, 2011).

Higgins, Hall, Wall, Woolner, and McCaughey (2005) conducted a literature review aiming to find out what impact the design of the school environment had on students' learning. They reviewed over 200 articles, the majority from the United States and United Kingdom, and concluded that it was difficult to generalize the benefits of design across overall learning because the research tended to be focused on a particular element, such as acoustics (Higgins et al., 2005). They found that improving particular elements, such as acoustics, to minimum standards significantly benefited the children though the authors were cautious about inferring a direct causal link (Higgins, et al., 2005). Higgins et al. (2005) also found that temperature and noise had significant effects on learning; conversely, they found conflicting evidence on the effects of lighting and color on learning. Landmarks significantly improved navigation (Higgins et al., 2005). These findings are informative relative to the purpose of this study.

Well-designed schools should be stimulating yet safe places to enable children to learn and explore (Walz, 2003), yet Kopec (2012) notes that not all schools are well-designed. Many are built as large, consolidated units housing a great number of students in an effort to save costs on buildings, maintenance, and staff, particularly in urban areas (Kopec, 2012). There are a variety of environmental physical factors in a school that influence people including space and form, materials and finishes, texture and pattern, acoustics, thermal comfort, wayfinding, color, and light (Jones, 2014). These are discussed in the following sections.

Definition of Corridor

According to the International Building Code (2000), a corridor is, “An enclosed exit access component that defines and provides a path of egress travel to an exit” (p.211). Harmon and Kennon (2011) define it as, “An enclosed passageway (i.e., hallway) that creates a single path of travel” (p.70). The term corridor is used in construction and design and is therefore used throughout this study except hallway is used when talking to participants as a more familiar domestic term.

Space and Form

Space is the design element that is contained within boundaries (Jones, 2014). In a school, the corridor space is bound by walls, floors, and ceilings. Form is defined as the two-dimensional (2-D) or three-dimensional (3-D) shapes that are found within a space, such as windows or furniture (Jones, 2014). Schools are usually laid out along a central corridor(s) with classroom space on either side (Lippman, 2010), though there are other space planning approaches depending on geography, building size, and climate. Corridors should provide suitable accessible routes within an unobstructed width of 60″ minimum to comply with the ADA (Department of Justice, 2010). The ADA is not mandatory but most states and cities pass codes that agree with ADA guidelines. A building owner can be sued if the building does not comply with the Act. Corridors in schools must also provide a means of egress in an emergency and as such must be unobstructed according to the *International Building Code* (IBC) (Harmon & Kennon, 2011). Unlike the ADA, the IBC is mandatory. Other regulatory codes that have to be complied with include local building codes, the *Life Safety Code*, a federal law, as well as other laws that should be taken into account (Harmon & Kennon, 2011). Lippman (2010) describes corridors as activity spaces allowing students to quickly transition from one class to the next, although they could be used for other activities such as accessing lockers or waiting for the next class. In a school corridor, 2-D shapes may be found in the shape of doors or skylights, and 3-D shapes in the form of lockers or door handles.

Materials and Finishes

Materials can be defined as the finishes that are applied to or used within the interior of the building (Jones, 2014). Materials could be applied to the walls, floors, and ceilings, and could be seen as part of fixed or loose furniture, and in applied objects such as window treatments or artwork (Jones, 2014). Materials selected for a space should be suitable for the users, durable, safe in use, and provide an aesthetic quality to the space (Jones, 2014). Materials selected in a school have to meet certain federal, state, and local building codes and regulations to ensure they are to a particular standard, particularly in relation to fire safety, flammability and spread of flame (Jones, 2014).

In a school corridor the wall finish could be decorative tile or paint applied to the sheetrock or brick or block could be used as both the building material and the finish. The concrete floors could be finished with a sealer or a vinyl, rubber, or carpet tile or sheet could be applied. Ceilings could be sheetrock with a painted finish, they could be enclosed with acoustic ceiling tiles concealing building services or systems above, or they could remain open revealing the building systems (Jones, 2014). These types of materials and finishes in a school corridor tend to fulfil needs for durability, safety, and maintenance over aesthetics.

Texture and Pattern

Another important design element is texture. Texture refers to the surface appearance of an object, whether it is rough or smooth, soft or hard, shiny or dull (Jones, 2014). Texture could be an actual applied finish or it could be a photograph or image representing texture (Slotkis, 2013). A combination of textures could be found in a school corridor such as in the smoothness of a terrazzo floor, or the irregular texture of brick walls, or the wood grain of doors, or the shiny metal of door handles.

Pattern is a decorative, aesthetic element of the interior adding interest and variety (Jones, 2014). Pattern can be composed of color, line, texture, and light (Jones, 2014). In a school corridor, pattern could be perceived in the arrangement of doors along the corridor, or bays of lockers, or brick patterns on the columns, or the pattern inherent in the flooring material. Pattern is also affected by scale; large plain floor tiles will be perceived differently from a carpet with a small pattern repeat.

Acoustics

Sound is measured in decibels (dB) with 30-40 dB being an acceptable level for working and concentrating, and 130 dB being a point of pain (Jones, 2014). Blesser and Salter (2007) describe acoustics in terms of the physical properties of the space and what they define as the cultural aspects of the space, i.e., the way that listeners perceive the space. It is important to control sound in an environment to keep noisy activities separate from quiet activities. The most common ways of doing this is through the use or application of sound absorbent materials on ceilings, floors, walls, and furniture; to separate noisy and quiet activities; and to install quiet machinery and appliances (American Society of Interior Designers, 2005; Slotkis, 2010).

In a school corridor, floor and wall surfaces tend to be non-absorbent, hard finishes. Furniture in the form of lockers also tends to be made of non-absorbent metal. The ceiling may be the only sound-absorbing surface. As a result, corridors can be noisy spaces, particularly at transition times when there are many students using them between class periods.

Thermal Comfort

Thermal comfort is important to an individual's well-being and can be measured in the built environment in terms of radiant temperature, relative humidity, and air movement (Rohles, 2007). An individual's physical activity (metabolism) or their clothing also influences thermal comfort (Rohles, 2007). However, individuals also measure their own thermal comfort very subjectively and what one person finds a pleasant temperature another may find unpleasant (Rohles, 2007). For example, in one experiment on thermal preference, Rohles (2007) reported that a group of 20-year-olds preferred a temperature of 72^{o} F but a group averaging 75-year-olds preferred a temperature of 76^{o} F. This has implications for children with ASD within a school who are hyper- or hyposensitive to the environment and therefore may experience the temperature differently from others in the space.

Wayfinding

In addition to the myriad factors in the school environment that affect the occupants, wayfinding is critical. For children with ASD, wayfinding is an important skill which could enable them to navigate the school corridors with less assistance from a para. One of the goals of interventions is that children can become more independent (Earles-Volrath et al., 2008). What follows is a narration of the definition and importance of wayfinding followed by a discussion about color and lighting, two important environmental factors that significantly influence wayfinding. Other wayfinding studies are discussed that have taken place in exterior environments with adults with intellectual disabilities and with typically developing children. Finally, the literature in relation to wayfinding in schools for typically developing children and children with ASD is explored. The summary outlines the wayfinding cues that will be used in this study.

Definition of Wayfinding

Gibson (2009) defines wayfinding as providing "guidance and the means to help people feel at ease in their surroundings" (p. 12). Salmi (2007) defines it as "the process individuals use to navigate in unfamiliar surroundings" (p. 1). The term wayfinding was first coined by Lynch in 1960 (Gibson, 2009). Lynch (1960) defined wayfinding as "a consistent use and organization of definite sensory cues from the external environment" (p. 3). Cognitive psychologists believe that wayfinding involves using several mental processes such as perception, memory, and problem solving skills (Pick, 2003). Signage and pictograms are concepts central to the discussion of wayfinding.

The term “signage” was first used by wayfinding pioneer Paul Arthur in the 1990s (Gibson, 2009). Although signage can be mobile this study is concerned with static signage (Society for Experiential Graphic Design [SEGD], 2015). In this context, signage is defined as “the careful design of information relevant to showing the users’ experience of a place” (SEGD, 2015). Signage can consist of visual characters such as numbers or text and these characters can be flush or raised against the background on which they are placed (SEGD, 2012). Signage can be accompanied by Braille characters (read by some people with vision impairment), pictograms, or a combination of these as shown in Figure 4 (SEGD, 2012).

Figure 4. Signage with pictograms, text, and Braille. (Retrieved from http://cdn3.volusion.com/jzqsc.subnj/v/vspfiles/photos/econ-rr-nhc-88-2.jpg?1403268521).

Pictograms, also known as symbols, are described by SEGD (2015) as “the universal vocabulary that can transcend words, languages, location, and cultures.” Key advantages of using pictograms are that they are concise, can be read quickly, understood by multiple users, and can help clarify complex environments (SEGD, 2015). Pictograms can be universally understood. For example, the International Symbol of Accessibility is depicted via a wheelchair symbol (Department of Justice, 2010). Unique pictograms can also be designed for a specific site (SEGD, 2015).

The ADA (2010) provides guidance on minimum standards required for room identification signage, including:

- signs should contrast sufficiently with the background,
- signs should be free of glare,
- pictograms should have text placed underneath them,
- text should be upper case sans serif,
- text designed to be touched should be between 5/8″ and 2″ high,
- text designed to be viewed and not touched should have minimum and maximum heights depending on the viewing distance,
- signs should be placed between 48″ and 60″ above floor level, and
- at a door, signs should generally be located adjacent to the door on the latch side. (Department of Justice, 2010).

Importance of Wayfinding

Wayfinding is important to our well-being. As Lynch (1960) explains, "let the mishap and disorientation once occur, and the sense of anxiety and even terror that accompanies it reveals to us how closely it is linked to our sense of balance and well-being" (p. 4). Gibson (2009) writes that individuals can become "overwhelmed or disorientated if they physically lose their way" (p. 12) and Salmi (2007b) notes that wayfinding is crucial "to living one's life" (p. 1).

Although no other study was found that specifically addressed the effect of wayfinding via environmental cues in a school on children with ASD, many researchers and authors writing about ASD point to the importance of the ability to wayfind (Paron-Wildes, 2008; Scott, 2009; Vogel, 2008). Paron-Wildes (2008), an interior design professional, offers environmental criteria for children with ASD, stating, “A child’s attention span and safe navigation can be greatly impaired by their ability to distinguish between important and unimportant stimuli” (p. 2). This is echoed by Vogel (2008), researching educational environments for children with ASD, “Everyone prefers a building that is easy to navigate. Predictability is key, particularly for populations who need consistency and visual cueing” (p. 2).

Color

School designers use the environmental factors of space, form, materials, texture, pattern, temperature, acoustics, temperature, color, and light to create safe and comfortable environments for students, teachers, and other users of the space. The task of wayfinding can be affected by all these design elements but color, seen with the aid of light, provides a particularly strong wayfinding cue.

Color is an important and powerful design element which can affect us physically, by raising heart rate or blood pressure; emotionally, by calming or exciting us; and biologically, by affecting our sense of well-being (Martinson, 2005). Also, how we individually perceive, describe, and specify color can affect the success of a design solution or research design. What follows is a discussion of several aspects of color considered important in the context of this study to test whether wayfinding aids in a school can help children with ASD navigate the corridors.

Color perception. Our perception of color depends on the functioning of our eyes and brains, the presence of light, and on the object of our view (Martinson, 2005). Perception of color is described in three planes, 1) hue, the color identifier; 2) tone, the light to dark value; and 3) chroma, the intensity of a color (Pentak & Roth, 2004). How we perceive color is also affected by the way colors are placed next to each other (Martinson, 2005). This phenomenon, known as afterimage, is where a color that we are looking at is influenced by the color next to it, and, since we rarely see colors in isolation, this happens all the time, even though we may not be aware of it (Martinson, 2005; Pentak & Roth, 2004). To perceive colors to help us understand an environment, there must be sufficient contrast between them (Martinson, 2005). Conversely, too much color contrast can create stress and anxiety (Martinson, 2005).

A further variable to consider when defining color is that color will be perceived differently depending on the surface it is applied to since a shiny surface tends to reflect more light that a rough surface (Martinson, 2005). While we have limited control over this effect we can record the amount of light reflected from a surface. Equipment to record light reflectance is expensive and testing is usually done under laboratory conditions. However, most paint manufacturers and many suppliers of other products have had their products tested and provide a light reflectance value (LRV) for each color.

Not everyone perceives the same color the same way. Color vision deficiency is an inherited condition also known as color blindness, passed on by particular genes (Genetics Home Reference [GHR], 2015a). There are three main examples of color deficiency, red-green, blue-yellow, and blue monochromacy (GHR, 2015). In red-green color deficiency individuals have difficulty distinguishing between red, green, and yellow; in blue-yellow color deficiency individuals have difficulty distinguishing between blue and green; and in blue monochromacy individuals can suffer partial or total lack of color vision (GHR, 2015). The GHR (2015) estimates that 1:12 males and 1:200 females of North European origin have red-green color vision deficiency. In addition, 1:10,000 people globally have blue-yellow color deficiency and 1:100,000 have blue monochromacy deficiency (GHR, 2015). Color deficiency is particularly pertinent to this study about wayfinding by children with ASD as more males are affected with ASD than females (Baio, 2014).

Another issue concerning color perception is that the color we perceive may have different connotations based on our culture or experience, what Fehrman and Fehrman (2000) term “culturally learned color associations” (p.108). When we perceive a color, we may react differently than someone else depending on our associations with that color. For example, regarding the color red, Mahnke (1996) described several color experiments he carried out asking participants to match particular colors with an associated word and found that a high percentage of participants associated red with “love,” whereas, other participants associated red with “hatred” or “life” (Mahnke, 1996). Fehrman and Fehrman (2000) reported red associated with danger or caution, hence red stop signs, red traffic lights, or red “no entry signs;” and Martinson (2005) noted that red is associated with passion or revolution.

Defining color. One of the issues of color perception is ensuring that there is a common vocabulary to describe it. Describing the color “blue” will have different connotations to different people, some may imagine a pale blue sky, some a deep blue sea, and some the color worn by their favorite football team. To overcome this problem and help identify and specify color, various color systems have been created representing the qualities of hue, tone, and chroma (Martinson, 2005; Pentak & Roth, 2004). One example is the Munsell color system, created in the early 1900s in the United States (Kuehni, 2001). Another is the Natural Colour System, developed in Sweden in 1874 and used throughout Europe. The Natural Colour System (2015) is a three dimensional color system containing hue, value, and chroma. Pantone is another color system based on the four colors used in the printing industry, cyan, magenta, yellow, and black known as CMYK (Pentak & Roth, 2004). Pantone can be used to specify a range of products including printing inks, industry materials, textiles, and colored films.

Perception of color in schools. The primary way that children explore the environment is through sensory experience, particularly using the sense of sight, so color is an important element (Walz, 2003). We know that many children with ASD experience heightened visual sensitivity compared to typically developing children (Wilkes, 2007). Hypersensitive children may be overloaded with an expanse of intense color; in contrast, hyposensitive children may be helped by a strong visual clue (Wilkes, 2007). Therefore, in a school, both the hyper- and hyposensitive needs of children with ASD should be considered. In a school corridor, color can be used as a design element on walls, floors, doors, furniture, fixtures, and artwork.

Light

In addition to visual perception and cultural norms, color appears differently depending on the conditions under which it is viewed, such as under natural or artificial lighting conditions (Ginther, 2004).

Daylight. Daylight is defined as the amount of natural light from the sun entering a space (Winchip, 2008). Daylight is beneficial in a space because it can have positive, mood-enhancing effects on people and it has been shown to increase student performance in schools (Winchip, 2008). In daylight, a color will appear different depending on the time of day, time of year, compass orientation, and the global location from which it is being viewed (Pentak & Roth, 2005; Winchip, 2008). Daylight can be provided by windows, skylights, or tubular skylights (Winchip, 2008). In a school corridor, daylight may come from skylights or tubular sunpipes rather than windows depending on the adjacent classroom layout.

Artificial light. Artificial light is produced by lamps housed in light fixtures and can be applied in three ways: 1) in ambient or general application, to create a mood or provide safe circulation in a building; 2) in task lighting, to provide sufficient light to perform a specific task such as walking safely along a corridor; or 3) as visual interest, providing light that enhances the aesthetic appearance of the space (Ginther, 2004). In a school corridor, artificial light could provide task and/or ambient light but typically is less likely to be installed for visual interest. The amount of artificial light required in a space is generally defined by regulations specific to the type of space within a building type (Winchip, 2008).

Light can be provided by various types of lamps (i.e., light bulbs) including fluorescent, halogen, and light emitting diodes (LEDs). Fluorescent lamps, familiar as linear tubes, are commonly specified by designers (Winchip, 2008), and are frequently found in school corridors. However, this type of lamp is increasingly being replaced by compact fluorescent lamps (CFLs) (Winchip, 2008). CFLs provide an alternative energy efficient source of light consuming around 70% less electricity than incandescent lamps and they also have a longer life span (Winchip, 2008). These types of lamps can be fitted into a variety of light fixtures.

The type of lamp used affects the color perceived (Winchip, 2008). Lamps can be measured in terms of their light output (in lumens); their amount of illuminance striking a surface (in lux or foot-candles); their chromacity, the warmth or coolness of the emanating light (in Kelvin); and their color rendering properties relative to how well the lamp maintains the true color of the surface or object (on a color rendering index [CRI]) (Winchip, 2008).

Common luminaire types (light fixtures) include ceiling recessed, surface mounted, suspended via a pendant, or track lighting. Choice of fitting can be dictated by cost, ease of installation and maintenance, and safety of users (Winchip, 2008). To reduce glare, control light distribution, and protect the exposed lamp, many luminaires are fitted with diffusers, baffles, or shields (Winchip, 2008). In a school corridor, luminaries are often recessed or surface mounted and the lamps shielded for safety and convenience of installation and maintenance and to minimize vandalism.

Legibility, Imageability, and Landmarks

The concepts of legibility, imageability, and landmarks are regarded as means to provide important visual clues in the environment. In 1960, Lynch, an urban planner, published an influential study entitled, *The Image of the City*. A search of Google Scholar on October 15, 2013, revealed 8,009 citations of his work. In a field study experiment conducted with participants in several major cities across the United States, Lynch (1960) set out to investigate what made a city visually memorable or distinguishable for its citizens, that is, what visual elements in the exterior environment enabled people to create a mental image of their city. He describes looking for "*imageability:* (of a city) that quality in a physical object which gives it a high probability of evoking a strong image in any given observer. It is that shape, color, or arrangement which facilitates the making of vividly identified, powerfully structured, highly useful mental images of the environment" (Lynch, 1960, p. 9).

Lynch (1960) identified five distinguishable elements by which people navigated "paths, edges, districts, nodes, and landmarks," which he described in detail (p. 46). "Paths" are streets, canals, or railway lines; "edges" are boundaries and barriers along the way; "districts" are recognizable, cohesive areas; and "nodes" are strategic, focal points such as train stations, pedestrian crossings, playgrounds, or "street-corner hangouts" (p. 47). "Landmarks" are well-defined features helping to orientate someone, be that on a micro-scale, such as a road sign, a mid-scale such as a building, or a macro-scale, such as a hill (Lynch, 1960, p. 48).

More recently, Salmi (2007) states that landmarks should be recognizable in both color and shape and that they should also be well-lit. Landmarks could consist of architectural features in the fabric of the building or they could be applied features such as artwork or sculpture (Salmi, 2007). A landmark should be paired with signage to reinforce its importance as a clue to wayfinding and signage should be consistently and regularly placed above eye level (Salmi, 2007). Color can be used on signage to reinforce colors in the environment and different colors can be used to differentiate zones within the building (Salmi, 2007). Salmi (2007) also recommends the use of pictograms with text to make wayfinding easier for users who do not read.

Although Lynch created the Elements of Legibility to apply to the exterior environment, he felt that it could be further studied in relation to the interior (Lynch, 1960). Subsequently, legibility has been used as a basis for designing architectural wayfinding strategies in interiors. For example, Weisman (1981) conducted a post-occupancy evaluation of legibility in the indoor environment and Hunter (2010) used an interpretation of legibility in both external and internal environments in an article on architectural wayfinding. Wayfinding studies specifically related to the focus of this architectural wayfinding study are discussed below.

Wayfinding in the Exterior Environment by Adults with Intellectual Disabilities.

Salmi (2007a) conducted a wayfinding study with 10 adults with intellectual disabilities in a shopping mall and a government center. Subjects described to the researcher what wayfinding cues they were using while they were moving through the interior spaces (Salmi, 2007a). Salmi (2007a) concluded that successful physical wayfinding cues included spatial arrangement, signage, landmarks, sensory cues, and odor.

Castell (2008) conducted a literature review into how buildings could be adapted to make them accessible for people with intellectual disabilities. Although focused on intellectual disabilities, many of his findings are applicable to those with ASD because some characteristics are shared. Regarding pictograms, Castell noted their importance in wayfinding, also stating that images are particularly important for those who cannot relate words to images, a trait that affects some children with ASD (Castell, 2008; Salmi, 2008). Castell (2008) also noted that landmarks should be notable, memorable, cognitive features, and that they should also be stationary since they would be little use without permanence.

Wayfinding in the Exterior Environment by Typically Developing Children

Several studies have investigated Lynch's (1960) elements using children as subjects in wayfinding experiments. Cornell, Heth, and Broda (1989) conducted an experiment using 72 typically developing children, 36 aged 6 and 36 aged 12, to see if they could find their way back across a university campus after the researcher had led the way to a destination point indicating landmarks along the route to help them find their way back. Children in both age groups were randomly assigned to one of four conditions, 1) uninformed (i.e., not told at the outset they would have to find the way back), 2) informed (i.e., told at the outset they would have to find the way back), 3) told they would have to find the way back while two near landmarks were pointed out to them along the route to help them navigate, and 4) told they would have to find the way back and one far landmark was pointed out to them along the route to help them navigate

(Cornell et al., 1989). Cornell et al. (1989) found that in both age groups the subjects experiencing the third condition (i.e., two near landmarks along the route were pointed out to them) performed better at finding their way back.

Cornell et al. (1989) noted that a limitation of the study was that subjects had to find their way back in a reverse order. They also stated that the subjects' performance would have improved if noticeable, reliable wayfinding cues had been pointed out along the route and the subjects reminded of their task instead of simply instructing them to pay attention (Cornell et al., 1990). It was important to address these variables in this current study. A camera operator followed the subjects (Cornell et al., 1989), but it was not noted whether this variable had an effect on the subjects' performance.

In a similar wayfinding study across a university campus, Cornell, Heth, and Rowat (1992) selected 60 6-year-olds, 60 12-year-olds, and 60 22-year-olds to test their performance in finding their way back to a start point. Subjects were randomly assigned equally within their age groups to one of three conditions, 1) the look-back group who were instructed to look-back at 11 points along the route to see where they had travelled from, 2) the retrace group who were told at 11 points to look around for familiar paths, and 3) the uninstructed group who were not given any wayfinding advice (Cornell et al., 1992). None of the groups were told they would be responsible for finding the way back (Cornell et al., 1992). Cornell et al. (1992) found that 12- and 22-year-olds performed similarly, better than 6-year-olds, and that 12- and 22-year-olds effectively used look-back strategies to identify landmarks to find their way back. The retrace group was not found to have the same level of success of wayfinding (Cornell et al., 1992).

Wayfinding in Schools by Typically Developing Children

The use of wayfinding systems in schools is important to create a positive impression of the school on those who use it (Poblocki, 2007). There is also a balance in applying sufficient signage without overdoing it so that it becomes overwhelming (Poblocki, 2007). Helvacıoğlu & Olguntürk (2011) conducted an experiment to find out whether children were more successful in a wayfinding experiment in a school with the use of colored wayfinding cues. One hundred subjects aged 7-8 participated, 32 in each of three experimental groups (Helvacıoğlu & Olguntürk, 2011). Any subjects with color-vision deficiency or who were familiar with the site were excluded (Helvacıoğlu & Olguntürk, 2011).

During the experiment, subjects were led by the researcher from the start to the end point and back to the start and then asked to lead the researcher back to the end point (Helvacıoğlu & Olguntürk, 2011). The researcher placed colored boxes as landmarks along the route, using colors from the Natural Colour System (Helvacıoğlu & Olguntürk, 2011). Group one experienced grey colored boxes along the route. Groups two and three experienced primary and secondary colored boxes, yellow, red, blue, green, orange and purple, placed in a different order along the route, these last two conditions so that researchers could test if children had a color preference that helped them in wayfinding (Helvacıoğlu & Olguntürk, 2011).

Helvacıoğlu & Olguntürk (2011) found that the use of color had a significant effect on children's ability to wayfind. However, children did not remember one color significantly over another and they tended to remember the first one or two colors they saw but not different colors thereafter (Helvacıoğlu & Olguntürk, 2011).   The researchers' recommendations were that color-coding was of benefit in wayfinding, but that only one or two colors should be used (Helvacıoğlu & Olguntürk, 2010).

Read (2003) conducted a field survey to investigate the use of color in the design of pre-school environments for 3- and 4-year-olds. She surveyed 101 licensed childcare facilities in Alabama and one of her findings was that colors were used to provide wayfinding and orientation clues within the classroom space and that nearly all the environments surveyed used bright accent colors (Read, 2003). Read (2003) concluded that color was an "accessible and powerful" feature in the environment (p. 238).

Wayfinding in Schools by Children with ASD

Scott's (2009) case study approach describes the key design features of four schools designed for children with ASD. Regarding wayfinding, he notes "the requirement to provide an ordered and comprehensible, spatial structure" (p. 41), and continues to describe a school where the corridor, "the internal street" (p. 42), has become very much the heart of the school and "a powerful orientation device" (p. 41). Assirelli (2011), an architect who has designed school environments for children with ASD, describes some beneficial features, including the importance of circulation spaces, (i.e., corridors whether open or closed) and the satisfaction a child can derive from gaining a degree of independence in them.

McNally, Morris, and McAllister (2013), using research collected from discussion groups and mailed, self-administered questionnaires from parents of children with ASD, used a narrative approach to describe the "lived experience" of a child's first day at school. McNally et al. (2013) also suggest the use of colors or artifacts to create "neighborhoods" in the school. McAllister and Li (2012) used architectural theory and a case study approach to consider the design of the school environment for children with ASD. Both studies state that "legibility" can benefit children with ASD (McAllister & Li, 2012; McNally et al., 2013). In the same way, Beaver (2010), a published author and architect of schools for children with ASD, reflects on his design experiences stating that children with ASD are supported when "geography is simple and uncomplicated" (p. 83). McNally et al. (2013) use similar language, that routes should be "clear and comprehensive" (p. 11).

From a literature review, Khare and Mullick (2008) collected information about the learning behaviors of children with ASD and the teaching strategies used by teachers. They created a matrix of the environmental features in the environment that could support learning and teaching behaviors. Their premise was that "performance of students with autism is enhanced in [the] appropriate physical environment" (Khare & Mullick, 2008, p. 2). In relation to wayfinding, their findings advocate for providing clues in the interior in a visual format, with uncluttered routes, and the inclusion of zoning to assist in wayfinding (Khare & Mullick, 2008).

Vogel (2008) refers frequently to Lynch's work in her study, which collated research data gathered from parents, teachers, and therapists of children with ASD, as well as adults with ASD, to create a set of interior design standards for schools. She uses examples such as making evident "paths" with colored tape or printed footprints, creating bold and memorable "edges" using murals, and using sculpture or a water feature as a “landmark” (Vogel, 2008). As Lynch (1960) imagines sensory information perceived by the dweller of the city, Vogel (2008) perceives interior environmental information coming to the child with ASD in the school environment via smell, sight, sound, and touch. Vogel also points generally to the use of color cueing in schools stating, “Everyone prefers a building that is easy to navigate. Predictability is key, particularly for populations who need consistency and visual cueing” (2008, p. 2).

Legibility has been identified in the United Kingdom in its non-statutory guidance to designers and architects in support of school building design. Building Bulletin 95 (Department for Education & Skills, 2002) states “legible routes are especially important” for those with unpredictable behavior (p. 53). Building Bulletin 94 (Department for Education & Skills, 2001) states that children with ASD “can suffer increased levels of anxiety if the building is difficult to understand, which can lead to stress and challenging behaviour in the classroom” (p. 24). Challenging behavior can often be associated with children with ASD (Edelson, 2011; Emerson, 2001; Harrison & Hare, 2004).

Mostafa (2008; 2014), an architect and researcher into educational environments for children with ASD, collected data via a questionnaire from teachers and caregivers of children with ASD and collated it into a Sensory Design Matrix. She identified four key architectural elements on which she based her sensory design proposals, 1) structure, containing the variables closure, proportion, scale, orientation, and focus; 2) balance, containing the variables symmetry, rhythm, harmony, and balance; 3) quality, containing the variables color, lighting, acoustics, and texture; and 4) dynamism, containing the variables ventilation, sequence, proximity, and routine, (Mostafa, 2008). She does not define these constructs or variables further, but they would presumably be familiar to architects at whom her work seems to be aimed.

Mostafa's idea is that, by correlating the sensory issues that children with ASD experience with the architectural elements in the built environment, designers could alter these elements and thereby mitigate some of the adverse sensory effects that the environment can have on children with ASD (2008). For example, if a child with ASD is hypersensitive to sound, better acoustics could be provided to mitigate this effect. Regarding wayfinding, she suggests that architects provide a memorable "node" or junction between the main circulation areas in a building (Mostafa, 2008). She notes that the use of pictures is important to children in wayfinding and can help raise self-esteem. For children who cannot read, habitually associating a pictogram with a word may eventually lead the child to come to comprehend the word (Mostafa, 2008). To date, Mostafa's (2008) concepts have yet to be tested by others.

Another wayfinding cue that is referred to in the literature is the use of color coding to help people with ASD. Building Bulletin 94 (Department for Education & Skills, 2001), Castell (2008), Sánchez et al. (2011), and Vázquez and Torres (2013) all advocate for the use of color coding. In particular, Sánchez et al. (2011) suggest the use of colored doors. Also, Irish (2013), in a case study approach describing a new school for children with ASD and other disabilities, used color coded doors to help children with ASD to navigate the school environment. However, none of these authors used a behavioral theory to explain why color coding could help individuals with ASD to wayfind.

Additionally, there is some research in the literature that points to children having sensitivity to color. Ludlow, Wilkins, and Heaton (2006) conducted an experiment to test the effect of using colored overlays on a reading exercise with children with ASD. They found that children with ASD were significantly more able to read faster with a colored overlay than a white page (Ludlow, Wilkins, & Heaton, 2006). Ludlow et al. (2006) suggested that this could have implications for the design of signage.

Wayfinding in other environments by children and adults with ASD.

Baumers and Heylighen (2010) conducted a study to find out how adults with ASD experienced the environment and what their views were on the design of the environment. Using a qualitative approach, they conducted a secondary data analysis of books written by people with ASD, termed "auti-biographies," to find out how they described their experience in the designed environment. The precise method used and the numbers of auti-biographies they referenced are unclear, though they describe it as "limited" (p. 22). However, their approach provides a personal insight into the difficulties people with ASD experience in wayfinding, including in the school setting. Their description of one person trying to find their way in a school vividly illustrates how important wayfinding cues could be, "She is not only aware of her problems in finding the right way, but also of the differences between her and her classmates in using this building" (p. 17). In relation to wayfinding, Baumers and Heylighen (2010) conclude that to find "the right way" (p. 18), users have to perceive what they cannot see, e.g. what is behind a door, and this they find difficult. They also indicate that what one person with ASD views as a memorable landmark could be different from what another person with ASD considers memorable (Baumers & Heylighen, 2010).

Sánchez, Vázquez, and Serrano (2011) conducted a literature review of previous studies to find the design criteria that were cited as supporting adults with ASD in the built environment, noting that pictograms or photographs used as pictograms could be useful in wayfinding. In a similar approach, Vázquez and Torres (2013) conducted a literature review on the built environment relating to adults with ASD, albeit “fleetingly and not in great depth” (p. 180). Through matching some of the characteristics of ASD with elements of the environment that support their characteristics, one of their conclusions was that the use of pictograms could help in wayfinding.

Tactile wayfinding aids have been mentioned in the literature as providing assistance to children with ASD (Barba, 2010; Whitehurst, 2006). A case study of a health center for children with ASD found that children navigate better by touching the walls (Barba, 2010) and a case study of a residential home for children with ASD reached a similar conclusion (Whitehurst, 2006). Unfortunately these studies are weak because they cannot provide research evidence that wayfinding skills have improved in children with ASD and they did not take place in a school so are less relevant.

Summary

From the literature, it is apparent that wayfinding is an important skill to learn for humans in general and especially important for children with ASD. However, most of the literature provided qualitative findings from small samples or presented findings from observations and/or surveys that need additional testing. Evidence-based research is limited in relation to children with ASD and especially within the school environment. However, legibility was identified as a key factor in wayfinding. Legibility could be provided by signage incorporating pictograms and text. Another key concept identified is that making the environment memorable could help children with ASD in wayfinding.

Discussion of Applicable Theories and Framework

There are few studies that describe an experimental approach to the design of the built environment for children with ASD. To identify a theory to serve as the foundation for this study various theories were considered including sensory stimulation theories, environmental theories, and a learning theory. Each theory is described below followed by the outline of the theoretical framework chosen for this study.

Sensory and Stimulation Theories

There is much discussion in the literature regarding theories of sensory stimulation. Various names have been given to the theories, but they are all based on the assumption that stimulation in the environment alters human behavior. The theories reviewed here will be stimulation theory, sensory design, and sensory processing. Theories of stimulation date back to the 1950s when behavioral scientist Levine used rats to determine that early handling of newborn rats decreased stress levels as adult rats (Sapolsky, 1997). Liu et al. (1997) replicated Levine's study, which was conducted in 1957 with the same outcome (Sapolsky, 1997; Liu et al., 1997). Sensory stimulation theories reviewed here include stimulation theory, sensory design theory, and sensory processing theory.

Stimulation Theory. Kopec (2006) describes stimulation theory as the relationship between human behavior and design as "a source of sensory information derived from sight, sound, touch, taste, and smell" (p. 23). Kopec (2006) refers to the traditional five senses, (sight, sound, touch, taste and smell), and how these can be hypo- or hyperstimulated. However, most researchers exploring design for individuals with ASD consider that there are additional senses involved, 1) proprioception, an awareness of the body in space, and 2) vestibular, an awareness of the sense of gravity and balance (Wilkes, 2007). Dunn (2002), in a briefing paper, describes sensory stimulation theory in the context of teaching, that by more stimulation of the senses and using a variety of teaching techniques, learners will be able to retain knowledge more effectively.

Zentall and Zentall (1983) put forward a theory of sensory stimulation that all individuals have an optimal level of stimulation which they self-regulate; when the level is reached or is surpassed, individuals will avoid the stimulation; when the level is not reached individuals will seek out stimulation. To develop the theory, Zentall and Zentall (1983) reviewed a large body of previous studies of stimulatory experiments on children and adults and put forward evidence for a theory of optimal stimulation noting how this affected children who were not typically developing, including children with ASD. Sensory overload/stimulus avoidance and sensory deprivation/stimulus seeking behaviors have been noted in many studies but Zentall and Zentall (1983) emphasize that responses are individualized.

Regarding children with ASD, Zentall and Zentall (1983) hypothesize similar patterns of behavior in that if children are over-stimulated their use of RRBs may be a mechanism for preventing their over-stimulation from becoming worse. Children with ASD may also be avoiding sensory stimulation by focusing on a limited area of interest, such as the spinning wheel of a toy (Zentall & Zentall, 1983). Zentall and Zentall (1983) also found research to support that RRBs in children with ASD also occur in environments of low stimulation suggesting that RRB is “multiply determined” (p. 452) and that children with ASD who were placed in environments that were low in stimulation for long periods of time showed significant reduction in RRBs. Zentall and Zentall (1983) concluded that optimum stimulation theory, shown to occur in typically developing and non-typically developing populations could provide a basis for further research.

Stimulation theory has also been studied in relation to children with Attention-Deficit Hyperactivity Disorder (ADHD), a disorder diagnosed in childhood where children exhibit a lack of attention in activities, hyperactivity, and a tendency to be impulsive (Antrop, Roeyers, Van Oose, & Buysse, 2000). The hyperactivity aspect of the condition bears similarities to the hyperstimulated symptoms of ASD. Antrop et al. (2000) tested whether children with hyperactive tendencies would become hyperactive to stimulate themselves in a situation where they had to wait in a room for 15 minutes either with no stimulation or with the stimulation of a video. As a control, children without hyperactive tendencies were also tested under both conditions (Antrop et al., 2000). They found that children who were hyperactive displayed more stimulatory and active behaviors in the sterile waiting period than the non-hyperactive children (Antrop et al., 2000).

Zentall (1986) also tested the stimulation theory using the effects of color stimulation on a lettering task. Zentall (1986) hypothesized that hyperactive children would exhibit less activity and less error in their task if colored stimulation was added. Subjects were assigned to conditions of no stimulation, early stimulation, and late stimulation. Zentall's (1986) findings from 66 hyperactive children and 80 non-hyperactive children were that children with hyperactivity engaged in a color stimulated task were able to concentrate at the same level as the control group of non-hyperactive children when stimulation was added early or late during the task (Zentall, 1986). If stimulation was added late in the task, hyperactivity was reduced in children who were hyperactive (Zentall, 1986).

Shabha (2006) used a questionnaire approach sent to teachers in 10 schools for children with disabilities, particularly with ASD, to find out what issues children had with the interior environment based on the theory that impaired sensory systems caused the child's behavior to fluctuate due to environmental stimuli. He found that visual and sound stimuli were reported as particular causes of hyperstimulation in the environment (Shabha, 2006).

Sensory Design Theory. Although Mostafa (2008) does not discuss the basis of her theory in relation to other theories, sensory design theory bears similarities to stimulation theory. In 2008, Mostafa published details of an experiment regarding whether changes in the design of the classroom environment improved behavior and learning outcomes of students' with ASD. In her work, Mostafa (2008) states that she devised a new theory which she termed sensory design (SD). In short, SD theory holds that architectural changes in the built environment affect the behavior and development of children with ASD (Mostafa, 2008). SD theory bases its premise on the notion that children with ASD have difficulty understanding their environment due to their heightened sensitivities along a range of senses, namely, sight, sound, touch, smell, and proprioception (Mostafa, 2008). By better design of the environment, Mostafa (2008) hypothesizes that sensory overload can be limited or prevented from occurring.

Mostafa (2008) credits her ideas to several experts working in the field of autism, specifically Rimland, Delacato, and Anderson, who she states believed that people with ASD experience difficulties in understanding their environment due to sensory overloading as they try to comprehend their surroundings (Mostafa, 2008). Mostafa's theory could be considered a propositional or descriptive theory because it is suggesting or proposing something that may be true (Schwandt, 2001). That is, she is suggesting that architectural design elements in the built environment could cause adverse sensory difficulties in children with ASD (Mostafa, 2008).

In her research, Mostafa (2008) used a questionnaire approach to ask teaching professionals, parents, and caregivers of children with ASD to rate the issues they were most concerned about in the educational environment. Using this data, Mostafa (2008) identified four key architectural elements on which she based her sensory design proposals, the concepts of dynamism, quality, balance, and structure. Mostafa (2008) went on to test the top two environmental variables cited by her respondents as having the most adverse effect in the learning environment, the effects of acoustic treatment in the classroom, and the effects of spatial layout in the classroom, on 12 subjects aged 6-

10.

Mostafa's (2008) methodological approach involved collecting quantitative data on subjects' attention span, response time, and self-stimulatory behaviors, and collecting observational data on subjects via behavioral mapping. Mostafa (2008) found that attention span, response time, and behaviors improved in the acoustically treated classroom and in the spatially arranged classroom. However, there has been criticism of the reliability of her research methods (Henry, 2012b). Henry (2012b) points out, for example, that participants were not randomly assigned to treatment and control groups and that staff in the study knew which were the treatment and control groups so there could have been a bias effect. Also, there could have been a group effect since children were taught together but their data points were treated separately (Henry, 2012b).

Although Mostafa (2008) describes sensory design as a theory, it has not been tested or used by others so it may better be described as a hypothesis. Hopefully in the future other researchers will test the interaction and influence of the constructs that Mostafa has identified.

Sensory Processing Theory. Sensory processing is described by Dunn (1997) as the ability children have to process the experiences around them. If children have poor sensory processing their social, cognitive, and physical functioning can be negatively impacted (Dunn, 1997). Dunn (2002) believes that issues in sensory processing stem from both maladaptation in the central nervous system and from human behavior in the environment. She notes that part of the environmental difficulties come from the exterior environment as representing "the sensory experiences available to young children throughout their daily lives" (Dunn, 2002, p. 25). In a conceptual model from data collected over several studies including with children with ASD, she describes four associated behaviors in children: 1) poor registration (low reaction), 2) sensitivity to stimuli, 3) sensation seeking, and 4) sensation avoiding (Dunn, 2002). Although Dunn (2002) is discussing children in general, these factors seem particularly pertinent to children with ASD.

One of the outcomes of Dunn's research was the creation of the *Sensory Profile* (2008b). This was put forward as a way to measure children's sensory processing behavior (Dunn, 2008b). It is a 125-item questionnaire designed to be administered by a professional to caregivers of children about the sensory processing abilities of their children (Dunn, 2008b). Items are selected on a 5-point Likert scale (Dunn, Myles, & Orr, 2002). The *Sensory Profile* is designed to be used as an evaluation tool for children between 4 and 10 years of age (Dunn, 2008b). The sensory processing factors listed in the *Sensory Profile* are auditory, visual, vestibular (movement), touch, multisensory (combined factors), and oral (taste) (Dunn, 2008b). Examples of questions in the *Sensory Profile* relating to sensory seeking behavior include whether the child spins their body during the day, or likes to make noise, or avoids wearing shoes (Dunn, 2002). The validity and reliability of the *Sensory Profile* was tested in several studies in the 1990s totaling 1,200 children, including some with ASD as described below (Dunn, 2008b).

Dunn et al. (2002) carried out a study to compare 42 subjects with ASD (note at that time the APA diagnosis was AD) (average age 11.33) with 42 subjects without disabilities (average age 9.6 years). Dunn et al. (2002) wanted to find out if children with

ASD performed differently to children without ASD on the *Sensory Profile* They found that on every level of the *Sensory Profile* children with ASD were said by their caregiver to exhibit more difficult behaviors in response to sensory input than children without ASD (Dunn et al., 2002). Dunn et al. (2002) specifically found that children with ASD had difficulty with auditory processing in relation to endurance level and with visual processing from a dark room or bright lights. They also noted that children could be hyper- and hyposensitive to stimuli; hyperactive in that children with ASD showed more reaction to stimuli than children without ASD, and hypoactive in that children with ASD showed a low tolerance to stimuli that children without ASD noticed (Dunn et al., 2002). They concluded that future research could involve evaluating the impact of stimuli found in the daily environment on the sensory processing performance of children with ASD (Dunn, 2002).

Environmental Theories

There are many environmental theories that describe interrelationships between the environment and human behavior. Two theories of the many that exist that are most appropriate to this study are discussed below: person-environment (P-E) fit theory and environmental preference (EP) theory.

Person-environment (P-E) fit theory. P-E fit is a theory borrowed from the field of workplace psychology describing the fit between a person and his/her place of work (Kristof-Brown & Guay, 2011). P-E fit theory has been applied broadly to examine what contributes to a good match between individuals and their work environment, between an individual's skills and the skills required of their job, and between an individual's values and the cultural values of the organization where they work (Kristof-Brown & Guay, 2011). A popular theory, its widest use has been in the field of what is termed "interactional psychology" (Kristof-Brown & Guay, 2011, p.4). Psychologists use an equation to define PE fit: B = f (P,E) behavior is a function of person and environment (Kristof-Brown & Guay, 2011). Kristof-Brown and Guay (2011) refer to fit as "a relationship between P and E, which implies that both work in concert to influence outcomes" (p. 4). Khare and Mullick (2009), whose work was described earlier, used the P-E fit theory as the guiding theory in their research, the purpose of which was to find out whether "performance of students with autism is enhanced in appropriate physical environment" (p. 46). They first define "fit" as "an environment that matches the abilities of the user with an appropriate level of support" (Khare & Mullick, 2009, p.47). If the architectural design suits the occupier then there is a good "fit," and if there are multiple "fits," they constitute "patterns" that can help support a particular behavior (Khare & Mullick, 2009).

Environmental Preference (EP) Theory. Research into EP theory has notably been driven by researchers Kaplan and Kaplan in a number of studies focusing on landscape preferences in the outdoor environment (Kaplan & Kaplan, 1982; Kaplan, Kaplan, & Brown, 1989). One study will be discussed in detail here to illustrate the theory. Kaplan, Kaplan, and Brown (1989) tested the theory of EP in relation to four specific domains they had identified in the landscape: physical attributes (the typography of land), land cover (landscape types such as agricultural or forest), informational domain (objects which provide information to the viewer), and perception (the viewer's thoughts about the qualities of the scene). Kaplan et al. (1989) showed 59 photographs of scenes to 180 subjects and asked them to identify which environment they preferred. Their findings were that altogether characteristics within three domains they had identified, physical attributes, informational domain, and perception, accounted for a large portion (83%) of the preference variance but the land cover domain was a negative preference indicator. Different domains have been tested in EP, for example, R. Kaplan's 1973 study tested preference, mystery, and coherence. EP theory has been used with subjects selecting photographs or videotape as stimulus and also using qualitative questionnaire and interview techniques (Lam, 2001), as the following examples illustrate.

Salmi (2007a) used EP theory in a wayfinding study discussed earlier. She focused her research on the domains of complexity, coherence, legibility, mystery, and prospect and refuge (Salmi, 2007a). Salmi (2007a) identified wayfinding cues in the environments prior to testing them and found several variables within each of the domains, including physical environmental and sensory environmental representing variables such as signage, landmarks, color, lighting, noise, and crowdedness. Interview and observation techniques were used to identify the wayfinding cues that subjects had used during the experiment (Salmi, 2007a). Salmi (2007) found that successful physical wayfinding cues included spatial arrangement, signage, landmarks, sensory cues, and odor.

In another example, Scott (1993) used four domains based on Kaplan and Kaplan's 1982 model: coherence, complexity, legibility, and mystery, showing 80 slides of interior environments to 309 students to identify their preferences. Scott (1993) was able to identify multiple variables affecting preferred and non-preferred scenes by factor analysis, confirming reports from previous studies that subjects preferred interiors with natural elements. Scott (1993) also reported that EP theory could be useful in other interior settings. Lam (2001) reports that the theory is also well used in studies of consumer preference in retail environments.

Universal Design for Learning (UDL) Framework

Several researchers cite Universal Design for Learning (UDL) as a framework in their work. UDL is defined under the Higher Education Opportunity Act of 2008 as a "scientifically valid framework for guiding educational practice" (CAST, 2011). Three main assumptions of the UDL guidelines are that 1) providing multiple ways of representation will create knowledgeable learners, 2) multiple ways of expression will create goal-orientated learners, and 3) multiple ways of engagement will create motivated learners (CAST, 2011). Woronko and Killoran (2011) used UDL as a framework to conduct a literature review to find out what interventions were used in the built environment to create "sensory responsive environments" for children with ASD (p. 214). The aim of their study was to demonstrate that all students are part of the whole learning experience and students with a disability such as ASD should not have a differential learning experience (Woronko & Killoran, 2011). From their review, they found that children's attention and performance improved in sensory sensitive environments (Woronko & Killoran, 2011). They concluded that, to facilitate this, the physical environment should be altered to enable the child with ASD to reach his/her learning goals (Woronko & Killoran, 2011).

Kinnealey et al. (2012) also used UDL theory to underpin their study that investigated the effect that environmental changes in the classroom had on children, including those with ASD. Interestingly, Kinnealey et al. (2012) are not actually working in the field of interior design, they are occupational therapists, but their study describes an interior design experiment. They conducted an experiment with a small number of subjects (four) to investigate whether the application of sound absorbent material and halogen lights improved student attention in the classroom. Applying the theory of UDL to learners, Kinnealey et al. (2012) found that all four subject's engagement increased after the application of the treatments, i.e., after the interior causes of distractions were removed. In short, if the interior design causes distractions, the aim should be to remove the distraction to promote engagement of children with ASD (Kinnealey et al., 2012).

Summary

Some theories which could be used to frame the research study to address the question of how assistive wayfinding aids can help children with ASD to navigate the school environment have been discussed, namely sensory and stimulation theories, environmental theories, and a learning framework. Each presents a framework that addresses some aspects of the critical variables that this study examined. They present varying degrees of acceptance as demonstrated via breadth of testing by researchers.

Theoretical Framework for the Study

The theory that has been selected as most appropriate for the aims of this research study is P-E fit theory. The way people fit into their environments has an effect on their behavior and the success of how well they fit into their environments can be measured by

P-E fit theory (Khare & Mullick, 2009; Kristof-Brown & Guay, 2011).

Discussion

Crouch and Pearce (2012) describe theory as "a way of hypothesizing the world as a way of understanding our interactions with it" (p. 39). To describe these interactions a theoretical model has been created to illustrate the relationship between the variables that will be used to test the hypotheses and address the research questions, 1) Can assistive wayfinding aids increase the ability of children with ASD to navigate the corridors in a school environment? and 2) Can assistive wayfinding aids increase the ability of children with ASD to navigate the corridors in a school environment *with minimal assistance*, thereby increasing their independence? The creation of framework models is an approach advocated by Svinicki (2010) to understand how theories relate to one another to guide the research.

A number of environmental stimuli have been discussed in relation to variables found in a school corridor. Many studies and authors have indicated that wayfinding aids, in particular sensory clues of color, shapes, and pictograms with text, could provide appropriate environmental stimuli to help children with ASD to navigate (Khare & Mullick, 2008; MCnally et al., 2013; Vogel, 2008). Figure 5 shows a theoretical model of the relationship between a child with ASD and the physical environment as these constructs interact to determine the wayfinding outcome behavior.

Figure 5. Conceptual Model: The fit between a child with ASD and the environment.

The literature review discussed the variables that might influence P-E fit in terms of the characteristics of children with ASD, the physical environment of a school corridor and the features of wayfinding. A research model identifying them is shown in Figure 6. The relationship between the constructs is illustrated, namely the independent variables (children with ASD and the physical environment of the corridor) and the dependent variable (wayfinding to reach a destination) as they are operationalized by P-E fit theory. Variables (i.e., characteristics) of the children with ASD construct will be measured. This exploratory study also documented the physical environment construct by recording the existing corridor variables (i.e., conditions) and by measuring the influence of the wayfinding aids as applied along part of the corridor system. These independent variables will be introduced and measured to document their influence on the outcome behavior construct (i.e., wayfinding to a destination) of children with ASD.

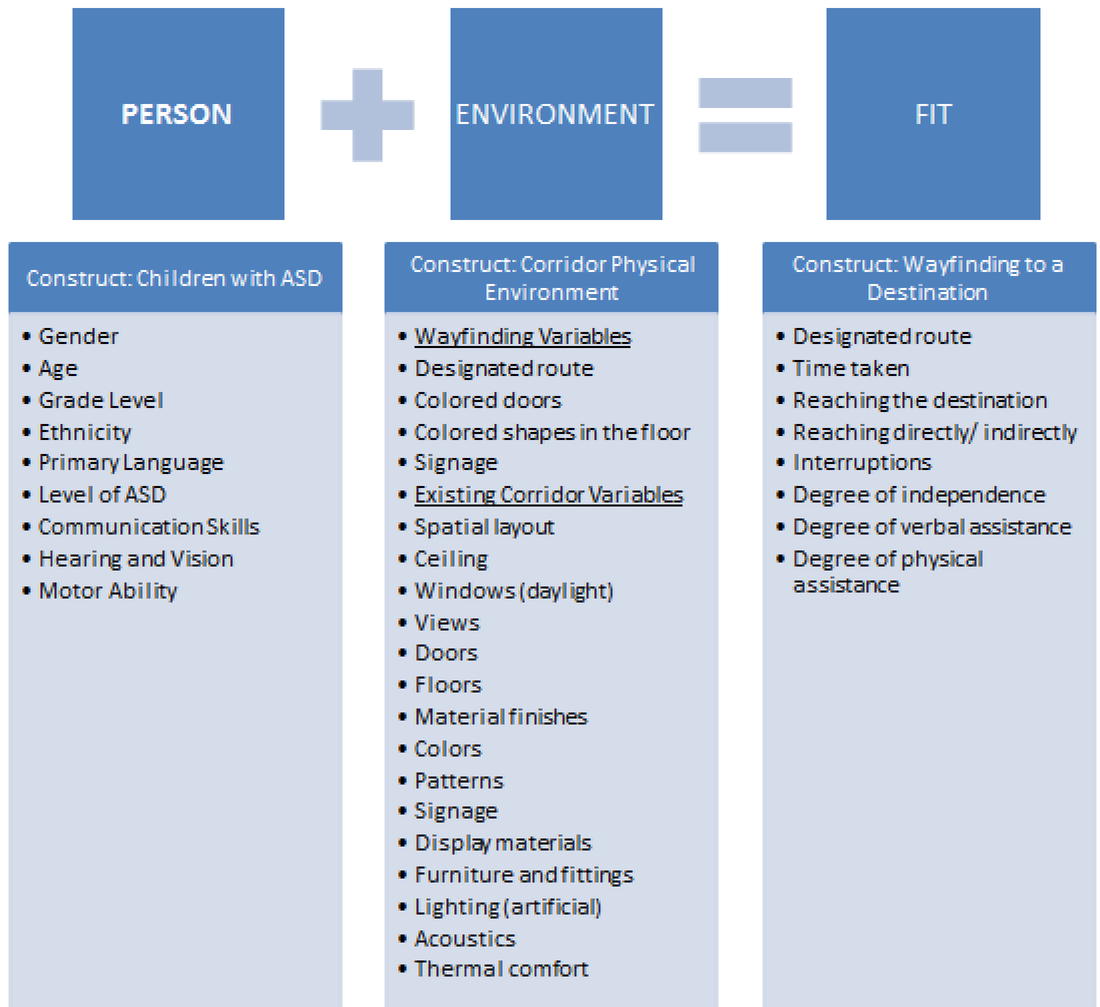

Figure 6. Research model: Variables in the study.

Hypotheses

Having reviewed the literature and identified the P-E fit theory to test the research questions identified in Chapter 1, the following hypotheses have emerged. Null and alternative hypothesis can be established:

Ho. The provision of assistive wayfinding aids in a school corridor will have no influence on the ability of children with ASD find their way from Point A to Point B in the school environment.

Ha1. The provision of assistive wayfinding aids in a school corridor will increase the ability of children with ASD to find their way from a start point to a destination point in the school environment with no verbal or physical assistance from the researcher.

Ha2. The provision of assistive wayfinding aids in a school corridor will increase the ability of children with ASD to find their way from a start point to a destination point in the school environment with minimal verbal or physical assistance from the researcher.

Conclusion

This chapter considered literature relating to the characteristics of ASD, education for children with ASD, the interaction between design and human behavior, environmental design factors in the school, and wayfinding. Several theories and a framework and their applicability to this research have been explored including sensory stimulation, environmental, and learning. From these theories, P-E fit theory was identified for use as a framework (Figure 5) and how it will be used to test the relationship between the variables (Figure 6) was illustrated. Chapter 3 will describe the research method intended to test the study's hypotheses that aim to answer the research questions about whether assistive wayfinding aids can support the wayfinding abilities of children with ASD.

CHAPTER 3: METHOD

Introduction

This chapter outlines the methods used to conduct this exploratory study. The study examined whether specific assistive wayfinding aids could help children with ASD to wayfind in the school environment. Details of the study, the participants and how they were selected, the approvals process, and a description of the school site for the study and the variables are included in this chapter. A timeline is also provided. A discussion of the measurement of variables that link to the theory framework and model provided in Chapter 2 are operationalized in this chapter. Data collection methods are described and examples of the data collection tools are provided. Finally, a description of data analysis techniques is provided.

Research Design

The research questions identified in Chapter 1 were operationalized as shown in Table 1.

Table 1

Operationalization of the Research Questions

Research Question	**How the question is explored in the research design**	**Theory**
1. Can assistive wayfinding aids increase the ability of children with ASD to wayfind along the corridors in the school environment **independently**?	Children with ASD are assigned to treatment (wayfinding aids) or control (without wayfinding aids) groups and wayfind along a school corridor **without assistance from the researcher.**	Person-Environment Fit (how well people fit into their environment [Khare & Mullick, 2009; Brown & Guay, 2011]).
2. Can assistive wayfinding aids increase the ability of children with ASD to wayfind along the corridors in the school environment **with minimal assistance?**	Children with ASD are assigned to treatment (wayfinding aids) or control (without wayfinding aids) groups and wayfind along a school corridor **with minimal assistance from the researcher.**	
3. What do children with ASD think about their experience wayfinding along the corridors in the school environment?	Children with ASD complete post study interview/ questionnaires.	

Exploratory studies provide an opportunity for researchers to investigate a new topic of interest (Babbie, 2010). The subjects via their parents or legal guardians were asked to take part in a wayfinding study to find out whether they could find their way from a set starting point to a given destination along the hallway of an elementary school where they attended an Extended School Year (ESY) Summer Program. Subjects were not familiar with the study route. Each participant was first shown the way and given wayfinding instructions by the researcher from the start point to the destination point.

Each participant was then taken back to the start point. Each was then given the task of finding the way themselves with the researcher in attendance. Participants were randomly assigned to the control or treatment groups with comparable numbers in each group.

A study pretest did not take place as there were concerns that the subjects would memorize the route, thereby confounding the study. The study was therefore a posttest only design which controlled against this type of invalidity (Frankfort-Naimas & Naimas, 2008). Babbie (2010) supports the posttest only control group design with randomization as a valid experimental design as put forward by Campbell and Stanley in their 1963 study. However, a pretest was carried out with typically developing participants to test the route and data collection instruments as discussed later.

Participants

Sample

A convenience sample of students with ASD was selected who attended an ESY Summer Program at an elementary school within a school population from a school district in the Midwest. Participants selected for the study were students who had a diagnosis of ASD and were aged 8-11 years old, typically in 4^{th}-, 5^{th}-, or 6^{th}-grade. The number of potential participants was estimated at 20 based on the previous year's attendance data from the ESY Summer Program. In considering logistics, available resources, time constraints, and availability of participants, smaller sample sizes are acceptable (Frankfort-Naimas & Naimas, 2008; Sommer & Sommer, 2002). Also, this was an exploratory study carried out at a particular school and the results are not intended to be generalized to the rest of the population (Babbie, 2010; Sommer & Sommer, 2002). In the field, a smaller sample size became necessary due to the fact that some potential participants had to be excluded from the study as they were familiar with the site.

Selection Criteria

Several selection criteria were developed to recruit participants to ensure a robust study as described below.

Familiarity with the school site. One of the difficulties in selecting a location for the study was finding a route with which participants were not familiar. If they were already familiar with the school and the routes around it, this knowledge could confound the study. To avoid this potential situation the study took place during an ESY Summer Program in summer 2016. Participants were excluded if they currently attended the school during the normal school year. Participants' level of familiarity with the school was also identified via a pre-study questionnaire to parents/guardians. Information collected included, for example, whether the participant had visited the school with an older sibling or attended a previous ESY Summer Program at the same site since their prior knowledge of the layout of the school could affect the findings of the study. To be eligible for the study, the child had to be registered to attend the ESY Summer Program. In addition, since there was more than one Summer Program site in the SD, the child had to have been assigned a place at the study site.

Identified diagnosis of ASD. Participants had a diagnosis of ASD as stated on their IEP evaluation report. Each child with special educational needs has an IEP that is developed by the school in conjunction with the student and his/her parents or guardians.

This plan details the child's educational goals, emotional needs, and the support needed in the school setting. These could include the services of a para, physical aids, and additional time allowance in which to take exams, etc. The condition of ASD is generally defined on the IEP using *DSM-5* (APA, 2013). However, since the APA diagnostic criteria were changed relatively recently in 2013, it is possible that some students were described under the older diagnostic description in the *DSM-IV* (APA, 2000).

Gender. Both male and female participants were sampled, but selection was expected to reflect the gender difference inherent in those with ASD, where more boys than girls are diagnosed with ASD, on a ratio of 5:1 (Baio, 2012).

Age. The age range of participants was 8-11 years. This age group was selected because these students were more likely to have greater maturity and ability to participate, to follow instructions, and to provide feedback than younger children. This was especially important as gaining direct feedback via the post study questionnaire was an important aim of the research study. Participants in this age group would also be more familiar with the routine of school and the school environment and more likely to feel comfortable walking around it than younger participants.

Primary language. The primary language used by participants was noted. This was particularly relevant since participants who did not use English as a primary language may have had more difficulty understanding the researcher and reading English text on the signage.

Ethnicity. The ethnicity of participants was documented as there are reports of a higher incidence of ASD in some populations, e.g., a higher incidence of children with ASD has been reported in the Somali population than in the general population (Hewitt et al., 2013).

Communication skills. Since the study involved finding out from participants what their views were about the wayfinding task via an interview/questionnaire it was important that participants were able to communicate verbally in simple words or sentences. This would also affect their ability to interact with the researcher during the study. Children who were non-verbal were therefore excluded.

Intellectual/cognitive functioning. To be eligible for the study participants had to be able to follow simple instructions and accompany the researcher for the duration of the study. This would likely indicate a higher IQ as children with a lower IQ may not have been able to fully understand the researcher's instructions and successfully complete the wayfinding task.

Motor ability. Motor functioning abilities were recorded noting any participants who had difficulty with walking or balance as these factors could affect the outcome of the study.

Hearing and vision. Sensory impairments were noted which could impact the study. For example, participants with a visual impairment or a hearing impairment could take more time to carry out the wayfinding task. Participants with color blindness were identified as any with blue monochromacy color deficiency, a total lack of color vision, would need to be excluded since they would be unable to perceive the colored wayfinding aids. Participants with red-green or blue-yellow color deficiency could be retained as they were likely to be able to discriminate the colors used in the study.

Familiarity with the Study Site

The researcher wanted to know whether the participant was already familiar with the study site and if so to what extent. For example, whether they had visited the school previously with a sibling, or attended the school for an ESY Summer Program in previous years. Parents/guardians were therefore asked to complete a pre-study questionnaire providing this information.

Excluded Participants

Participants were ineligible to take part in the study if they had an indicator that they were prone to challenging behavior such as physically violent behavior and need physical restraint, for example, a "Rule 40." Rule 40 refers to Minnesota's Rules Governing Aversive and Deprivation Procedures (Minnesota Department of Human Services, 2015; Positive Supports Rules, 2013). Parts 9525.2700 and 9525.2810 refer to people who have a developmental disability (Minnesota Department of Human Services, 2015; Positive Supports Rules, 2013). These procedures were under review as of January 2015 (Minnesota Department of Human Services, 2015). Challenging behaviors could impact the ability of the participant to take part in the test in a calm manner or to participate at all. The SD had their own Crisis Prevention Intervention and this was used to screen participants. This ensured the safety of participants in the study.

Selection Process

Using the selection criteria (Appendix A), the SD identified 8 children who met the research criteria. Recruitment packs containing an informational letter with statements of consent, a pre-study questionnaire, and a stamped addressed envelope addressed to the researcher were sent to parents/guardians on behalf of the researcher by the SD. Recruitment was slow and a request was made to the university's Institutional Review Board (IRB) to change the original protocol from 9-12 year olds to 8-11 year olds because there were no 12 year olds enrolled in the ESY Summer Program (it had been anticipated that there may have been a few 12 year olds held back a year who would attend but this was not the case). Expanding the criteria to include 8 year olds increased possible participants by 11 and the SD sent out additional recruitment packs on behalf of the researcher. By the start of the observation period of the study six participants had been recruited. Reminder letters were sent out to non-responders by the SD on behalf of the researcher via the children attending the ESY Summer Program. One more participant was recruited in this way. Due to concerns that some participants might drop out due to unforeseen circumstances a further request was made to the IRB to offer a $20 gift card to encourage participants. This would be retrospectively applied to those who had already agreed to participate. The IRB agreed to this change. This yielded another two participants. The total number of participants was therefore nine.

Assignment to Groups

Participants were randomly assigned to the treatment or control group to avoid selecting participants who could be predisposed to one condition or the other which could lead to erroneous results (Frankfort-Nachmias & Nachmias, 2008). Random assignment was achieved by drawing participants' names out of a hat and assigning them to a group so that each participant had equal chance of being selected for the control or treatment groups (Babbie, 2010).

Control group. One group of participants was assigned to take part in a wayfinding experiment along the school corridor without the incorporation of wayfinding aids.

Treatment group. One group of participants was assigned to take part in a wayfinding study along the same school corridor using applied wayfinding aids as an intervention. However, there was an issue with one participant assigned to the treatment group. During the observation period, in discussion with the teacher, it became apparent that one participant (Freya) currently attended the school and had erroneously been selected by the SD as meeting the selection criteria. However, based on discussions with the teacher, it was decided to retain her as a participant because it would be unethical to withdraw treatment that may be of benefit to her. Freya was therefore purposefully retained in her assigned treatment group. Her data is highlighted in the study.

Approvals

This research proposed to use participants from a vulnerable population, children with ASD. As such, there were a number of approvals that needed to be obtained before the study could occur. Both University of Minnesota IRB and the School District (SD) approvals were required, a difficult and lengthy process to satisfy the two different bodies. Note that the name of the SD has been changed to protect confidentiality. In addition, as the participants were minors, consent to take part in the study needed to be obtained from their parents or guardians. The school head teacher was also asked to allow the study to occur in his school. This section documents the approval process.

Description of the School District

The SD, as noted on their Web site, is the largest school district in a metropolitan area in the Midwest with a population of approximately 37,880 students attending 24 elementary (grades 1-5), 6 middle (grades 6-8), and 5 high schools (grades 9-12) (North Metro School District, 2015a). The district was appropriate from which to draw participants because they reported a high incidence of students with ASD amongst their students with disabilities, namely 19% when the state incidence is only 13% (North Metro's Special Education Advisory Committee, 2015b). The SD also reported that the number of children diagnosed with ASD more than doubled in the district between 2005 and 2011 from 490 to 1,110 (North Metro School District, 2015b).

In the SD, most students with a disability are educated in the general education setting (i.e. mainstreamed) at least 80% of the time, known as Setting I, and 15% are educated in the general education setting between 60% and 80% of the time, known as Setting II (North Metro School District, 2015b). Students may be mainstreamed fulltime or part-time, i.e., integrated for part of the day but spend some time away from the general education setting, usually in a resource room or a self-contained special education setting (North Metro School District, 2015b). Descriptions of these settings were provided in Chapter 2.

School District Approval

The SD required a research application form to be completed and approved by their Department for Research, Evaluation, and Testing (RET). RET required full details of the purpose of the research, the research design, and the method, as well as copies of supporting consent forms, informational letters, and data collection instruments. They also requested details of the outcome of the study after it had been completed. Preliminary discussions had been held with the SD as early as Spring 2014. In Spring 2015 the researcher met with the Associate Superintendent and the Director of Special Education as well as other personnel in the SD to discuss the research proposal. They suggested that a suitable venue for the research could be a school during the SD Extended School Year (ESY) Summer Program. This program took place over 5 weeks in the summer and was intended to prevent children slipping behind educationally compared to if they did no studying throughout the summer months. The advantages were that high numbers of children with ASD would attend so there would be more potential participants convened in one place. Arrangements were made for the researcher to meet the Special Education Department supervisor of the ESY Summer Program. After this discussion the researcher arranged to visit a typical class for children with ASD in an elementary school during the ESY Summer Program. Based on this visit and observations, the researcher concluded this would be a suitable venue.

A formal application to conduct research was submitted by the researcher to the SD in October 2015. There followed several months of negotiations via e mail regarding queries, clarification, requests, suggestions, requiring many iterations of method and data collection instruments and the provision of updated information. Approval was received in February 2016. Approval included the need for the researcher to sign a confidentiality agreement, to apply to become a school Student Teacher which entailed a criminal background check, and the responsibility of hiring a para to cover for paras involved with the study.

After the SD approval was received the researcher submitted an approval to the university's Institutional Review Board (IRB) as discussed below. IRB approval included the need to amend the consent form. This involved additional discussion and amendment of documents with the SD. The IRB also required specific letters of support and approval from the SD and these also had to be obtained. Once full IRB approval had been received and the requirements of the SD had been satisfied the researcher was able to commence the study. During the setting up period prior to the study, more detailed queries were raised by the SD and needed to be resolved, e.g. hiring the para, exact days of the study, and the type of wayfinding materials to be used.

In addition to developing the study it was necessary to inform affected SD staff about the study. In May 2016 the researcher made a presentation to RET and Special Education staff, ASD specialists and the lead teacher at the study site to explain the study direct. A further meeting was held at the SD to explain the study to teachers and paras who would be teaching at the ESY Summer Program. They were advised that they may be asked to help identify participants via the selection criteria and that they may have additional forms from the researcher to be sent with the normal ESY Summer Program information that was sent out to parents.

Institutional Review Board Approval

Approval for the experiment was required by the University's Institutional Review Board (IRB). To check whether a full review or an expedited review would be required a *Determination of Human Subject Research V1.2* form was submitted to the IRB. They determined that a full review would be required. The forms identified as requiring submission were *Social Behavioral Application Form, V6.2; Appendix J: Students as Principal Investigator; Appendix M: Research in Schools;* and *Appendix Y: Research Including Children.* In addition, copies of consent forms, data collection instruments, and other supporting information were required. The IRB also required written approval from the school district where the study was to be conducted before they would review the case. The application was submitted in February 2016 and reviewed by the IRB Student Social Committee during its March 2016 meeting. The researcher, as Principal Investigator, and the researcher's adviser, waited outside the meeting to answer any questions that might arise, but were not called.

The IRB approved the application with certain stipulations that had to be met before final approval was granted, including revision of the consent forms. This necessitated some new discussion with the SD to agree the revisions. Additional information was provided to the IRB and the documents amended as requested. Final approval was received to commence the study in May 2016.

Change in protocol 1. The original IRB application was for participants aged 9-12. Elementary school is usually maximum age 11 but 12 was considered in case any child was kept down a grade or had a birthday in the summer vacation. This yielded only eight participants and no child was aged 12. The SD checked their records and no child who met the criteria was aged 12. On this basis an amendment was submitted to the IRB requesting approval to amend the protocol to participants aged 8-11. IRB granted approval for this yielding a further 11 possible participants who met the criteria to whom consent forms were sent.

Change in protocol 2. Since participant recruitment was still low and there was a concern iterated by SD staff that there was a dropout rate for students attending the ESY Summer Program, a further protocol change was sent to the IRB requesting to be allowed to offer a $20 gift card to each child for participating. Participants who had previously consented to be in the study would retrospectively receive a gift card. IRB also approved this change. This brought in two more participants totaling nine.

Facilities Management Approval

Another area that had to be negotiated with the SD was the application of wayfinding aids. In April 2016 the researcher met with the SD Director of Buildings and Grounds to explain the study taking samples of potential materials that she had researched. Criteria for consideration were that they had to be of temporary nature, would not damage existing surfaces, would be easy to apply, and were available in contrast colors. Agreement was reached as the section on wayfinding variables outlines. A meeting was also convened with the head teacher to seek approval to conduct the study in the school, although the head teacher would not be in attendance, and to request the cooperation of janitorial staff. The head teacher granted approval and a subsequent meeting was held with the janitor supervisor and assistant supervisor to explain the study, to agree an area of the school for the study, and to seek cooperation from janitorial staff that the study route would be clear of equipment and janitorial staff during the times of the study.

Informed Consent of Parents/Guardians

Informed consent was required from the parents/guardians of the children participating (see Appendix B). The format of the consent forms was based on IRB templates. Documents included an informational letter explaining the aims of the research and seeking permission to allow their child to take part in the study. Permissions were itemized separately so that parents/guardians were clear about what they were consenting to and could opt in or out of an item if they chose. Separate consents were therefore required, consent for the participant to participate; consent for the participant to be videotaped; and consent for the participant to be audiotaped.

A pre-study questionnaire was also enclosed for parents asking for information about their child's familiarity with the study site (see Appendix B). Instructions were included to return the completed forms to the researcher via email or in the stamped addressed envelope provided. Parents/guardians were also offered an opportunity to attend an Optional Informational Meeting to meet the researcher and find out more about the study at the school site where the study was to take place. Note the researcher and a representative of the SD held the meeting as scheduled but no parents or guardians attended.

Disclosure of demographic information. To access demographic information held by the SD, parents/guardians were also asked to authorize the SD to provide information to the researcher regarding the demographics and functional level of participants relevant to the study. Information requested included gender; age, as there may be a difference in performance between younger and older children; ethnicity, as there were reports of a higher incidence of ASD in some populations; primary language, as the child may have more difficulty understanding the researcher if their primary language was not English; intellectual disability, and whether none, borderline, mild, or moderate, as this may be an indicator of the child's ability to understand the researcher; and any visual, hearing, or motor disability so that the researcher could make any disability accommodations. Parents/guardians were asked to signify agreement to release each part of the information to protect the SD.

Child Assent

In accordance with IRB policy, the child was asked to agree to take part in the study via a Child Assent Form (Appendix C). Parents/guardians were asked to review the assent form with their child to help them understand that they were being asked to take part in a fun study with a researcher from the University of Minnesota that involved walking around the school.

Information to Teachers/Paras

The researcher attended a meeting at the SD headquarters for managers and staff involved with the ESY Summer Program and presented a PowerPoint explaining the aims of the study. Staff asked questions afterwards. The researcher also attended the ESY Summer Program work day at the school site to inform teachers/paras about the study. This ensured that all staff knew about the project, would recognize the researcher if they saw her walking around the school, understood the aims of the research, and informed teachers/paras that some may have participants in their class. Teachers were asked for their cooperation in preparing and releasing participants for the study. Teachers were also advised that they would be asked to provide a para to escort participants in the study but that they would be provided with the cover of a para hired by the researcher. The IRB did not require informed consent from teachers/paras as they were not considered participants in the study.

Bias

To avoid the potential for bias, parents/guardians and participants were not given detailed aims of the study. Teachers/paras were advised not to tell participants what they would be doing. This was to guard against what Frankfort-Nachmias & Nachmias (2008) describe as "demand characteristics" (p. 199), where people who take part in a study act in a way they think the researcher desires.

Protection of Participants

For this study, the data relating to participants in the experiment was anonymized by allocating letters and pseudonyms. Also, as a means to follow appropriate and ethical behavior as the Principal Investigator, the researcher completed the required University of Minnesota training *Collaborative Training Initiative (CITI) Program: Social/Behavioral Research Investigators and Key Personnel – Basic Course* in November, 2013. The researcher had also completed three data protection training courses as required by the University of Minnesota Privacy and Security Training program: Data Security in Your Job, Securing Your Computer Workstation, and Using University Data. In addition, a para was hired by the researcher to assist with the study. This para would remain in the child's classroom to cover for their normal para who would follow the child and the researcher during the study to intervene in case of need.

School Site for the Experiment

The researcher gathered data describing the location of the school selected, its setting, the type of building construction, and the interior environment as well as some details about the type of school and the general school population. Uncontrolled and controlled variables are discussed. Uncontrolled variables include the existing features in the corridor. Controlled variables include the wayfinding aids, the wayfinding scripts, and the personnel involved in the study.

Corridor Location for the Study

The study took place during the ESY Summer Program 2016. As was normal practice, the ESY Summer Program was in a designated area of the school and the remainder of the school was cordoned off to allow janitorial staff to deep clean the building during the summer recess. An area of the school that was not being used by the ESY Summer Program was agreed between the researcher, janitor, and RET representative that was suitable for the study. The janitor agreed the study route would be cleaned before and after the wayfinding task and not during. Janitorial staff would also avoid walking along the corridors or coming out of rooms during the study period as this could affect the results. Janitorial staff cooperated fully with this. Note that this area included not only the study route but also other corridors visible from the route, as indicated on the plan (Appendix D).

Also, in many of the corridors allocated to the ESY Summer Program, there was evidence of the cleaning process, e.g. furniture cordoned off and janitorial equipment, such as waste bins, mops and cleaning machines, so children were accustomed to seeing this.

Designated Route

A single designated route was identified in the school corridor for both treatment and control groups from a start point to a destination point. A plan of the corridor route is included (Appendix E). The start point was a designated area in the corridor. The destination point was a specific destination, characterized as one that students might typically visit during the school day. An Art Room was selected for this purpose. Note that the room was actually a general classroom designated Art Room by the researcher to provide a specific, purposeful destination for the wayfinding task. A route was established where the destination point was out of sight of the starting point. The length of the route was measured. Start and destination points were described.

The route had opportunities for right and left turns (one right and three left). Two sets of double doors had to be opened along the route. One set of glass doors in the corridor was permanently held open. The route included the opportunity for participants to take a wrong turn or direction. There was one opportunity to miss a turn (into the yellow corridor) and three opportunities to take wrong directions; at the library counter there was a choice of three possible directions; entering the red corridor there was a choice of three possible directions; and at the green corridor there was a choice of two possible directions.

The total distance of the route measured from the center of the corridors was approx. 483'. The number of steps/paces from the start point to the destination point was about 185 measured by an adult male so would have been more for a child.

Typical School Corridor (Uncontrolled Variables)

Physical data was collected regarding the corridor to inform future research. All doors along the corridors, shapes in the floor, signs, noticeboards, and other notable artifacts are indicated on the plan (see Appendix F). Photographs show typical areas of the corridor under existing (control) conditions to supplement written description and information (see Appendix H).

The following variables were not controlled but data was collected to inform future studies including:

- Spatial layout of the space (width and ceiling height);
- Plan, elevation, and ceiling details;
- Presence, size, and location of windows and skylights;
- External views visible along the route and type of view;
- Material finishes of floors, walls, doors, hardware, and ceilings, including texture of the finishes, (e.g. rough or smooth, soft or hard, shiny or dull);
- Color palette of all materials and finishes, identified using the Pantone color system;
- Type and location of existing patterns on floors;
- Type and location of existing doors, including any glazed vision panels;
- Type and location of existing signage, including fire exit signage;
- Type and location of light fixtures and lamp types, including their condition, e.g. whether all lamps were operational, whether any fixture lenses or baffles were missing, damaged, or dirty;

- Type and location of existing furniture and fittings, e.g. lockers, display cabinets, and fire fighting equipment
- Type and location of existing noticeboards, posters, display materials, etc.

Wayfinding Aids (Controlled Variables)

In this exploratory study an experiment was conducted to find out the effect of a combination of wayfinding aids applied in a typical school corridor as the treatment in comparison with the corridor without application of wayfinding aids. Wayfinding aids consisted of colored doors, colored shapes in the floor, and colored signage. Wayfinding aids were those associated with landmarks, imageability, and legibility as described by Lynch (1960). Colored doors act as landmarks and cues along the route (Helvacioğlu & Olguntűrk, 2011; Sanchéz et al. 2011). Colored shapes in the floor act as imageable paths and cues (Lynch, 1960; Vogel, 2008), especially for students who often walk looking down. Signage (pictograms and text) act to give legibility (Castell, 2008; Lynch, 1960; Mostafa, 2008; Salmi, 2007a; Vázquez & Torres, 2013).

A combination of wayfinding aids was proposed rather than testing an individual type of wayfinding aid on the basis that, because children with ASD are so individual in their needs and degrees of sensitivity (Edelson, 2011; Martin, 2014), one single type will not benefit all children. Also children with ASD can be hyper- or hyposensitive to environmental stimuli and what one child perceives or finds stimulating may be different to what another child perceives or finds stimulating. Other researchers have identified that there are many wayfinding cues that help children and adults to navigate (Castell, 2008; Lynch, 1960; Mostafa, 2008; Salmi, 2007a; Vázquez & Torres, 2013). For these reasons, several aids were incorporated in this study. Given this approach, wayfinding aids that would be relatively inexpensive to manufacture and install were selected since school districts who may come to install them in the future would have limited funds to expend on them. The wayfinding aids were applied to the designated route for the treatment group.

Wayfinding aids are described in detail below, including their manufacture, location, size, color, texture, and finish. Wayfinding aids consisted of colored doors, colored shapes on the floor, and signage.

Color Selection of Wayfinding Aids

Wayfinding aids were proposed in four different colors with the aim of signaling to the child with ASD that there was a change in direction involved in traveling along the corridors from the start point to the destination point. Previous research had found that typically developing children were able to successfully perceive and wayfind with two different colored wayfinding cues (Helvacioğlu & Olguntűrk, 2011). The existing color palette of the school corridor was neutral block walls broken up by expanses of blue lockers. Doors and door frames were pink but because they were generally recessed and often covered in photos, posters, etc., they did not appear as dominant as the blue lockers. The floor was a neutral flecked beige vinyl broken up by blue squares 2′ x 2′. At intersections in the corridors were larger squares 8′-6″ x 8′-6″ overall consisting of blue squares 7′ x 7′ offset to form a diamond shape with pink triangles forming the corners. There was also a pink vinyl border approx. 14″ wide along the corridors. Both blue and pink vinyl was similar style flecked material.

Colors of wayfinding aids were selected that contrasted to the existing color palette of the corridor as much as possible so that they would be visibly perceived. Since the overall impression was blue in the existing corridor, the first color selected for the treatment route was orange, being the contrast complimentary color on the color wheel and thus having greatest impact. Yellow and red were then selected as forming strong contrasts at one third distance from blue on the color wheel. The final color selected was green as there was no green in the existing corridors and this would provide a color contrast.

The color palette for the matboard was limited and much research was done to source matboard in the quantities and size required that also provided the range of necessary colors. Orange and yellow matboard was obtained in a strong, bright, chromatic intensity against the existing colors; the red matboard did not provide such a strong chromatic intensity; and the green matboard obtained provided a color contrast but was a more muted color with similar chromacity as the existing lockers and doors. The matboard was entirely plain whereas the existing floor had flecks in it. The stronger contrast colors were used at the start of the treatment route, orange, yellow, red, then the more muted green.

Colors were identified in the corridor using a Pantone color chart though, since this was done by eye, it was subjective. Also, the vinyl floor contained flecks of colors so the overall color impression was noted. Materials and their texture were photographed and noted.

Colored Doors

Detailed dimensions were taken of the doors along the wayfinding route, including location and size of vision panels, door handles, door closers, etc., in order to manufacture the wayfinding aids. Detailed investigation took place to identify the most suitable material to cover the doors that would not damage the existing surface, would be easy to apply, would be cost effective, was of suitable size, and was available in a variety of colors. Comparison of materials included various film and cardboard qualities. Visits were made to a number of suppliers and retailers to inspect the products. The best product selected that met the criteria was colored matboard. Matboard is available in various qualities, sizes, and colors but not all suppliers carried the permutations of stock needed for the study. A supplier was finally sourced that could provide the matboard in the size, colors, and quantities required. These were purchased on-line and delivered by special arrangement to the researcher's home; quantities of this order were usually delivered to a retailer.

As previously stated, matboard is available in various sizes but a manageable size was 40" x 34". Since the average door in the corridor was 82" x 36", two pieces of matboard would be needed to cover each door, leaving an approx. 1" gap either side of the door and an approx. 2" gap at the bottom of the door. However, when covered by the matboard, the overall impression was of a one-color door.

After detailed dimensions had been taken, a scale drawing was made of each door. From these scale drawings full size templates were developed for common door types. Doors were assigned door numbers, D1, D2, etc., to help identify and position the wayfinding aids. Left hand and right hand opening doors were also identified since the templates differed for each. The matboard color for each door template was allocated depending on its location along the route. These templates were used to measure cutting guidelines in pencil on the reverse of the matboard. Cuts were generally required for vision panels, door handles, door closers, and push bars. The matboard was cut to size using a wall mounted guillotine. Each door was labelled with a door number to top and bottom template so that they could easily be located and applied. The double doors D7 and D12 required matboard applied to both left hand and right hand doors and on both sides, i.e. eight templates in all, because the reverse of the doors would be seen on the reverse trip when the researcher led the way back.

To fix the matboard, various adhesive tape products were purchased and considered. Blue decorator's tape was selected as it would not damage the existing door surfaces and would be easy to apply and remove. To test adherence, a matboard door template was fixed with blue decorator's tape at the researcher's residence but fell down after a few hours. After several attempts a system was developed of using multiple pieces of decorator's tape applied to the reverse of the matboard, adhering the matboard to the door and then wiping the surface of the matboard over with a cloth to firmly adhere. This technique was trialed on the inside of a door along the corridor route and found to be effective. No door template fell down during the study.

To test the door wayfinding aids, the appropriate matboard templates were applied to each door along the route to check that they fitted correctly (see Fig. 7 for examples). Final adjustments were made on site, e.g. to allow for door closers or door handles. The door templates were then removed and stored for the treatment group. As previously mentioned, doors had to be applied in two templates but the join was not visible and the overall impression was of one visually colored object in the corridor. In all over 20 doors required templates involving nearly 50 pieces of matboard which had to be installed and transported to and from site.

Also note, in a normal school situation, doors would generally be open at passing times which would obscure the door color. In this situation an additional 4″ wide matching strip of colored material would need to be applied around the door frame so that the color would visible when the doors were open at passing times.

Figure 7. Examples of colored doors.

Colored Shapes on the Floor

Before a route had been identified, research was undertaken to find suitable material to use as wayfinding aids on the floor. At that time it was unclear whether the route would have a vinyl or a carpet floor finish, both materials being evident at the school. Accordingly the materials investigated included carpet tiles, rubber tiles, cardboard, and vinyl material. As for the doors, the criteria selection included ensuring the material would not damage the existing surface, would not be a trip hazard, would be easy to apply, would be cost effective, was of suitable size, and was available in a variety of colors. Information was collected on-line as well as by visiting home improvement stores and flooring specialists. Samples were gathered. Particular interest was focused on the thickness and profile of the material so it would not be a tripping hazard to participants as they walked over it. As well as flooring material, appropriate fixing methods were considered, such as Velcro tape, decorator's tape, masking tape, etc. Discussion took place with the SD Director of Buildings and Grounds and in conjunction with this officer it was agreed that carpet or cardboard could be used as neither presented a tripping hazard, they were not being used in a public situation, and they would only be used during the study for a short period of time.

The existing floor area was surveyed. The area identified for the study route was a vinyl floor finish with colored squares 2′ x 2′ along the length at regular intervals. The decision was made to cover these squares with wayfinding aids so that the existing floor would not cause confusion with the wayfinding aids. At junctions in the corridor larger colored squares had been inset into the floors. Again, the decision was made to cover these with wayfinding aids to provide a distinct wayfinding cue. As the existing floor was vinyl, matboard was selected as the floor finish as it had a lower profile to complement the vinyl rather than a thicker carpet tile. Another advantage of using matboard was that the color exactly matched the door wayfinding aids so there was a cohesive color scheme in each corridor.

Matboard was sourced the exact size of the existing 2′ x 2′ squares in the floor so the appropriate amount of matboard was purchased in the colors required. The matboard was loose laid and tested in the researcher’s residence to see whether it moved or needed adhering when walked on. Because the matboard was relatively heavy it was found that it stayed in place well and only occasionally shifted out of place if walked on. The low profile on the hard floor was not found to be a tripping hazard. The advantage of loose laying the material without fixing was that it could easily be taken up at the end of each day’s study.

For the larger squares, 3′ x 3′ squares provided full coverage for the larger area with some contrast color “pink triangles” left visible underneath. It was decided to leave these triangles as not only could the floor wayfinding aids have looked too overpowering but it would have and required numerous more matboard pieces to cover. Rows of three squares were taped together and loose laid in position. The overall impression was of a large single colored area, as shown in Figure 8.

As stated, there were existing squares in the main corridors which were covered with squares of matboard as the floor wayfinding aid. The researcher also wanted to use different shapes in the floor to test whether different shapes had an effect so in the Media

Center circles were applied over the existing squares. Due to the limitations of matboard size there was an approximate ½″ squared edge where blue tile was visible underneath the matboard but the overall impression was of a circle shape. Circles were 2′ -8″ in diameter cut to size with a laser cutter, the rough edges sanded down with sandpaper.

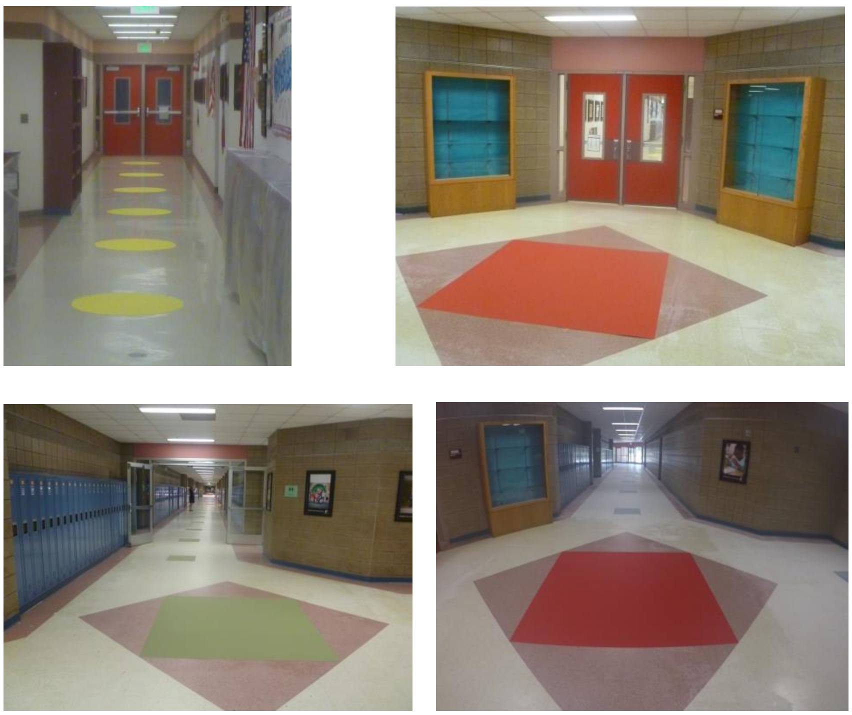

Figure 8. Examples of colored shapes on the floor

Signage

Existing signage in the school corridor was surveyed. Signs were consistent, white tactile raised characters on a dark burgundy background with Braille below, enclosed within a frame, complying with the Americans with Disabilities (ADA) standards (Department of Justice, 2010). Text was all in upper case. Signs were fixed at approx. 60″ which complied with the ADA statement that height should be between 48″

and 60″ (1220mm and 1525mm) from finished floor level to comply with the ADA (Department of Justice, 2010). Signs were generally positioned consistently at the side of the door on the wall adjacent to the door handle. Some signs also had labels added to them by teachers, e.g. teacher's names. Signs generally consisted of a room letter/number and a room name. Photos and overall dimensions were taken of existing signage along the route to develop the script for the control group and in turn to develop the wayfinding route.

Looking at the overall plan, the researcher could determine that some door letter prefixes derived from orientation, e.g. W and N for west and north but for others, e.g. F, it could not be determined why they had those prefixes. In addition, it was not clear how the sequence of numbers had been determined, e.g. F10 room opposite S34 room, N19 near W23. Some doors in the Media Center did not have a sign on or adjacent to the door but had a non-ADA compliant sign above the door. The researcher decided to use only the ADA signage in the script as these were the doors that were properly signed. The signs above the doors were left in situ for both control and treatment groups who could use them as wayfinding aids if they chose.

Due to the confusing signage system, the researcher decided to streamline them and make them more understandable and user friendly for an elementary age child. Along the treatment route classrooms were therefore labelled as C1, C2 etc., to indicate Classroom 1, Classroom 2, etc. N or W, e.g., was not prefixed as the color of the sign became the orientation. This approach would also help determine whether clearer signage aided participants. In a new school design clearer labels could be provided. The names of some rooms were also changed to make them more understandable, e.g. the same Work Room sign on two different doors in the Media Center became Media Work Room 1 and Media Work Room 2; Inter. Music became Music Store; a door with "No occupancy permitted by order of the Fire Marshal" was replaced with a simple "No Entry" sign.

As previously mentioned, one of the general classrooms was designated as an Art Room for both the control and treatment groups. This was so that both groups had a relevant task to complete during the study, that of collecting a book from the Art Room. For the control group the existing classroom sign was covered over by a color printed Art Room sign that matched the existing signage so that it would be perceived the same as the existing signage and would not have an effect by being different.

Manufacturing the signs. Signs were created in the Word program. They were color matched to the matboard door and floor aids as far as possible and the colors identified in Pantone colors. Orange, yellow, and green signs were printed on colored paper and laminated. Orange and yellow matched the matboard well but the green was a lighter color. For the red signs, since it is very difficult to print white on red paper as few printers are set up with white ink, signs were color printed in red with white lettering. Several trials were made before a red color was found that was a good match for the red matboard. All signs were printed to letter size paper 7″ x 11″ which allowed room for pictograms and text at an appropriate size and covered over existing signs. Signs were laminated to ensure robustness.

At the study site, signs were applied over the existing signs with concealed blue decorator's tape. In the Media Center a white textured wallcovering proved difficult to adhere to so in these cases signs were positioned on the doors. Doors in the Media Center were provided with signs where they did not have them. It was not possible to replicate the tactile raised characters and Braille in the wayfinding aids without expensive manufacturing so that aspect of the signs did not comply with the ADA. Also, children with ASD were unlikely to be able to read Braille. Other aspects complied, including the height of the signage which was the same as existing signage since the wayfinding sign aids were applied directly over the existing signs. Text comprised the name of the room and number as appropriate as shown in Figure 9.

Pictograms. In addition to text, signs in the treatment route were supported by pictograms since children with ASD are often taught pictorially to supplement the written word. Signage consisting of pictograms and text ensures that they can be read by multiple users (SEGD, 2015). Pictograms were intended to be either from a recognized graphic symbol system that the SD used, such as the PECS system, or a site specific pictogram system that the school used (SEGD, 2015). However, on investigation it was found that the SD did not use an overall system of pictograms. They reported that Boardmaker was used but was considered expensive, that another system, Pogo Boards, was being considered, and that some teachers used Google images. In view of this and because participants could come from a number of different schools, the researcher decided to use Google images. A number of images, sourced from free image websites, were considered before finalizing. Several images were tested on a typically developing teenager to determine the most appropriate. Pictograms and text were in black on a colored ground except for red which had white pictograms and text to provide an appropriate contrast. The application of signs was tested in the researcher’s residence adhered to the walls with decorators tape. See Figure 9 for examples of signs.

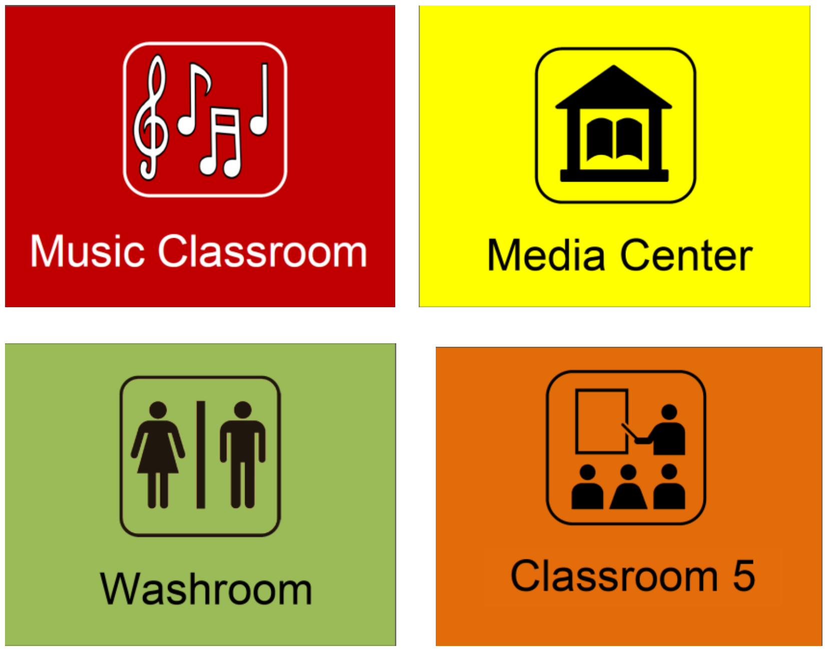

Figure 9. Examples of signage.

Wayfinding Scripts

As part of the study design, wayfinding instructions were provided to participants in the control and treatment groups. This was on the basis that, when children with ASD are shown something in class, instructions are often repeated numerous times before the child remembers. This also fitted in with previous studies by Cornell et al. (1989) and Helvacioğlu and Olguntűrk (2011). Also, as adults, we are frequently shown the way the first time we go to an unfamiliar destination before being expected to remember it ourselves the next time. To provide consistent instructions to participants, wayfinding scripts were developed. The scripts for both groups were kept as comparable as possible (see Appendix I and Appendix J).

The scripts were developed considering how Lynch (1960) believed people saw their environment, e.g. doors as edges, floors as paths, the library counter as a node or a landmark, and signs to provide legibility. In the scripts, the terms right and left were not used in case some children were not sure of their right and left and because it could become confusing reversing right and left on the reverse journey. Instead, the researcher used the terms "this way" and "that way" and indicated right or left with hand gestures.

Start point. A start point was selected for the study route and all participants were told, "First, I am going to lead the way to the Art Room. I'll show you things along the way to help us find the way there. Then I'll lead us back here to the start point. Next, I will ask you to lead the way to the Art Room. Try to remember what you see along the corridor to help you find your way there when you are leading." This script was based on similar developed by Cornell et al. (1989) and Helvacioğlu and Olguntűrk (2011).

Destination point. To provide participants with a meaningful purpose in walking around the corridors a task was given them to collect a book from a designated room, the destination point. The destination point was designated as an Art Room as this was a room that children were likely to visit during the normal school day. There were two designated art rooms in the school but they were not in areas used by the ESY Summer Program.

Stage 1. Participants in the both groups were pointed out select wayfinding cues on the way to the destination point and reminded of their task, a technique employed by Cornell et al. (1989). Examples of wayfinding aids pointed out to the treatment group included, “Notice there are two orange doors here”; “We are going to turn here and go through these big yellow doors into the Media Center”; and, “There’s another door here and a sign Media Work Room 2 and the same picture of someone working at a desk.”

Participants in the control group were given similar instructions but without reference to the wayfinding aids for example, “Notice there are two doors here”; “We are going to turn here and go through these big doors into the Media Center”; and, “There’s another door here . . .” Note that no colors or squares on the floor were referred to in the control group on the basis that this could be confusing and misleading because, firstly, the only dominant color was blue, and, secondly, there were blue squares on all the corridors which all looked the same.

Stage 1 return trip. On the way back, participants in the treatment group were reminded about some of the wayfinding cues, for example, “Now, we are heading back to the start point. We are starting off in this green hallway”; “Remember these three red doors with the red signs to do with music”; and “There is the yellow door with the yellow No Entry sign on the door that we passed earlier.” Participants in the control group were given similar instructions but without reference to the wayfinding aids such as, “Now we are heading back to the start point. We are starting off in this hallway”; “Remember these three doors?”; and “There is the door with the sign on the door.”

Stage 2. During the second stage of the test, participants in the treatment and control groups were told by the researcher, “Now we have arrived back here at our Start Point. Now you are going to lead us back the same way to the Art Room.” Participants in both groups were assured that the researcher would be right behind them and they could ask her for help if they did not know the way. They were also reassured that the researcher knew the way so they would not get lost as often children with ASD can experience anxiety about this.

Contingency comments. Contingency comments were also prepared in case a participant from either group seemed unsure of the route, such as, “Do you need some help?” or “Do you remember which way to go now?” (Cornell et al.,1992). If a participant walked for 10 steps or more in the wrong direction, or appeared confused, or tried to enter the wrong door, they would be instructed, “You are not going the right way. We walked past this door/shape/sign. Carry on and try again.”

Landmark. Above the library counter in the Media Center was a distinctive domed ceiling, partly lit for the study as had been observed during the normal school day. Both groups of participants were reminded in the script to “look up and remember this place” as it was a node or landmark in Lynch’s theory and terminology (Lynch, 1960).

Omissions. The researcher made the decision not to refer to two doors in the Media Center a) so it would not be too much information for the child, b) to find out whether participants noticed these doors anyway. In the treatment group the doors were colored with the wayfinding aids and had pictograms/signs applied. There were also two doors in the Media Center that were not mentioned in either script and left untreated of wayfinding aids for the treatment group to find out whether they would be noticed by either group. There were other features that were not mentioned in the script that were of interest to find out whether the participants would mention them, e.g. two large, empty display cabinets featured prominently either side of the Media Center doors in the (red) corridor, most visible on the return route.

Visual distractions. Some doors had pictures or posters fixed by teachers beside the door. These were retained as they were typical distractions encountered by children when wayfinding in a school situation to replicate the real school experience as much as possible. Similarly, some doors had colored material posted generally behind or sometimes over the front of the vision panel in the doors. There were also a number of posters in the Media Center corridors, framed pictures of presidents, and two US flags. These were retained for both groups and the researcher was interested particularly whether the US flags would become wayfinding aids.

Termination of the study. The researcher also considered circumstances in which to terminate a participant's participation in the study. For example, if a participant became upset or refused to take part, their participation would cease immediately and the termination documented in relation to time and location, i.e., how much of the task the participant completed before it was terminated. It was not necessary to terminate any of the participants during the study.

Wayfinding Task

To ensure that all participants had a reason to carry out the wayfinding task to make it more realistic they were instructed that they had to find their way to the Art Room to collect a book. When it was their turn and they arrived at the Art Toom the researcher instructed them to go inside and collect the book.

Physical Prompts

The researcher reinforced the script to participants by using physical gestures, pointing in the direction of an object or wayfinding aid, e.g. “We are leaving the start point here at this orange square (indicate down) by this wall with the orange sign washroom (indicate left). We are going to walk down this corridor with the orange squares (indicate the direction).” And similarly for the control group, “We are leaving the start point here (indicate down) by the washroom (indicate left). We are going to walk down this hallway (indicate the direction).”

Independence

The researcher also ensured that participants in the control and treatment groups would have a consistent physical proximity. The researcher would wait at the start point once the participant began the task of finding their way to the destination point on their own. If the participant appeared to need a presence the researcher followed about 6-8 feet behind the participant; if the participant appeared to need a closer presence the researcher followed at arm’s length; and if the participant appeared to need maximum support the researcher walked next to the participant.

Researcher as a Controlled Variable

During preparation for the study it became apparent that the researcher, in accompanying the participants, delivering the scripts, interviewing the participants, and generally directing them, became a human variable that needed to be controlled. The following measures were therefore taken to ensure that the
researcher provided a reliable stimulus and consistency between all participants.

Class introductions. The researcher was advised by the SD, when observing the participants, to take the opportunity to read to the class so they would become familiar with her English accent. In the first class observations the researcher read *Chicken Licken.* In the second classroom the teacher asked each child to introduce themselves to the researcher. One boy became very excited when he realized the researcher was from England and disrupted the class, "You're from England! I never thought I'd meet someone from England!" This child subsequently sent in a signed consent form. Children also had the opportunity to ask the researcher questions but all were very excited and this was the most excitable class observed. In the third classroom the children sat on a mat in rapt attention as the researcher read a story about pirates. In the fourth classroom the researcher read the next chapter in the class reading book and at the end all the class clapped. One child asked if the researcher was Australian and thereby began a discussion about England. In addition to the classroom observations, participants also frequently saw the researcher in the corridors, outside at recess, calling in to talk to their teacher, and they often recognized and acknowledged her. In this way participants became familiar with the researcher.

Practicing the scripts. The researcher practiced the scripts numerous times before the study. Slow pace, clarity, tempo, inflection, and hand gestures were practiced so that delivery was the same as far as possible for all participants. The researcher wore the same plain black clothes throughout the study so her attire would not stand out against any colors in the corridor. This also disguised the video camera that the researcher wore throughout on a chest strap. The researcher also wore black ballet slippers both for ease of walking over the wayfinding aids and also so that her shoes would not be a distraction, several children having commented in class during the observation period about her shoes. The researcher was also careful not to wear any perfume which could distract or disturb participants who could be sensitive to smell.

Paraprofessional as Controlled Variable

During the study a paraprofessional (para) followed each participant and the researcher along the wayfinding route in case an emergency arose. A para was hired by the researcher to cover in class releasing the para who was familiar with the child to follow them. Paras were instructed to stay about half a corridor distance behind the participant and researcher. They were also instructed to be as discreet as possible so that they could see the participant/researcher but they were not obvious to them. The only time the researcher was occasionally aware of the para's presence was when they turned around for the Stage 2 return trip. Only two of the participants showed any awareness of the presence of the para. After the conclusion of the wayfinding exercise, the para waited outside the interview room and when that was concluded followed the researcher and the participant back to their classroom.

Visual Distractions

As expected, there were a variety of visual distractions along the study route, such as existing notices, posters, and pictures displayed. These were retained for both groups to replicate as far as possible a normal school corridor in use. Visual material was photographed and documented on the plan, including a description of location and type of content. The material was controlled by the researcher in that there were no staff or teachers around to alter the material. However, as a precaution, each morning before the study began the researcher made a visual comparison to check that no alterations had been made to the appearance of the study route.

Visual distractions in the corridors included framed pictures and posters (see Fig. X). The Media Center contained a number of displays including a large poster on the solar system; miscellaneous posters; a large U.S. flag; a small U.S. flag; posters and pictures of presidents; commemorative plaques; and other memorabilia. In addition, many teachers had decorated their classroom doors, and/or their vision panels, and/or the wall outside their classroom doors with posters or notices. These were retained for both groups with the only difference being that in the treatment group any materials on the doors were covered by the wayfinding aids. The vision panels, however, were not covered so they were the same for both groups.

Presence of Others

To enable optimum observation and video recording opportunities the study was conducted in an area which was prohibited to the rest of the school. This helped participants to concentrate on the wayfinding task and also helped those who were liable to be distracted by other students, or sensitive to noise, or uncomfortable with the close proximity of other people. Also, if the corridor was crowded, it could affect the time taken to reach the destination. Janitorial staff were aware of the study and co-operated fully with it. They were asked to avoid using the corridor whilst the study was ongoing so they did not distract participants. Since children with ASD are particularly sensitive to the environment, these details were important to identify and avoid. During the study, a janitor passed one participant in the control group.

Description of the Experiment

This section describes the preparation of the school corridor for the experiment, the process of pretesting the study route, installing the wayfinding aids, and the pre-study checks that were made. It goes on to describe how the study was conducted with the participants, including observation periods, preparing them by asking parents/guardians and teachers to remind them about the study, and the study procedure itself.

Pretesting the Control Group

The researcher pretested the study route to become aware of any potential difficulties in data collection, observation, or video and audio recording techniques. Once the route had been established, appropriate wayfinding aids were planned and purchased. The task of fabricating the wayfinding aids was a mammoth one. Originally it had been intended to put up the wayfinding aids to pretest, then take them down and put them back up for the treatment group. However, there were concerns that the wayfinding aids could be damaged in putting up/taking down and also concern at the length of time involved in this process. Instead, a typically developing child was recruited to test the control route. The pretest participant was a convenience sample known to the researcher. Appropriate consent was obtained.

The reason that a typically developing child was recruited for the pretest was because there was a limited number of participants with ASD who were needed for the study. Also, given that the expectation was that all participants could behave differently, a single pretester may not provide a balanced test. A typically developing child would likely give a more balanced perspective.

The researcher tested the wayfinding script, the observation plan (behavioral map), and the questionnaire, and practiced operation of the body camera and the audio recorder, including testing the recording equipment for clarity afterwards. The researcher noted the actions and reactions of the pretest participant as this could provide a cue to the study participants' behavior. At the end of the wayfinding task the questionnaire was tested on the pretest child.

The pretest alerted the researcher of the need to practice making observations on the plan. This was subsequently done by the researcher following her son along the neighborhood streets recording his actions. From the pretest participant feedback, adjustments were made to the equipment, logistics, process, and questionnaires.

Pretesting the Treatment Group

Regarding the treatment group, the main concern was ensuring the wayfinding aids would adhere to the existing surfaces, particularly the door aids. Fixing methods for wayfinding aids had previously been tested in the researcher's residence. Fixing a door template to the inside of a door along the study route had also been successfully tested. The wayfinding aids were installed after the control group had finished. It took the researcher and two assistants around 4½ hours to install the wayfinding aids. All but floor aids were installed (these only needed to be loose laid) so they would not be a nuisance to janitorial staff and/or get damaged. Another treatment pretest participant (the researcher's son) was tested along the wayfinding route to test the treatment script and provide feedback. After the treatment pretest some yellow circles behind the library counter were removed as they were considered surplus to requirements. A couple of incorrect colors cited in the script were also amended.

Recruitment of Paraprofessional

As part of the agreement with the SD to conduct research, the researcher was required to hire and pay for a paraprofessional (para). The para would be needed to cover in the participant's classroom while their usual para followed the participant and the researcher during the study. The SD had various employment criteria that had to be met to become a para, they must be a high school graduate; they must be able to lift; they must be able and willing to work with students to correct behaviors; and they may be required to toilet students. Experience working with special education students was desirable. The applicant would have to go through the formal SD application process.

A recruitment advert was posted on the SD website (see Appendix K). The SD rate of pay was included. One person came forward for the position who was known to team members in the SD. She was subsequently interviewed by the researcher, found to be suitable, and recruited for the study. During times when there were no participants physically taking part in the study the para stayed in the classroom to assist the teachers.

Recruitment of Participants

Shortly after student participation in the ESY Summer Program had been confirmed, the SD used the screening criteria (Appendix A) to identify potential participants. The researcher passed recruitment packs to the SD ESY Summer Program administrator who had agreed to assist by including them with information about the ESPY Summer Program that was routinely posted to parents/guardians on the basis that the information would be more likely to be read. A follow-up letter (Appendix L) was sent out to non-responders during the first week of the study, i.e. the observation period, via the children. Further recruitment packs were sent out by the SD via the children during the second week of the study after the change in protocol 1 and 2 (as discussed in IRB approval section). In total 22 recruitment letters were sent out.

Assignment of Participants

Participants were randomly assigned to the control or treatment group and a running order was developed to determine the date and time for each child to take part in the study. Teachers were provided with a list of participants whose parents/guardians had consented to let their child take part in the study and the day each participant had been assigned to participate. Teachers were asked to inform the researcher if there were any conflicts with the scheduling and if so participants would be assigned an alternative day.

Instructions to Teachers

Once participants had been assigned to groups and their class teacher identified, they were provided with a timetable and a script for each child that included a general introduction to the class for the researcher and the dates on which to remind the child when they would be taking part in the study (see Appendix M). Teachers were primed to remind the child that they would be taking part in a fun activity that day with a researcher from the University of Minnesota to encourage the child and diffuse anxiety.

Reminders to Parents/Guardians

In addition, each parent/guardian was sent a note advising them when their child was due to take part in the wayfinding study and asking them to remind their child that they would be taking part in a fun activity with a researcher from the University of Minnesota to encourage the child and diffuse anxiety (see Appendix N). These reminders worked well in that each of the participants went willingly with the researcher, generally excited and eager to take part. It had been anticipated that some children may have been anxious and refused to participate but this was not the case.

Pre-study Observations

The researcher spent time in the participants' classrooms both to acclimatize participants to the researcher and to observe their behaviors and interactions during class activities. This data was used to frame participant's actions during the wayfinding task. A data collection sheet was established for this purpose (Appendix O). The researcher also read aloud to each class with participants in so they became familiar with her English accent.

All participants were observed by the researcher for a minimum of one hour on at least one occasion except for one participant whom it was not possible to observe due to timing issues. However, that participant, a late recruitment to the study, had been present in the class on each occasion of the researcher's observations in class, including the reading session, so he was familiar with her and she had an awareness of his behaviors. In one class with three participants, the researcher observed in class for a total of approx. 4 hours; in another class with one participant observation took place for a total of approx. 1 ½ hours; and in one class with three participants observation took place for a total of approx. 3½ hours. Two participants in the treatment group had been on vacation the week before so had fewer opportunities to interact with the researcher or see her coming and going in the classroom or around the school

Researcher Interaction with Participants

During the study it was important to ensure that the researcher provided reliable stimuli to participants. The researcher dressed in the same neutral clothes during the wayfinding task. The researcher also practiced delivering consistent prompts to participants.

Video and audio recording equipment. The researcher wore a body camera with video and audio recording facility on a harness camouflaged by clothing so it would not distract participants or make them conscious and act differently.

Observation. The researcher used a behavioral map (as shown in Appendices S and T) to record information such as the distance between the researcher and the participant, the route the participant took, and the number of verbal prompts.

Time Order

Due to the complexity of fitting the wayfinding aids it was decided to run the participants in the control group first, install the wayfinding aids, run the participants in the treatment group, then remove the wayfinding aids. The time order of several participants had to be changed as two were on vacation during the first week of the study. Time order was unlikely to have affected the results since none of the participants had access to the part of the school set up as the wayfinding route at any time.

Time Schedule

The ESY Summer Program ran from 8:50 am-11:50 am Monday-Friday. At 8.50am children were collected from their buses by paras and taken back to their buses at about 11.45am. This schedule allowed for a maximum of two students per day for 5 days per week. Participants were randomly allocated a time of either 9.15am or 10.30am to take part in the study. Each participant was allocated one hour in which to be collected from their class, undertake the wayfinding route, complete the questionnaire, and returned to their class by the researcher, i.e. 9.15-10.15am or 10.30am-11.30am, allowing a 15 minute changeover period. In practice most participants finished within 30-40 minutes allowing the researcher time to write observational notes between participants giving them more reliability.

Pre-study Checks

Each morning before the study commenced, using a checklist (Appendix V), checks were made to confirm that the study route was clear, lights were on, and wayfinding aids for the treatment group were in place. Dialogue also took place with the janitor supervisor and his assistant to appraise them of the study schedule.

Control and Treatment Group Arrival at Start Point

Each participant was collected by the researcher at the appointed time, sometimes waiting until they had finished their current activity. Paras were given their instructions by the researcher. Introductions were made to the participant by the researcher according to the script. Smalltalk was made by the researcher on the way to the start point to put participants at ease as indicated in the script, such as, “How old are you?”; “When’s your birthday?’; and, “What grade will you be in when you go back to school in September?” Before arriving at the start point the researcher’s assistant had removed yellow tape cordoning off the corridor and another assistant indicated discreetly to the researcher that the video camera was operating correctly. With smaller children the researcher knelt down to begin the script to be on a more child-friendly level.

Control Group

The aim of the study was for participants to find their way from the start point to the destination point without the presence of wayfinding aids. The method used for the control group of participants matched exactly that used for the participants in the treatment group, as described below. However, the control group participants were not given prompts to look at the wayfinding cues but were given prompts about typical characteristics/landmarks in the school corridor, as described earlier (see Appendix I).

Stage 1. Participants were taken to the start point by the researcher. The researcher reminded the participant to take notice of where they were going as they would have to lead the way on their own next time. This approach is used in the wayfinding literature (Cornell, Heth, & Broda, 1989; Helvacioğlu & Olguntűrk, 2011). The researcher then took the participant from the start point to the destination point, the Art Room, pointing out existing features in the school corridor.

Stage 1 return. Participants were then taken back to the start point via the same route. On the return, participants were reminded to look around them, reminded of cues they had previously passed, and reminded that they would be
finding their way to the Art Room next time.

Stage 2. Once the participant and researcher arrived back at the start point, the participant was immediately instructed by the researcher (using the given script) to find his/her way back to the Art Room. Verbal and physical interaction was planned by the researcher to assist the participant depending on their needs, such as telling the participant they were going the wrong way or reminding them of the task. Participants only carried out the wayfinding task once.

Installation of Wayfinding Aids

After the control group had finished, the wayfinding aids were applied in areas inaccessible to all children in school. The start of the route could be seen by some children if they passed from their classroom to an outdoor play area for recess. Only one participant in the control group was likely to have passed this route but otherwise participants had no reason to pass by this corridor. To further mitigate participants seeing the start point of the route, floor wayfinding aids and the restroom sign by the start point were only installed by the researcher's assistant just before the first participant arrived so they would not be visible from the adjoining corridor. The other floor aids were only laid after the bell had sound for start of classes in case participants from the treatment group happened to walk past and could have familiarized themselves with the corridor. The green floor aids and the large squares were laid in advance as they could not be seen from the start of the corridor. Floor wayfinding aids were removed as soon as the last day's participant had finished. Doors were recessed in the corridor and, once the colored wayfinding aids had been applied, they could not be seen from the
start of the corridor and neither could the signs.

Treatment Group

The study tested the participant's ability to find their way from the start point to the destination point, the Art Room, with the assistance of wayfinding aids. The procedure followed that exactly for the control group described above but the wayfinding scripts were different as the researcher was pointing out wayfinding aids along the route (see Appendix J).

Post-Treatment Group Removal of Wayfinding Aids

After the treatment group completed the wayfinding task, the wayfinding aids were removed. One final participant was run in the control group using the procedure already described.

Post-Study Interview/Questionnaire to Participants

After the wayfinding part of the study concluded, the researcher administered a questionnaire to the participant asking for his/her reactions to the wayfinding task (Appendix P). Interviews were conducted directly after the wayfinding task, in a spare classroom allocated for the purpose close to the start point, with a sign "Miss Julie's Interview Room" to help participants feel at ease. Two chairs were positioned next to one another at a desk so the child could avoid eye contact with the researcher. The researcher explained the questionnaire and provided a separate sheet of emojis (sad and smiley faces) for each participant to use. The researcher asked the questions and completed the questionnaire and the child was encouraged to point to the relevant emoji. The questionnaire took around five minutes to administer. The fact that the questionnaire was administered moments after the completion of the wayfinding task increased the validity of the questionnaire and gave participants the best opportunity of recalling how they felt about the wayfinding activity.

Certificates and Gifts

Using an on-line template, the researcher created individual certificates for each participant which were printed in color and laminated (see Appendix Q). Participants were handed their certificate at the end of the questionnaire process together with a University of Minnesota branded notebook and pen to thank him/her for taking part in the study.

Thanks

A few days after the study concluded, parents/guardians were sent a thank-you letter enclosing the $20 gift card referred to earlier (see Appendix R). Teachers and janitorial supervisors who had assisted with the study were also given a hand-written thank-you card and a $5 gift card (the maximum amount permitted by the SD).

Timeline

The study, an exploratory experiment, took a long time to set up to ensure protection of participants and that the methodology would be robust. The study took place during a five week ESY Summer Program. The first week was used as a settling-in period for participants to adjust to the program and become familiar with the school and routines. During the second week of the program the researcher attended the class during school hours to observe participants and so that they became familiar with the presence of the researcher. The study took place during the third and fourth weeks of the ESY Summer Program. The timeline for the study is detailed in Table 2.

Table 2

Timeline for the Study

Date	**Activity**
Summer 2015	• Meet SD personnel to discuss proposal • Meet SD ESY Summer Program administrator • Visit a school site for the ESY Summer Program to observe a class with students with ASD
Fall 2015	• Submit formal application to conduct research to SD • Revise study protocol multiple times based on SD feedback
Spring 2016	• Submit research application to IRB • Agree the school site for the study with the SD • Presentation to SD staff to outline the study • Meet the SD Buildings Supervisor to outline the study and agree materials to be applied as wayfinding aids • Meet the Head Teacher to outline the study • Meet school site janitor supervisors to outline the study and agree the available corridors • Select the study route • Select materials/suppliers for wayfinding aids • Develop data collection instruments, methods, scripts, and behavioral maps • Procure data collection recording equipment

Summer 2016	• Provide participant selection criteria to SD
	• Provide recruitment packs to SD
	• Attend parent/guardian informational meeting at study site
	• Gather physical data of the study route
	• Purchase wayfinding aids/materials
	• Recruit paraprofessional
	• Return signed consent forms to parents/guardians who had consented
	• Assign participants to groups
	• Finalize study schedule
	• Send out reminders to parents/guardians
	• Hand out reminders to teachers
	• Week 1
	  ○ Conduct class observations and reading aloud
	  ○ Set up the control route and pretest with a typically developing child
	• Week 2

<table>
<tr><td></td><td>

Conduct study with control group
Set up the treatment route and test with a typically developing youth

Week 3

Install wayfinding aids
Conduct study with the treatment group
Remove wayfinding aids
Conduct study with an additional control group participant

Gather demographic data
Purchase gifts for participants and teachers
Hand out gift cards to teachers
Send thank-you letters with gift cards to parents/guardians

</td></tr>
</table>

Budget

In 2014, the researcher was awarded a grant of $3,656 from the College of Design Graduate Program Block Fund, which was expended to support the study. The video camera hire was provided at reduced cost by a local supplier.

Data Collection Methods

Multiple types of data were collected to provide triangulation of the results which increased validity of the findings (Frankfort-Naimas & Naimas, 2010). Data collection included data mining for demographics provided by the SD, questionnaires, environmental recording instruments (light and sound meters), photographs, observations, and video and audio recordings. The contribution of each method is discussed. How the data was coded is discussed in the data analysis section.

Data Mining

The SD used the Screening Criteria previously discussed (Appendix A) to identify potential participants which included a diagnosis of ASD, their communication level, their ability to understand the researcher, and their ability to take part in the study. The SD also data mined their records to provide demographic information to the researcher (reported in Chapter 4). Parents/guardians had all given permission for the SD to provide all the information requested. Information included the participant's gender; date of birth; ethnicity; primary language; intellectual disability functioning level; visual disability; hearing disability; and motor ability.

Pre-Study Questionnaire

Parents/guardians were asked to complete a brief pre-study questionnaire to find out how familiar their child was with the school where the study took place as this could affect the results (see Appendix B). The questionnaire was included in the recruitment pack. There were five "tick box" questions asking, e.g. whether the child had attended the ESY Summer Program at the school in previous years or whether they had visited previously with a sibling. Parents/guardians could tick one or more boxes if they applied. All parents/guardians completed and returned the pre-study questionnaire.

Post-Study Interview/Questionnaire

A key part of the research study was finding out what participants felt about their wayfinding experience. It was considered beneficial to gain this feedback directly from the participants, although communication difficulties sometimes mean that they are not able to describe their experience directly to the researcher (Tufvesson &Tufvesson, 2008). A post-study questionnaire was used to determine participants' perceptions of the wayfinding task (Appendix P). The researcher conducted this in the form of an interview as participants may have had difficulty completing it themselves. Questions are generally asked to elicit the participative attitudes and opinions of the participants about the task (Frankfort-Naimas & Naimas, 2008). This is useful because it can tell us what participants felt about their experience (Frankfort-Naimas & Naimas, 2008), in this case how they felt about the wayfinding task. Qualitative, open-ended questions especially are an opportunity for respondents to provide their own answers (Babbie, 2010). Qualitative questions complemented the quantitative data collected since each method has its limitations (Sommer & Sommer, 1997). Questionnaires had been piloted on a typically developing child.

The questionnaire contained 11 questions and three supplementary questions. Of these 11, three were closed questions and eight were open questions. Some questions were on a Likert-type scale with emojis ranging from sad to smiley faces to measure participant's perceptions. Open-ended questions were analyzed and coded in a notebook. Due to the small number of participants giving generally simple responses the need for coding was minimal. The same questionnaire was administered to participants in both the control and treatment groups. All participants took part in the interview process and the researcher completed all the questionnaires. The interview sessions were audio recorded.

Observations

Observation is a key method of data collection used in scientific research to explain a phenomenon (Frankfort-Naimas & Naimas, 2010). However, observations alone can be flawed by such artifacts as experimenter bias (Frankfort-Naimas & Naimas, 2010). For example, the participant could have knowingly or unknowingly exaggerated the observations they made if they thought that is what the researcher wanted them to record (Frankfort-Naimas & Naimas, 2010). The researcher had become familiar with the participants so that she was able to directly observe them although some researchers have reported that the researcher presence can be intrusive to the participant (Creswell, 2009; Frankfort-Naimas & Naimas, 2010). Creswell (2009) also notes that children may experience difficulty gaining rapport with the researcher, which, combined with the communication difficulties typical of children with ASD, may be more pronounced.

In-class observations. It was important to acknowledge that on the day the participant took part in the study there may have been external factors that adversely affected their behavior. Changes or negative influences can confound a study (Creswell, 2009). In-class observations prior to the study gave the researcher some context and qualitative assessment as to how participants' might behave or perform during the study.

Study observations. To enable optimum observation opportunities the study was conducted during the SD ESY Summer Program when there were no other users of the study route. The researcher made observational notes on a behavioral map. Immediately after each participant had finished taking part in the study the researcher wrote up detailed notes of her observations. Observations were later triangulated with the video and audio recording.

Behavioral Mapping

Behavioral mapping is an empirical technique used by researchers in the field to record peoples' behavior (Sommer & Sommer, 2002). Behavioral mapping is particularly effective for use with children where an interview or questionnaire may be less appropriate (Sommer & Sommer, 2002). An individual-centered mapping process was used to record each participant's actions along the study route (Sommer & Sommer, 2002). Modified versions were prepared for control and treatment groups (see Appendices S and T). The physical movement of participants in the treatment and control groups was mapped on the plan by the researcher.

Video and Audio Recordings

To supplement observation and behavioral mapping techniques, a video recorder with audio facility was used during the wayfinding task. The interview/questionnaire session was recorded with an audio recorder. This enabled the researcher to triangulate the data increasing reliability and validity. Video and audio recordings provide a less intrusive method of data collection for participants (Creswell, 2009). Video recordings were obtained by the researcher wearing a body camera. Audio facility augments the video footage.

All parents/guardians had given permission for their child to be videotaped and audiotaped. The researcher recorded participants using a GoPro Silver Hero X in 1080p. Photos of the route were also taken with the GoPro with and without wayfinding aids. The researcher wore a chest strap with the GoPro attached and angled towards the participants. Originally, to preserve battery and memory card, the researcher had intended to record only the participant leading the route during Stage 2. However, whilst the first participant was silent during Stage 1, the second participant made interesting and valuable comments during Stage 1, after which the researcher decided to also record participants during this stage too. None of the children commented or appeared to notice when the researcher switched on the video recorder apart from one participant who suggested it was a spy camera. The researcher did not observe that the video intruded or affected the performance of participants.

After each participant had completed their wayfinding task the video recorder was switched off to save battery and memory and an audio recorder was switched on to record the questionnaire sessions. The audio recorder used was a Sony IC Recorder.

Time Taken to Reach the Destination

It was important to time how long it took participants in the control and treatment to reach the destination so that comparisons could be made. During the normal school day, students are expected to reach their classroom in a timely manner, which may only allow them a few minutes passing time between classes depending on school policy. For the purposes of the study, a longer period was allowed. Since no literature had been found to suggest what would be a reasonable time period for children with ASD to find their way around the built environment, it was decided that if they had not finished after a period of 20 minutes the test would be aborted. The start and end times were recorded for all participants but they did not know that they were being timed in case this put them under undue pressure, as discussed in Salmi's (2007) wayfinding study. The researcher originally intended to time each participant using a stopwatch but felt it would be another item of equipment to manage. Instead, this data was collected from the timings on the video recorder.

Environmental Recording

Baseline environmental conditions for light and sound levels were recorded using meters. Data did not correlate with the timing of participants' wayfinding task so it cannot be stated that these environmental factors directly affected the outcome but they provide a general view of the environmental conditions during the study. All data was logged on a recording sheet (Appendix U). Measurements were taken every day at mid-morning at four fixed points along the study route.

Light levels. Lighting was controlled so that the wayfinding route had the same appearance for both study groups. Lights were put on in the Media Center to highlight all the possible routes and to highlight the glazed roof area over the library counter. Lights were also put on in the corridors containing other possible routes so that lack of or evidence of light did not give participants a clue to the route. Lights were not put on in any of the classrooms (they were all unoccupied) so this did not become a visual clue since light could be visible through the vision panels. The amount of light was measured using a light meter in lux.

Sound levels. Sound levels were recorded using a simple sound level meter and measured in decibels. Any particular auditory distractions during the wayfinding task were noted in the observations. The sound levels were generally consistent, generally no ambient noise, since the study route was out of bounds to the rest of the school.

Temperature. General conditions in the study route area were noted every day according to the weather, e.g. humidity, rain, etc.

MEASUREMENT

Introduction

This study measured whether wayfinding aids installed along a school corridor influenced the ability of children with ASD to find their way to a predetermined destination with or without assistance as a measurement of independence. As a reminder, the hypotheses established were:

> **Ho.** The provision of assistive wayfinding aids in a school corridor will have no influence on the ability of children with ASD find their way from a start point to a destination point in the school environment.
>
> **Ha1.** The provision of assistive wayfinding aids in a school corridor will increase the ability of children with ASD to find their way from a start point to a destination point in the school environment with no verbal or physical assistance from the researcher.
>
> **Ha2.** The provision of assistive wayfinding aids in a school corridor will increase the ability of children with ASD to find their way from a start point to a destination point in the school environment with minimal verbal or physical assistance from the researcher.

The study also wanted to find out what children with ASD felt about their experience wayfinding along the corridors in the school environment. This exploratory study therefore used a mixed methods approach and both quantitative and qualitative data were collected and the results analyzed (Creswell, 2009). The demographic data, the environmental data collected at the start of and during the study, the observations made during the study, and the answers received from the questionnaires together measured the contribution that each of the variables made to answering the research questions.

The independent variables included in the study measured the following constructs:

- children with ASD (the persons in PE fit theory) as measured by demographic variables and
- physical environment of the corridor (the environment in the PE fit theory) as measured by the existing conditions of the corridor variables (e.g. form, materials) and the wayfinding variables (i.e. colored doors, colored shapes on the floor, and signage)

The ‘fit’ of the independent variables was measured by their interaction with each other and their influence on the dependent variables in the study, measured by the following constructs:

- Wayfinding to a destination as measured by reaching the destination and the degree of independence in reaching the destination variables

The constructs and the variables were described in Chapter 2.

After the data was collected, consideration was given to how to measure and code each variable prior to analysis (Frankfort-Naimas & Naimas, 2008). Table 3 identifies the variables, how the data were coded and analyzed, and how each variable was measured by the data collected. Further descriptions of the variables are also provided. Descriptive statistics included frequency distributions on nominal, ordinal, and ranges of variables (Frankfort-Naimas & Naimas, 2008.

Table 3

Measurement and Analysis Coding Scheme for Variables within the Study by Construct

Construct: Children with ASD			
Independent Variables	**Data Collection Method**	**Measurement Scale**	**Coding Scheme**
Gender	• Data mining SD	Nominal	Male (0), Female (1)
Age		Ordinal	Years + Months
Grade Level		Nominal	4^{th} (0), 5^{th} (1), 6^{th} (2)
Ethnicity		Nominal	White (0), Black Somali (1), South Pacific Islander (2)
Primary language		Nominal	English (0), ESL (1)
Level of ASD		Ordinal	Level 1 (0), Level 2 (1)
Intellectual/cognitive functioning	• Data mining SD	Ordinal	IQ > 85 (average), 71-85(borderline), 50-70 (mild), 35-49 (moderate)
Communication skills	• Data mining SD	Ordinal	Verbal speaks in full sentences (0), Verbal speaks in simple sentences (1)
Hearing and vision	• Data mining SD	Nominal	No hearing or vision impairment (0); hearing impairment (1), vision impairment (2)
Motor ability	• Data mining SD • Observation	Nominal	No impairment in gross motor skills (0), impairment in gross motor skills (1)

Construct: Corridor Physical Environment			
Independent Variables	**Data Collection Method**	**Measurement Scale**	**Coding Scheme**
Designated route	• Plan (tape measure)	Ordinal	Feet/inches
Colored doors	• Documentation • Photographs		
Colored shapes in the floor	• Documentation • Photographs		
Signage	• Documentation • Photographs		
Spatial Layout	• Plan (tape measure) • Elevations • Photographs	Ordinal	Feet/inches
Ceiling	• Reflected ceiling plan • Photographs	Ordinal	Feet/inches
Windows (daylight)	• Elevations • Photographs	Ordinal	Feet/inches
Views	• Documentation • Photographs		
Existing doors	• Elevations • Documentation • Photographs	Ordinal	Feet/inches
Existing floors	• Documentation • Photographs		
Material Finishes	• Documentation • Photographs		
Colors	• Documentation • Paint color swatch	Nominal	Pantone references
Patterns	• Documentation • Photographs		
Existing signage	• Elevations • Documentation • Photographs	Ordinal	Feet/inches
Display materials	• Documentation • Photographs		

Furniture and fittings	• Documentation • Photographs		
Light levels	• Light meter	Ordinal	Lux, average per day
Sound levels	• Sound meter	Ordinal	Decibels, average per day
Presence of others	• Observation • Video camera	Ordinal, least to most	No-one (0); 1 (1)
Construct: Wayfinding to a Destination			
Measurement of Influence of Variables	**Data Collection Method**	**Measurement Scale**	**Coding Scheme**
Time taken to reach the destination	• Video recorder timer	Ordinal	Minutes/seconds 2.00-2.30 (0), 2.31-3.00 (1), 3.01-3.30 (2), 3.31.4.00 (3), 4.01-4.30 (4)’ 4.31-5.00 (5)
Reaching the destination	• Observation • Video camera	Ordinal	Reached (0), did not reach (1)
Reached directly; reached indirectly	• Observation • Video camera	Ordinal	Reached directly (0), reached indirectly (1)
Interruptions (stops)	• Observation • Video camera		Not required
Degree of independence (researcher presence)	• Observation • Video camera	Ordinal	Extensive presence walks next to participant (0), close presence < 3’ (1), minimal presence > 3’- < 6’ (2) moderate presence > 6’ - < 9’ (3) maximum presence away > 9’ - < 12’ (4)

Degree of assistance verbal to wayfinding task	• Observation • Video camera audio • Video camera	Ordinal	No verbal prompts (0), minimal verbal prompts 1-5 (1)
Degree of assistance verbal to keep on task	• Observation • Video camera audio • Video camera	Ordinal	No verbal prompts (0), minimal verbal prompts 1-5 (1), frequent verbal prompts 6-10 (2)
Degree of assistance physical (touch)	• Observation • Video camera	Ordinal	None provided
Use of colored doors	• Observation • Audio recordings • Q7-Q10 PSIQ		Ranges selected once data had been collected
Use of colored shapes on the floor	• Observation • Audio recordings • Q7-Q10 PSIQ		Ranges selected once data had been collected
Use of signage	• Observation • Audio recordings • Q7-Q10 PSIQ		Ranges selected once data had been collected
Intellectual/cognitive functioning	• Q7-Q10, Q12 PSIQ	Ordinal	Ranges selected once data had been collected
Social, emotional, and behavioral functioning	• Q1-Q2, Q6, Q11 PSIQ	Ordinal	Least-most (very unhappy-very happy)
	• Q3-Q5 PSIQ	Closed question	Yes/No
	• Q3-Q6, Q11 follow up PSIQ	Open question	Ranges selected once data had been collected

Note. PSIQ = post-study interview/questionnaire to participants

Time Taken to Reach the Destination

The time taken to reach the destination point was important as a measure of whether there was a difference in the speed that participants in the treatment group found their way with the wayfinding aids compared to participants in the control group without the wayfinding aids. In a school situation children would need to find their way as quickly as possible from room to room during passing times. This data was collected from the timer on the video recorder.

Reaching the Destination

The success or failure of reaching the destination could be narrowly measured as whether participants in both groups found their way from the start point to the destination point or whether they failed to find their way. However, there were also other factors to consider, such as whether the participant reached the destination point directly or indirectly. For example, they could reach a destination, realize it was the wrong destination point, but continue on to find the correct destination. Similarly, they could take a wrong turn, be prompted that they were going the wrong way, turn around and find their way to the destination point. The ability to reach the destination (or not) and the route the participant took to reach the destination were recorded by the researcher on the behavioral map.

The researcher recorded whether the participant found his/her way directly from the start point to the destination point; whether the destination was reached indirectly, e.g. after taking a wrong turn; or whether the destination was not reached, e.g. the participant got lost, stopped during the task, or gave up out of frustration. Collecting these patterns of behaviors provided valuable data.

Degree of Independence

One of the aims of using interventions with children with ASD is for them to become more independent (Earles-Vollrath et al., 2008). This study tested whether assistive wayfinding aids enabled participants in the treatment group to reach the destination point with minimal assistance from the researcher. Participants in the control group were tested to find out whether they reach the destination with minimal assistance from the researcher without the use of assistive wayfinding aids. Minimal assistance included the presence of the researcher, verbal prompts, and physical prompts. The use and frequency of any of these forms of assistance was documented. The term “minimal assistance” to convey independence is used in recognition that the researcher was present to observe/record. Also, some children with ASD will still need a measure of assistance with navigation, such as having a teacher or para close at hand, to ensure they do not endanger themselves or others, or simply wander off (Nguyen, 2009). Independence was documented as combinations of types of assistance as defined below.

Presence of the researcher. The presence of the researcher was noted on the behavioral maps. Since the degree of presence could vary throughout the study, measures were taken at several strategic points along the route as indicated on the behavioral map. This data was later correlated with the video recording.

Verbal prompts. The researcher anticipated the need to provide verbal prompts to participants to keep them on task and in case they had difficulty finding the way. The number of times the researcher provided verbal prompts to each participant was noted on the behavioral map and confirmed by the audio recording.

Physical prompts. The researcher anticipated the need to provide physical prompts to participants to keep them on task and in case they had difficulty finding the way. Physical prompts would be documented as the researcher using gestures (pointing) or touching the participant on the arm, hand, or shoulder. The number of times and the type of physical prompts the researcher provided to each participant would be recorded, however, no physical prompts were administered during the study.

Use of Wayfinding Aids or Environmental Cues

The researcher recorded how many times the participant in the treatment group used each wayfinding aid to find his/her way to the destination point, i.e. Stage 2 of the study, i.e. when the child was leading the way. In the control group the researcher recorded how many times the participant used a particular cue in the environment. Using a wayfinding aid or an environmental cue was defined as the participant verbally referring to the aid, i.e. colored doors, colored shapes on the floor, and signage. This data was gathered from the video audio recording.

Perception of the Wayfinding Experience/Task

Participant's opinion was sought about how they felt about the wayfinding task using the post-study interview/questionnaire (PSIQ) (Appendix P). Questions 1-2, 6 and 11 asked participants how they felt about finding their way to the Art Room on their own and with the researcher leading, rated on a Likert-type scale of 1-5 by emojis showing "very unhappy" to "very happy" faces. Questions 6 and 11 had a follow-up question asking why the participant felt like that. The participant's opinion was also sought as to whether they found finding the destination point on their own scary, or difficult, or easy (Q3-Q5). These were closed questions yes or no with follow-up open questions asking why if they answered yes. Participants were also asked what they could remember about the wayfinding route. Specifically what three things they could remember seeing (Q7), and any color, shapes, or signs they could remember seeing (Q8-Q10). For questions 8-10 follow-up questions were asked if the answer was yes. Question 11 was an open question designed to obtain participant's general opinion of how they felt when they are wayfinding somewhere unfamiliar. Question 12 asked participants what the main thing was that they remembered seeing.

Questions can be divided into those which tested intellectual or cognitive functioning Q7-12, e.g. "What three things can you remember seeing?", and those which tested social, emotional, and behavioral functioning Q1-6 and Q11, e.g. "How did you feel about finding the room when you were leading?" These answers were interpreted by qualitative assessment of the questionnaires. Babbie (2010) recommends being flexible in interpretation of questionnaires which may redirect the approach in the analysis phase as there may be unexpected data collected from the questionnaires.

Presence of Others

The presence of others using the corridor was documented by the researcher as this may have caused an effect. This was measured by observation in ordinal least to most.

Data Analysis

Data Analysis Techniques

Analysis techniques were chosen as appropriate to the data collected and measurement techniques; both descriptive and inferential statistical analyses were conducted. Quantitative and qualitative analysis was conducted with the data collected. Statistical operations were related to the level of measurement (Babbie, 2010). In common with social science research, the statistical standard used to reject the null hypotheses was $p < .05$. Measurement techniques are described on the next chapter. A model showing the interaction of variables and how they are being measured is shown in Figure 10.

Children with ASD Variables

Descriptive statistics were produced to provide demographic information about participants, including their gender (nominal); age (range); ethnicity (nominal); primary language (nominal); intellectual/cognitive functioning level (ordinal); communication skills (ordinal); hearing and vision ability (nominal), and motor ability (nominal). Qualitative description and data analysis also provided information about participants' perceptions about the wayfinding experience.

Corridor Physical Environment Variables

Plans, elevations, annotations on drawings, and photographs described the experimental space. Qualitative annotations and photographs described materials and finishes, colors, light fixtures, doors, signage (existing), and visual distractions. Presence of others using the corridor was measured by observation.

Wayfinding to a Destination Measurement of Influence of Variables

Data from observations of participants' behavior was measured as summarized:

- Time taken to reach the destination
- Success of reaching the destination
- Route taken: direct; indirect
- Degree of researcher presence (distance)
- Number of verbal prompts
- Number of physical prompts
- Number of times each wayfinding aid is used (verbally referred to)

The success of reaching the destination was measured by whether the participants reached the destination, whether they reached it directly, and the time it took them to reach the destination. The degree of independence of reaching the destination was measured by the presence of the researcher and by the number of verbal and physical prompts. In addition, the frequency of use of each of the wayfinding aids was measured by observation and by analysis of the video recording. Qualitative assessment of the PSIQ to participants also measured what they remembered of the wayfinding task.

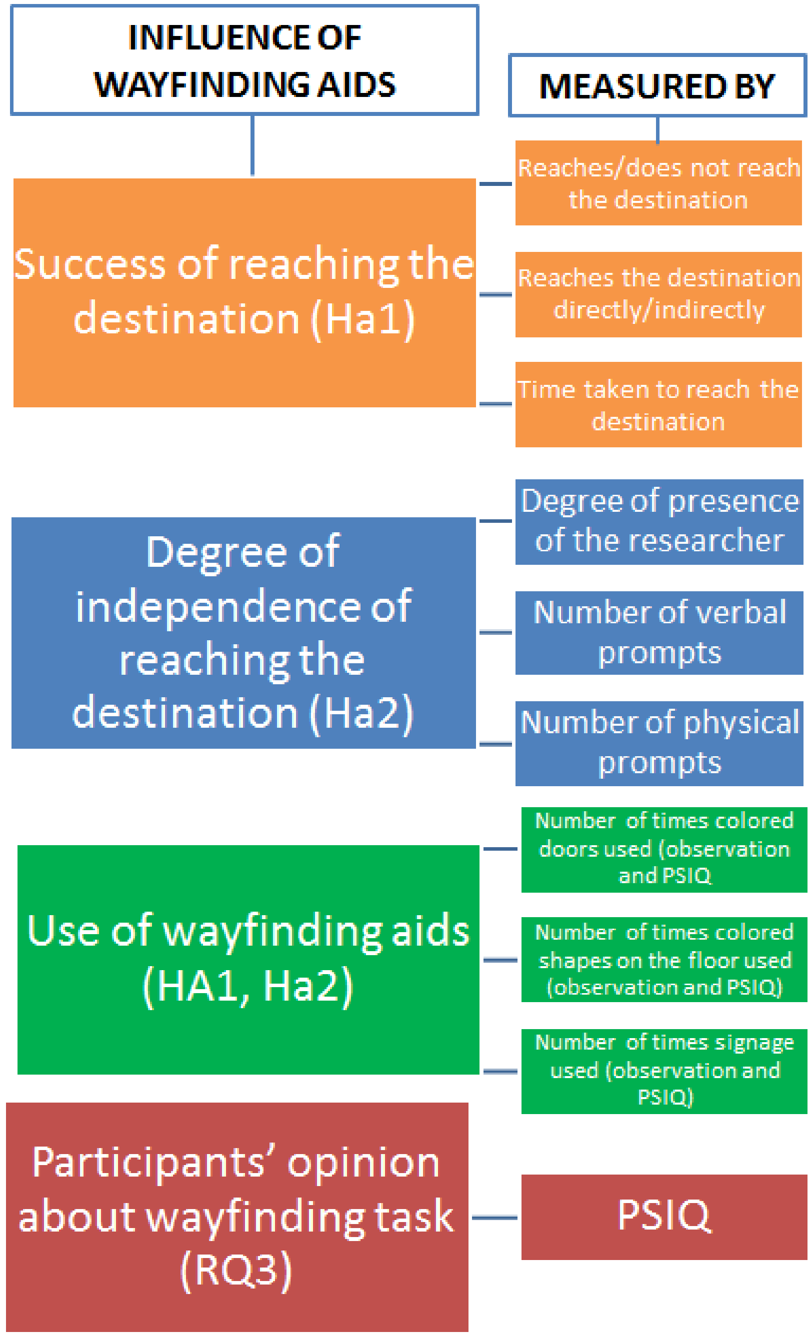

Figure 10. Model of interaction of variables and how they are measured.

Limitations

There is a lack of research into the design of the educational environment for children with ASD, which a number of authors have drawn attention to (Castell, 2008; Martin, 2014; Salmi, 2007; Sanchez et al., 2011; Shabha & Gaines, 2011; Vázquez & Torres, 2013). This research attempted to fill that gap by conducting an exploratory experiment. This experiment took place in a real life setting rather than under a controlled laboratory condition. This enabled the researcher to observe the participants first-hand in the natural course of their day so that the study is realistic (Frankfort-Naimas & Naimas, 2008). Participants were randomly assigned, increasing the validity of the study (Frankfort-Naimas & Naimas, 2008).

However, there are study limitations when working with vulnerable populations in a live setting. These limitations included small sample size, the fact that several wayfinding aids were applied simultaneously, the possible prior knowledge of participants of the wayfinding task route, the use of a convenience sample, and time order. These issues are discussed below.

The study had a small sample of nine participants which means the findings cannot be generalized to the population of children with ASD. This study used a treatment group to find out whether participants found their way from a start point to a destination point along a school corridor using a variety of wayfinding aids. In a normal experimental situation, each wayfinding aid would be applied individually as a treatment so that the researcher could find out which individual aid, if any, were supportive for children with ASD to find their way to the destination. However, logistics related to planning, access to participants, and finding a sufficient number of participants to test each aid individually was not possible. A combination of wayfinding aids produces less clear results, but the combination of aids allowed participants the ability to use a preferred aid that may suit the spectral nature of ASD.

One of the issues in experimental wayfinding is to ensure that the participants are not familiar with the route and have not memorized it. For this reason participants were selected who did not attend the school during the normal school year (apart from one participant in the treatment group previously referred to). This ensured that participants did not have prior opportunity to navigate along the designated route of the wayfinding study and memorize it. One participant in the control group had previously visited the school but is not likely to have travelled the study route. The selection criteria also had the effect of limiting the number of participants.

Time order can be considered a limitation of a study (Frankfort-Naimas & Naimas, 2008). In this study, the tests for treatment and control groups could obviously not be carried out simultaneously but since no participant had access to the study route prior to the wayfinding task it had no effect. Since the study spanned two weeks, it is possible that participant's performance was affected by which day they took part in the study due to extrinsic factors.

Despite the potential limitations stated above, the study used a mixed methods approach to triangulate data and avoid researcher bias such as data mining, questionnaires, observation, and video and audio recordings. Any additional limitations found post-study will be reported in Chapter 5.

Summary

The research methods used to find out whether assistive wayfinding aids helped children with ASD to navigate the corridors in the school environment have been described. The research hypotheses are based on the PE fit theory that if a person is well-matched to their environment it can have a positive effect on them. In this study, the environment was made more suitable by providing wayfinding cues, including colored doors, colored shapes on the floor, and signage. These cues may have had an effect on the ability of children with ASD to wayfind. This research is important because if it can be shown that wayfinding aids can assist children with ASD then schools would have preliminary evidence as to the benefit of installing wayfinding aids. If it can be demonstrated that children can navigate with more independence there are implications in that some of the time spent by a para escorting children with ASD around the school could be reduced. Chapter 4 describes the data collected, how they were analyzed, and the findings of the study.

CHAPTER 4: FINDINGS

Introduction

This chapter reports the findings of this exploratory study examining whether assistive wayfinding aids helped children with ASD to navigate the school environment. Data collected included observations, behavioral mapping, video and audio recordings, completed interview/questionnaires, and data mining. After the data was collected it was coded. Coding is the process of generating themes from participants' descriptions, creating narrative information about participants and their actions (Creswell, 2013). The chapter begins by reporting environmental characteristics and continues by reporting demographic characteristics and findings of the variables concerned with wayfinding to a destination. Finally, an individual case study report is provided on each of the participants.

Environmental Characteristics

A survey was undertaken to record the existing environmental conditions along the study route. Although the existing environment was not controlled it was important to document the conditions to inform future studies. Existing conditions are described including spatial layout, ceiling, windows, doors, floors, signage, notices and posters, furniture, colors and materials, and lighting. Environmental conditions at the time of the study are also provided.

Location

The study site was at an elementary school in the Midwest US. The school was a typical single storey building housing 1300 children from kindergarten to 5th grade.

Kindergarten and lower grades were located in one particular area of the school and higher grades were located in another area.

Spatial Layout

The main hallways measured approx. 12′-6″ wide reduced to 10′-5″ where lockers were positioned on either side of the hallway. The music room hallway was measured 12′-3″ reduced to 10′-2″ where one bank of lockers was located on one side. In the Media Center the corridor width was reduced to 7′-6″ and there were no lockers. The ceiling height throughout was approx. 8′-10″.

Ceiling

Ceilings throughout the study route were suspended ceilings, white acoustic tiles in a white lay-in exposed grid frame. Ceiling tiles measured 2′ x 2′. Above the library counter there was an elaborate lightwell enhanced by strip lighting which was lit during the study.

Windows

All of the corridors in the study were on internal routes so there were no windows in the space. In the red corridor proceeding to the green corridor there was a set of glazed doors ahead and to the left that led to an exterior vestibule but no views were visible from the route and the doors were not in use during the study period.

Doors

Doors were generally the same style throughout the study site, being finished in a plastic laminate and pink in color. Average door size was 34″ w. x 82″ h. Classroom doors all had rectangular vision panels. Other doors varied, e.g. the Audio Visual

Room's doors had no vision panel but a glazed screen beside them, the music suite doors had square vision panels, and the ″no entry" doors into the courtyards had no vision panels. Double doors leading in and out of the Media Center were in the same pink plastic laminate color with vision panels and panic push bar hardware on the inside of the doors. The only doors noticeably different were a pair of aluminium frame glass doors at the start of the green corridor which were held open during the normal school day and which therefore remained open during the study. They were not referred to in the script and no participant referred to them. Often classroom doors were arranged in pairs, with opposite left hand and right hand opening hands.

Doors had satin anodized aluminum hardware, including kickplates, butt hinges, key holes, and some had handles. Several doors had exposed door closers where doors opened outwards. Doors were surrounded by timber door frames painted blue in the main corridors and pale pink in the Media Center. There were 23 single doors and 2 sets of double doors along the study route. 21 doors had wayfinding aids applied to the face; only 2 doors in the Media center were retained in their original material/color for both control and treatment groups. Double doors had wayfinding aids applied to both faces as they could be seen on the return journey when the researcher
led the way back, the same color to both faces.

Floors

All the floors in the corridors were finished in the same vinyl tile material. The floor was beige with flecks of beige color. There were existing blue squares in the floor formed of blue vinyl tiles measuring 2′ x 2′ overall formed of four vinyl tiles set 8′ apart from edge to edge. At junctions of major doorways, e.g. into the Media Center, there was a large blue square 6′ x 6′ comprised of 36 blue tiles, surrounded by four pink triangles made of pink vinyl floor tiles so that they could be perceived as a diamond. The whole shape measured 8′-6″ x 8′-6″. The blue and pink vinyl was also composed of a background color with flecks of color over the background but the overall impression was blue or pink. Along the sides of the corridors there was an edge skirting of blue vinyl in the main corridors and pink in the Media Center corridors approx. 4″ wide. Wayfinding aids were applied over the existing blue squares with the exception of the Media Center where circles were applied over the squares.

Signage

Signage was located throughout the study route of uniform appearance. Typical signs were 8″ w. x 6 ½″ h. x ½″ d. The bases of the signs were positioned 4′-9″ from finished floor level. Signs were plastic material in dark red color (Pantone 19-1762) with white lettering (see Figure X). Lettering was raised text with Braille underneath, in compliance with ADA regulations. Text was all in upper case. Most doors were assigned a door number which featured prominently at the top left hand corner. Some doors had teachers' names printed or written underneath. Signs were proprietary framed and mounted. In addition to the wayfinding signage, there were a number of illuminated fire exit signs located along the route at ceiling height. Again, these were not referred to in the scripts and no participant referred to them.

Display Materials

Throughout the study route there were a number of existing notices, posters, and pictures which were retained during the study to resemble as much as possible a normal school in use. Items ranged from pictures that teachers had applied to the doors (retained for the control group but not visible to the treatment group since the door wayfinding aids covered them); pictures applied behind or on the face of the vision panels; and pictures or posters that teachers had put up near the doors. In the corridors, there were a number of framed pictures at various locations (see photographs Appendix H).

There were also a variety of posters in the Media Center. For example, on the first part of the corridor there was a poster about the solar system and another about fish. In the second part of the corridor past the library counter there was a large poster "reading is magic." This was opposite two US flags. The flags flanked an information poster about the US presidents. There were also a number of smaller framed certificates and notices, including a three dimensional raised emblem. It was interesting to note the small details that some of the participants noticed on the posters during the study. The location of major posters and notices are shown on photographs (Appendix H).

Furniture

The notable furniture in the main corridors was banks of lockers with sloping tops 5′-4″ at the highest point and 12″ deep. There lockers were generally on either side of the corridors. Lockers were metal finished in a blue paint Pantone 17-4030. The other prominent items of furniture were two glazed display cabinets in a light oak finish positioned either side of the exit doors from the Media Center into the red corridor. Display cabinets were empty, having been cleared out prior to the summer recess. While these display cabinets seemed noticeable none of the participants seemed to notice them and none referred to them. The researcher did not refer to them in the scripts. One other notable feature was a fire hydrant at the entrance to the Media Center but again this feature was not referred to in the scripts and was not mentioned by any of the participants.

Walking through the Media Center, a variety of bookshelves, chairs, and tables could be seen. Some shelving was wrapped in protective plastic film. In some areas, chairs were stacked on top of tables, again for cleaning purposes. Although the Media Center would not normally have looked like this during the school year the appearance was the same for all participants. The library counter was a fixed feature in the Media Center that was pointed out as a landmark feature to participants in both groups. The location of furniture is indicated on the plan (see Appendix D). On occasions, cleaning equipment could be seen in the restroom off the corridor route.

Colors and Materials

The overall impression of the main corridors was that they were beige from the walls and floors with blue from the lockers and door frames and pink from the doors. This color scheme was predominant throughout the study site. Walls in the main corridors were clad in a concrete tile 7″ x 7″, a beige/brown color. In the Media Center walls appeared whiter as they were finished in an off-white linen effect texture, doors and door frames were pink, so there was less predominance of blue. Colors were identified with Pantone colors (Eiseman & Herbert, 1990) as indicated below. However, note that these colors were selected by eye not by some scientific method so they act as a guide to the color only. Also, since the flooring was a plain background overlaid with flecks of color the background color only as the overall impression is provided not colors of individual flecks. Floors and doors were smooth texture.

- Floor colors: Beige base 12-0000, fleck 13-1007

  Blue base 15-4008

  Pink base 15-1614

- Doors: Pink laminate 16-1712

  Blue door frame 17-4111

  Pink door frame 15-1607

- Walls: Main corridors: 15-1215

  Media Center 11-0603

Lighting

Luminaires ran down the center of the ceiling composed of fluorescent lamps covered with Perspex lighting baffles approx. 10′ x 4′. Lighting baffles appeared slightly discolored with a yellow light. Additional lights were put on above the library counter to highlight this as a feature.

Environmental Conditions

Daily checks were made of the environmental conditions along the study route at approximately the same time each day to check whether conditions were the same for each participant. Environmental data included light (amount of illumination) and sound. Data was collected at specific points along the study route (see Appendix U). Since the study route consisted of internal corridors and there were no windows with daylight issues to affect the lighting, light readings were consistent throughout the study. A point to note is that the lighting levels in the corridors were generally uniform except the light level outside the three music room doors was lower as there were no hallway lights nearby. This was the same for all participants. Regarding the sound levels, again data was consistent throughout the study, as might be expected since no other people were using the area.

The study took place during the summer at a time of consistently hot weather but because the study route was internal the observed temperature appeared consistent throughout. In short environmental conditions, particularly light and sound levels, which can adversely affect children with ASD, were consistent to participants throughout the study.

Demographic Characteristics

Demographic data was provided to the researcher by the SD in accordance with parental consent. All parents/guardians agreed to release the data (collated in Table 4).

Table 4

Demographic Characteristics

	Participants *n=9*		
Gender	Male	Female	
Control Group	4	0	
Treatment Group	3	2	
Age	8 < 9 years	9 < 10 years	10 < 11 years
Control Group	2	1	1
Treatment Group	2	2	1
Current grade	Gr 2	Gr 3	Gr 4
Control Group	2	1	1
Treatment Group	2	2	1
Ethnicity	White	Black	Asian Pacific Islander
Control Group	3	0	1
Treatment Group	4	1	0
Primary language	English	Non English	
Control Group	4	0	
Treatment Group	5	0	
ASD Disability	Level 1	Level 2	
Control Group	4	0	
Treatment Group	5	0	
Communication skills	Communicates in full sentences	Communicates in simple words	
Control Group	4	0	
Treatment Group	5	0	
Other recorded disability	None	Impairment in fine motor skills	
Control Group	4	0	
Treatment Group	4	1	
Observed disability	None	Ambulatory difficulty	
Control Group	4	0	
Treatment Group	2	3	

Nine participants took part in the study, seven male and two female. Since this exploratory study was set up as an experiment it was important that participants were randomly assigned to control and treatment groups. Four participants were assigned to the control group and five assigned to the treatment group. The control group consisted only of males but there were two females and three males in the treatment group. The average age of participants was 9 years 3 months. Four participants were aged 8, three were aged 9, and two were aged 10. Ages corresponded to grade level in that the same four were in Grade 2, three were in Grade 3, and two were in Grade 4; grade was based on the grade the participants were in in the previous semester. Five participants identified their ethnicity as white, one as black, and one as an Asian Pacific Islander. All participants spoke English as their primary language. All had a diagnosis of ASD Level 1. Regarding communication abilities, all participants were able to speak in full sentences. One participant was noted as receiving support during the school year for fine motor skills. In addition, three participants in the treatment group, one male and two females, were observed by the researcher to have difficulty in walking, although not recorded as a disability on the demographic information provided by the SD. This had an effect on the speed with which they carried out the wayfinding task. All participants accompanied the researcher and all completed the study.

Familiarity with the Study Site

Prior to the study, all parents/guardians were asked to complete a pre-study questionnaire to find out how familiar their child was with the study site. All parents/guardians completed the questionnaire. Results of the Pre-Study Questionnaire can be found in Table 5.

Table 5

Familiarity with the Study Site

Familiarity	Control Group	Treatment Group
Never visited	1	2
Visited occasionally	0	0
Visited 3 or more times	0	0
Visited 5 or more times	1	1
Attended previous ESY	2	2

Three participants had never visited the school before so were unfamiliar with it. Four participants had attended the school in a previous ESY Summer Program. They would thus have been familiar with the school but they would not have been familiar with the study route since it was in an area inaccessible to children and staff during the Summer Program period to allow janitors to deep clean the area. Two participants had visited the school on five or more occasions, one of whom attended the school during the regular school year and had been inadvertently selected as meeting the criteria for the study by the SD. Her regular classroom was located in a different area of the school from the study site; her case will be discussed later.

Wayfinding to a Destination

During the method phase various categories were identified that would be taken to measure the influence of variables on the construct, i.e., wayfinding to a destination. After the data had been collected some of the coding schemes for the measurements needed to be revised; some metrics were not required; some new categories had to be added; and some had to be re-categorized to make sense of. Each of the measurements is discussed in turn as it relates to the research questions followed by an analysis of confidence intervals for these data. Given the small amount of data collected, professional advice was sought from the University's Statistical Consulting Unit as to the most appropriate and valid statistical analyses. Table 6 shows the overall results as they relate to the measurement variables which are discussed in turn. In common with statistical analyses we have rejected the null when the p-value is less than 0.05 (or 5%).

Table 6

Results Related to the Measurement Variables

ID	Group	Reached	Direct	Time (mins/secs)	Distance (feet)	Verbal prompts	Number reminders
Alex	Control	Yes	Yes	3.28	6.57	Yes	0
Brad	Control	Yes	No	2.57	8.88	Yes	0
Corey	Control	Yes	Yes	2.52	6.33	Yes	0
Danny	Treatment	Yes	Yes	3.53	6.88	Yes	0
Edward	Treatment	Yes	Yes	2.46	7.33	Yes	1-5
Freya	Treatment	Yes	Yes	3.43	4.77	Yes	0
Gemma	Treatment	Yes	Yes	4.46	6.22	Yes	6-10
Harry	Treatment	Yes	Yes	2.58	7.33	No	0
Ian	Control	Yes	Yes	2.21	5.44	Yes	0

Key:
Reached: reaches the destination or not
Direct: reaches the destination directly or not
Time: time taken to reach the destination
Distance: average distance from the researcher
Verbal prompts: accomplished without verbal prompts
Number reminders: number of verbal reminders administered to keep on task

To recap, the alternative hypothesis was that the provision of wayfinding aids would increase the ability of children with ASD to find their way from a start point to a destination point in the school environment with no verbal or physical assistance from the researcher or, alternatively, with minimal verbal or physical assistance from the researcher. Success of reaching the destination was defined as whether the child reached it or not, whether they reached it directly or not, and how long it took them to reach.

Success of Reaching the Destination

One of the measures of success of the wayfinding aids was whether they enabled participants in the treatment group to find their way more frequently than participants in the control group. The success of reaching the destination was measured in terms of whether the participant reached the Art Room or not (Table 7). It was further defined as whether the participant reached it directly, i.e., straight away or first time, or not, i.e., indirectly, such as went somewhere else first.

Table 7

Reaches the Destination

Reaches the Destination	Control Group	Treatment Group
Yes	4	5
No	0	0

All participants successfully reached the destination point whether with or without wayfinding aids. No statistical analysis was carried out on this metric as 100% completed the task. Although this means statistically that the first research question was not found, the assistive wayfinding aids did not help the participants in the treatment group to find their way more frequently than participants in the control group, from the qualitative data collected, as reported further in this chapter, we could not say that the wayfinding aids had no influence on children in the treatment group. In fact, the wayfinding aids influenced some participants in the treatment group so that they followed the aids at Stage 1 before the researcher had pointed them out in the script. What this data probably indicates is that children with ASD, when given detailed wayfinding instruction and wayfinding strategies, can find their way from a set start point to a given destination in a school corridor with and without wayfinding aids.

Reaching the Destination Directly or Indirectly

The second measure of success was whether the participants reached the destination directly or indirectly (see Table 8).

Table 8

Reaches the Destination Directly or Indirectly

Reaches the Destination In/Directly	Control Group	Treatment Group
Directly	3	5
Indirectly	1	0

Only one participant, in the control group, did not reach the destination directly. From this we could say that one out of every nine participants reaches the destination point indirectly if there were no difference between them. This result supports the hypothesis that wayfinding aids increase the ability of children with ASD to find a destination point directly as a measure of increased success. The participant who selected the wrong room realized his mistake and went on to find the correct room. In mitigation, the room he erroneously selected was in the same orientation as the Art Room but in the corridor before it. The participant was also one who found it difficult to concentrate and was taking in a lot of sensory information from the environment so this could also account for his error.

Time Taken to Reach the Destination

The time taken to reach the destination was important to find out if one group took longer than the other to find the destination. It was anticipated that participants in the treatment group would find their may more quickly that participants in the control group because of the cognitive support and confidence provided by the wayfinding aids. It was also expected that participants overall would take longer to find the destination than they actually did so the ranges were revised to suit (Table 9). A scatter plot shows this information graphically (Figure 11).

Table 9

Time Taken to Reach the Destination

Minutes/seconds	Control Group	Treatment Group
2.00-2.30	1	0
2.31-3.00	2	2
3.01-3.30	1	0
3.31-4.00	0	2
4.41-4.30	0	0
4.31-5.00	0	1

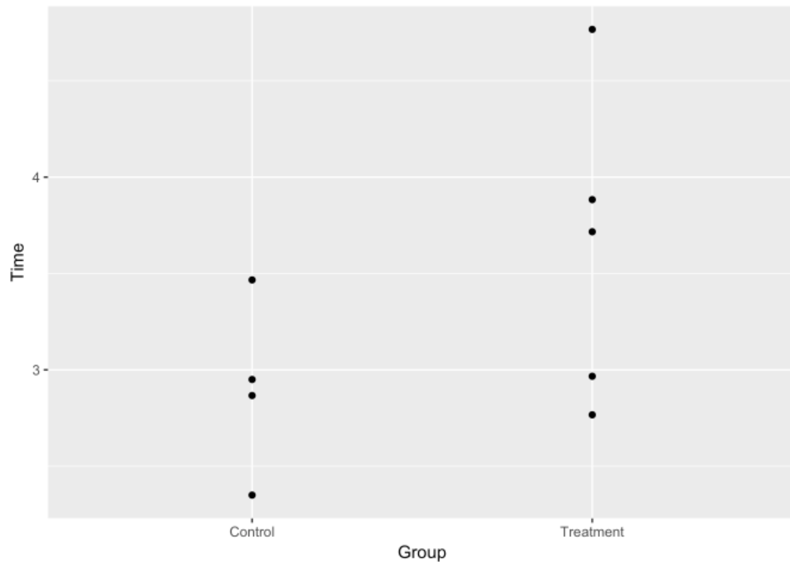

Figure 11. Scatter Plot of Time Taken to Reach the Destination

The fastest time was by a participant in the control group who was also the oldest participant so had advantages of experience and maturity. The slowest participant, in the treatment group, took twice as long as the fastest participant, in the control group. The three slowest times were participants in the treatment group who were noted to have ambulatory difficulties. Of these, the slowest participant was the one who continually interrupted the researcher to talk about other topics and she also made frequent complaints that her feet were tired. The next slowest participant was the one who stopped to call off and point to every sign along the treatment route. These intrinsic factors make the data seem less valid but they are likely indicative of actual performance in a school. Some children with ASD will have an accompanying ambulatory difficulty and walk more slowly and some children will become easily distracted by the environment and therefore take more time. These are characteristics common in this population as noted in the literature review.

To look for differences in time between the two groups, we performed independent t-tests using unequal variance and reported p-values and 95% confidence intervals.

Table 10

Time Differences Between Control and Treatment Groups

	Difference	Control	Treatment	p.value	Conf.low	Conf.high
Time	-0.71	2.91	3.62	0.14	-1.73	0.31

We might have expected the treatment group to perform better, i.e., to reach the destination point more quickly with the aid of wayfinding aids. At 14% the difference is not small enough to err in favor of the alternative hypotheses. However, these figures need to be treated with caution because the time was affected by other factors discussed, e.g. ambulatory difficulty and distractions.

Degree of Independence

One of the aims of the study was to find out whether children with ASD could wayfind to a destination with no assistance or with minimal assistance. Minimal assistance was defined as the presence of the researcher, i.e., the proximity of the participant to the researcher during the study, and the number of verbal and/or physical prompts that the researcher needed to provide to the participant. After the data was collected and analyzed the category of physical assistance was not required since no participant required this type of assistance. An additional category was added, that of the number of reminders participants required to keep them on task. This probably tells us more about the behavior of children with ASD as participants: in the general population the frequency of prompts required to keep on task is likely to be less.

Distance from the researcher. The distance that participants walked away from the researcher was collected from data on the behavioral maps correlated with the videotapes. This measurement was more difficult to measure than anticipated because the route passed through two sets of doors and at these points participants usually paused and held the door open for the researcher. One measurement point had to be discarded for this reason. The distance that the participants were away from the researcher was therefore noted at nine points on the plan and the tenth point, the exit doors to the Media Center which participants held open for the researcher, was discarded. The remaining nine data points taken for each participant were calculated at an average distance (Table 11). Figure 12 shows graphically the average distance that

participants were from the researcher as a measure of independence.

Table 11

Distance from the Researcher

Average Distance	Control Group	Treatment Group
Walks next to	0	0
< 3′	0	0
3′ - <6′	2	1
6′- <9′	2	4
9′- <12′	0	0

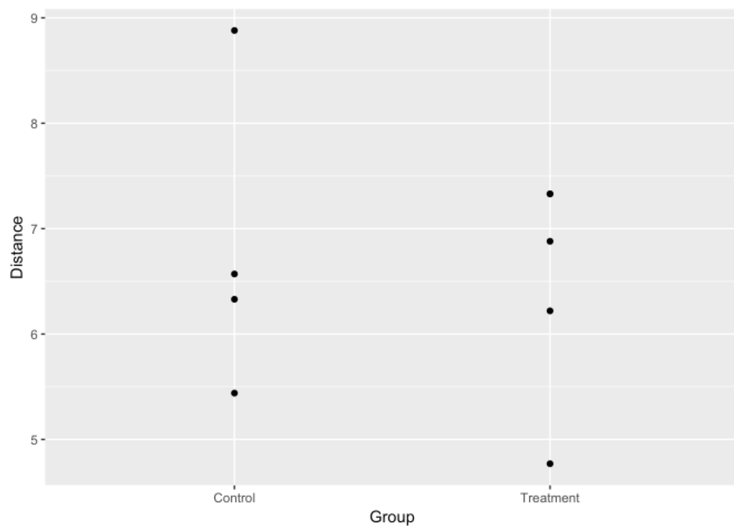

Figure 12. Scatter Plot Showing Average Distance from the Researcher

All participants walked next to the researcher was between 3′ and 9′ which averaged out at 6′-6″ overall. The participant who walked closest to the researcher, at an average of 4′-9″, was Freya in the treatment group, perhaps understandably since she was known to have anxiety about finding her way around. Brad was the participant, in the control group, who went furthest from the researcher than anyone else, an average of 8′-9″, perhaps indicative of his stated sense of adventure and exploration.

To look for differences in distance between the two groups, we performed independent t-tests using unequal variance and reported p-values and 95% confidence intervals (Table 12).

Table 12

Distance Differences Between Control and Treatment Groups

	Difference	Control	Treatment	p.value	Conf.low	Conf.high
Distance	0.30	6.81	6.51	0.75	-1.91	2.50

We might have expected participants in the treatment group to feel more confident using the wayfinding aids and hence walk further away from the researcher. However, the difference of 75% was not statistically significant so we cannot reject the null. In other words, the wayfinding aids did not increase the ability of participants to be more independent of the researcher. However, these figures need to be treated with caution as there were a number of factors affecting the data. The distance was affected by the personality traits and confidence levels of the individual participants as to how comfortable they were leaving the researcher. Participants also stopped to open doors for the researcher and to point out features along the route. There also seemed to be an optimum distance away from the researcher that participants in both groups felt comfortable with that none exceeded, perhaps because they knew they were being accompanied. An alternative method in a future study would be to ask the participants to perform Stage 2 of the wayfinding task without the researcher following and using fixed cameras to record their movements. However, in that case, the rich qualitative data would be lost.

Verbal prompts to task. This measure formed part of the second alternative hypothesis, whether the provision of wayfinding aids would increase the ability of children with ASD to find their way from a start point to a destination point with *minimal* verbal assistance. It had been anticipated that some participants in both groups would need a number of verbal and/or physical prompts to help them find the way. The number of participants who required verbal prompts to find the Art Room is shown in Table 13.

Table 13

Participants Requiring Verbal Prompts to Task

Verbal Prompts	Control Group	Treatment Group
Prompt to find Art Room	0	1
No prompt to find Art Room	4	4

Only one participant, in the treatment group, sought reassurance from the researcher that he was going the correct way near the end of the task and she confirmed the route direction. The participant went on to accomplish the task. It was surprising that a participant in the treatment group needed a reminder rather than a participant in the control group.

Verbal reminders to keep on task. This category was selected after the data had been collected and analyzed (see Table 14). Distractions in the environment had a significant effect on the performance of some of the participants since it caused them to take more time finding their way. This variable had not been anticipated and may not be required in the general population.

Table 14

Participants Requiring Verbal Reminders to Keep on Task

Reminders	Control Group	Treatment Group
Reminder to keep on task	0	2
No reminder to keep on task	4	3

Two participants in the treatment group needed reminders to keep them on task. One participant needed reminding eight times to keep her on task. These results may indicate that some children with ASD may not be able to accomplish the task of wayfinding independently as they would simply become distracted and forget what they should be doing.

Physical prompts. The researcher did not need to provide any physical prompts so this category was excluded as a measure but could be required in a larger sample. Overall this indicates that children with this level of ASD may not need any physical prompts to find their way around.

Confidence Intervals

To assess the percent of participants that accomplished the wayfinding task in a certain way, we computed 95% confidence intervals for the percent of each group using the Agresti-Coull method because some of the values were near or equal to 100% (Table 15). In this table, x is the number that did accomplish it, n is the total that attempted it.

Table 15

Confidence Intervals

task	group	x	n	percent	lower	upper
reached	control	4	4	100	45.4	100.0
reached	treatment	5	5	100	51.1	100.0
direct	control	3	4	75	28.9	96.6
direct	treatment	5	5	100	51.1	100.0
verbal prompts	control	4	4	100	45.4	100.0
verbal prompts	treatment	4	5	80	36.0	98.0
reminders	control	4	4	100	45.4	100.0
reminders	treatment	3	5	60	22.9	88.4

From this data we can reasonably say that all participants in both groups could accomplish the task, i.e., reach the destination point, but it would not be surprising if only half accomplished the task in a larger group (45.4% in the control group and 51.1% in the treatment group). This may be the effect of more participants in the treatment group.

Regarding directness, over a larger sample we could expect that in the control group perhaps only a third (28.9%) would find their way directly to the destination point without wayfinding aids but they may nearly all find their way directly. For the treatment group we could expect that only about half (51.1%) would find their way directly but they may all find their way directly. This supports the hypotheses that wayfinding aids helped the treatment group perform better.

Regarding the number of verbal prompts needed by participants to complete the task, in the control group we could expect that, in a larger group, just under half (45.4%) would need verbal prompting but it would not be surprising if all participants completed the task without verbal prompts. In the treatment group, in a larger sample, we could expect just over one third of participants (36%) would need verbal prompting but it would not be surprising if all participants completed the task without verbal prompts. However, this interpretation needs to be treated with caution as there were more participants in the treatment group than the control group so the data differs by one participant. In a larger group the results may be evenly distributed.

Another confidence interval analysis was the number of verbal reminders participants needed to keep them on the wayfinding task. In the control group data indicates that we could be reasonably confident that in a larger population nearly half may need prompting (45.4%) but it may be that all accomplish the task without prompting. In the treatment group 40% of participants needed prompting. In a larger population, according to the data, we could be reasonably confident that around a quarter of participants would need prompting to stay on task but it may be that 90% of participants need verbal prompting to stay on task. From the data it appears that participants in the treatment group were more distracted and needed more verbal prompting to stay on task. We would probably have expected participants in both groups to be equally distracted during the wayfinding task. Alternatively, in the treatment group, did the wayfinding aids distract participants? Or did the wayfinding aids cause participants in the treatment group to feel over confident that they lost focus on the task? The data may simply indicate the variance in the characteristics of children with ASD.

Presence of Others

The presence of others using the study route was regulated as far as possible by asking janitorial staff to avoid the area during the study period. This was so that participants would not be distracted from their task and so that all participants would receive the same treatment. Despite that a janitor walked past one participant in the control group during his turn at wayfinding but this did not seem to disturb the participant or affect his actions during the study.

Use of Wayfinding Aids During the study

The study aimed to find out from participants what they thought about their wayfinding experience, both from the perspective of how they felt about it and what they remembered from the route as this could help designers create suitable school corridors. To find out what wayfinding aids the treatment group used or what environmental cues the control group used to navigate participants were asked in the script to tell the researcher when it was their turn to lead if they remembered “any colors, any shapes, any signs, or anything else" they remembered from walking the route the first time. In analysis, this category was revised to include doors that participants referred to and colors were omitted as a separate category as participants referred to color in the context of doors, shapes, or signs. A category also had to be created of other items participants referred to during the study, namely lockers and posters.

Refers to doors during the study. The number of participants who made comments about doors during the study was collated (Table 16).

Table 16

Refers to Doors During the Study

Refers to doors	Control Group	Treatment Group
Doors referenced	1	1
No doors referenced	3	4

Two participants referred to doors during their turn at wayfinding. One participant in the control group referred to doors W25 and W27. One participant in the treatment group made two comments, one referring to the pair of red doors leading out of the Media Center and the other to the pair of red classroom doors Classroom 7 and 8.

Refers to Shapes During the Study.

Table 17

Refers to Shapes During the Study

Refers to shapes	Control Group	Treatment Group
Door	1	0
Circles	0	1
Squares	0	1
No shapes referred to	3	3

One participant pointed out the shape of door W27 as he travelled along the control route, the unique stable door . In the treatment group, one participant referred to the yellow circles and another to the large green square. The comments are too few to make further inference.

Refers to Signs During the Study. The researcher wanted to find out whether participants in the treatment group would refer to the specially fabricated wayfinding signs more than participants in the control group who were using existing signage. A count was done of the number of signs each participant referred to during Stage 2, i.e. when they led the researcher around, using the videotape data.

Table 18

Refers to Signs During the Study

Refers to signs	Control Group	Treatment Group
No reference	2	2
1-5 signs	1	0
6-10 signs	1	0
11-15 signs	0	0
16-20 signs	0	0
21+ signs	0	3

Participants in the control group rarely referred to signs as they travelled along the route. One participant referenced six signs and one referenced only one. Two participants in the control group and two participants in the treatment group did not reference any signs, although one of these in the treatment group referenced posters along the route and seems to have used these as a wayfinding strategy. Three participants in the treatment group referenced nearly all the signs. They were clearly reading and focusing on the signs during the study.

Refers to Other Items During the Study. It was also of interest to find out what other items participants remembered along the route. Four participants recalled eight different items (see Table 19).

Table 19

Refers to Other Items During the Study

Refers to other items	# references in Control Group	# references in Treatment Group
Lockers	1	1
Bulldog poster	1	0
Plaque	1	0
Fish poster	0	1
Cat poster	0	1
Crocodile poster	0	1
Presidents poster	0	3
Planet poster	0	1

The main items that participants said they remembered were the posters. In fact it was the two female participants in the treatment group that remembered and talked about the posters, fish, cat, crocodile, presidents, and planets. Presidents were particularly noted by both, one recalling two different presidential posters. One participant in the control group and one participant in the treatment group noted the lockers. One participant in the control group also remembered a plaque in the Media Center, unique because it had a three-dimensional emblem on it. The same participant remembered a bulldog poster in the first corridor. The subject matter and presumably size is likely to have made posters memorable to participants. Interestingly, the items the researcher thought participants might refer to as a landmark were a pair of large (empty) display cabinets at the entrance to the music corridor but no-one referred to them.

Post-Study Interview/Questionnaire (PSIQ)

The PSIQ was developed to find out how participants felt about their wayfinding experience, if it had been an enjoyable experience or not, as this could be an indication of whether they would be more likely to practice wayfinding skills willingly in school. The researcher also wanted to find out what participants remembered about their wayfinding experience so that comparisons could be drawn between the control and treatment groups to find out whether wayfinding aids aided cognition. The PSIQ could also provide a window into the mind of the child with ASD as to what they see as they move through the designed environment. Each question is noted and analyzed in the order given with corresponding tables.

Q1 How did you feel about finding the art room with me leading? This question was designed to find out how participants felt about wayfinding in the environment and whether there was a difference in their feelings with the researcher leading or not. This was measured on a 5-point Likert type scale from "very unhappy," "unhappy," "just ok," "happy," and "very happy."

Table 20

Feelings about Wayfinding with Researcher Leading

Researcher leading	Control Group	Treatment Group
Just ok	0	2
Happy	3	1
Very Happy	1	2

The reason one female participant in the treatment group gave for finding the task "just ok" was because it was a lot of walking and the other reported he was worried he was going to get lost. During the wayfinding task he was the participant who showed most anxiety and lack of confidence. Participants in both groups felt happy they did not get lost, one thought it could not be that hard, and one was happy he did something he had never done before. The "very happy" participants gave a range of answers, one felt very happy because it was an adventure, one felt very happy because he found the book, and one felt very happy because he had learnt how to get to the Art Room.

Q2 How did you feel about finding the art room when you were leading?

This question was also asked on the same Likert scale from "very unhappy" to "very" happy." It was intended to complement Question 1 and could indicate whether participants felt less happy, and likely less confident, when they had to lead than when the researcher was leading.

Table 21

Feelings about Wayfinding with Participant Leading

Participant leading	Control Group	Treatment Group
Just ok	1	1
Happy	2	3
Very Happy	1	1

The participant in the treatment group who thought the task was "just ok" said this was because she had difficulty remembering things. Participants were variously "happy" that they had found the room, that they had got the book, that now they knew where the room was, and one was happy she got to lead the researcher. Participants who were "very happy" said this was because they found the goal, the book.

Q3 Did you think finding the art room on your own was scary? This question was a closed question with a follow up question *Why did you think it was scary?* if participants said they thought the task was scary. This was designed to find out whether the act of wayfinding on their own had been an anxious experience as this could be an indicator of children's feelings if they were asked to wayfind on their own in school.

Table 22

Feelings of Anxiety about Wayfinding

Anxiety	Control Group	Treatment Group
No response	0	1
Yes	0	2
No	3	3

Most of the participants in both groups did not think the wayfinding task was scary and many seemed surprised and a couple even scornful that the researcher would think such a thing. One participant in the treatment group thought the task was "a little scary" because it was dark in the Art Room (the lights were off), and another felt scared because he got lost at one point. This was the participant who also expressed concern he was going to get lost in Question 1.

Q4 Did you think finding the (art) room on your own was difficult? This was a closed question with a follow up question *What made it difficult?* if participants answered in the affirmative. This question intended to find out what elements of the wayfinding task were perceived as difficult by participants as this could help designers consider how to design and implement wayfinding aids.

Table 23

Difficulty of Wayfinding

Difficult	Control Group	Treatment Group
No	1	4
A little difficult	3	1
Yes	0	0

Four out of five participants in the treatment group perceived the wayfinding task as not difficult. The reason that the other participant gave for it being a little difficult was because her feet were tired and she wanted to sit down! The participant in the control group who did not think the task difficult said that it was because he knew the researcher was behind him. Other participants in the control group found the task a little difficult. One said this was because he had never been to the Art Room before and another said it was because of the "turns and twists" along the route.

Q5 Did you think finding the art room on your own was easy? Question 5 was a closed question with a follow up question if participants said they thought it was easy *What made it easy?* Participants who did not think it was easy were asked why they thought this.

Table 24

Ease of Wayfinding

Easy	Control Group	Treatment Group
No	1	1
A little	1	0
Yes	2	4

The participant in the treatment group who did not think finding the Art Room was easy said this was because she lost track of the task (she was the one who needed constant reminders to stay on task). The participant in the control group who said he did not find the task easy was not able to articulate why he felt this way. One participant in the control group thought the task was "a little easy." Four participants in the treatment group thought the task was easy giving various reasons. One said the color yellow helped and another reported it was "following the colors, orange, green, red." The participant who attended the school during the school year said it was easy because she goes to the school and could remember (although we know she had not been to that particular route/destination). Of participants in the control group, one thought it was easy because he said he has a long term memory and the other thought it was easy because he could remember from the first time when the researcher led the way.

Q6 How would you feel if you had to find the art room on your own? Participants were also asked how they would feel if they had to find the art room on their own on a Likert type scale from "Very unhappy" to "very happy." In a follow up question, participants were then asked to explain why they would feel like that. This question aimed to find out participant's confidence levels in their wayfinding ability.

Table 25

Feelings about Wayfinding by Self

On your own	Control Group	Treatment Group
Unhappy	0	1
Just ok	2	1
Happy	1	1
Very Happy	1	2

The participant in the treatment group who said he would feel unhappy at finding his way on his own said this was because he had already done it (and by implication did not want to have to do it again). In the "just ok" category, the participant in the treatment group said this was because her feet were so tired. One participant in the control group said it was because it was a little hard and the other did not articulate. In the "happy" category, the participant in the control group felt happy he could lead the class if they needed to go there someday. The "happy" participant in the treatment group gave a lengthy and excited explanation describing the route to the Art Room. In the "very happy" category, one participant in the treatment group felt very happy he now knew where he was going and the other, the one who attended the school, felt "very confident" because she could remember everything about the school. The participant in the control group was very happy because he was a good navigator and could find places on his own.

Q7 What three things can you remember seeing in the hallway when you were finding your way to the art room? This question wanted to find out what participants in the control and treatment groups would remember from the wayfinding route and particularly whether participants in the treatment group would remember the wayfinding aids indicating they had helped them navigate. One participant in the control group could only remember two things. One participant in the treatment group gave one answer but referred to all four colors.

Table 26

Three Things Along the Wayfinding Route

Items remembered	Control Group	Treatment Group
Doors	0	1
Door with a line across	1	0
Shapes on floor	1	0
Going on the orange, yellow, red, and green	0	1
Signs	1	1
Pictures	1	0
Presidents	0	1
Crocodile poster	0	1
Reading is magic poster	0	1
Books	0	1
Colors	0	1
Classrooms	0	1
Media Center	1	2
Music Rooms	1	1
Room 1 and 2	0	1
Bathroom	1	1
Library desk	1	0
Lockers	1	0
Locker labels	1	0
Annoying music	1	0

Participants gave a surprising range of answers for what they remembered of their experience. Some remembered generic objects and others remembered very particular items. There was no pattern except that participants in both groups remembered doors, shapes, colors, signs, posters, furniture, rooms, and one even remembered sounds, “that annoying music.” This may point to the diverse nature of ASD or this variation may also be found in typically developing children. What may be more interesting is to compare the three things mentioned by participants in both groups.

In the treatment group, Danny remembers “going on the orange, yellow, red, and green;” Edward remembers classrooms, music rooms, and the Media Center; Freya remembers Rooms 1 and 2, presidents, and the crocodile; Gemma remembers the Media Center, books, and the magic sign; and Henry recalls “doors, colors, and signs.” In the control group, Adam can only remember “a door with a line across” and a rectangular locker. Ben particularly recalls signs, the library desk, and “annoying music.” Corey remembers the library, the bathroom, and the music room. Ian remembers shapes on the floor, pictures (he explains these as a dog poster, a people poster next to the Art Room, and a badge on the wall), and colors on locker labels.

Q8 Can you remember seeing any colors in the hallway when you were finding your way to the art room? This question was of particular interest to find out what colors the participants in the control group would recall and whether participants in the treatment group would recall the colors of the wayfinding aids. If the participant answered yes or no this was followed up with a supplemental question, *If you did, what colors do you remember seeing?* The number of colors referred to have been collated in Table 27.

Table 27

Colors Along the Wayfinding Route

Colors	Control Group	Treatment Group
None	1	0
Pinkish purple	1	0
Brown	2	0
Grey	2	0
White	1	0
Blue	1	0
Red	0	4
Orange	0	5
Yellow	0	5
Green	0	5

In the control group, one participant could not remember any colors. One could remember only one color, a “pinkish purple” at the library desk. Another remembered the library desk as being brown, a brown book, and grey doors (unclear where these were as the researcher was unable to identify any grey doors). The final participant in the control group remembered blue lockers, grey metal from the bathroom handwash fixture, and white walls (probably in the Media center). All the participants in the treatment group could remember all four colors of the wayfinding aids apart from one participant who did not call off the color red. Interestingly, only one participant in the control group and no-one in the treatment group referred to blue, the dominant color throughout the hallway.

Q9 Can you remember seeing any shapes in the hallway when you were finding your way to the art room? Participants who answered this question positively that they could remember shapes were asked the supplemental question *If you did, what shapes do you remember seeing?* Again this question aimed to find out what participants in the treatment group remembered about the wayfinding aids and whether participants in the control group remembered any shapes from the environment.

Table 28

Shapes Along the Wayfinding Route

Shapes	Shapes on items	Control Group	Treatment Group
Rectangles	Doors	1	0
	Shape on door	1	0
	Bookshelf	1	0
	Tiny sign D78	1	0
	Lockers	1	0
	Classroom tables	1	0
	Media Center tables	0	1
	Could not remember	0	1
Squares	Square on floor	0	2
	Orange square on floor	0	2
	Blue square on floor	1	0
	Large square on floor	0	1
	Lockers	1	0
	Library shelves	0	1
	Book	1	0
Circles	Circles	0	1
	Circles on floor	0	1
	Yellow circles on floor	0	2
	Handwash sink	1	0
Octagon	Desk	1	0
	Picture with person	1	0
Rhombus	On floor	1	0
Oval	Library counter	0	1

Regarding shapes, participants in the control group perceived more rectangular shapes for a variety of objects, e.g. doors, lockers, and bookshelves but there were only two comments about rectangles by participants in the treatment group. Square shapes featured particularly, especially squares on the floor. All five participants in the treatment group could remember the squares on the floor but only one participant in the control group could remember the blue floor squares. Only one participant in the control group remembered seeing a circle, the circular handwash sink in the washroom off the hallway compared to all but one participant in the treatment group who remembered circles on the floor, two remembering particularly that they were yellow. One participant in the control group remembered an octagonal desk (probably the library counter) and another an octagonal picture but it was unclear where this object was. Another, the participant in the control group who said he could remember shapes, perceived a rhombus in the existing square with triangles on the floor. One participant in the treatment group remembered the library counter as oval.

Q10 Can you remember seeing any signs (pictures with words) in the hallway when you were finding your way to the room? This question tried to find out how effective the wayfinding signs had been to the treatment group and what existing signs might have been used in the control group. Only the participants in the treatment group were asked the statement in parentheses, i.e., if they remembered any "picture with words" (pictograms) as this would not have made sense to participants in the control group as there were none. If participants said they could remember the supplemental question asked was *If you did, what signs or pictures or words do you remember seeing?* Some participants responded to this question by recalling posters with words on so these comments have also been included.

Table 29

Signs along the Wayfinding Route

Signs	Control Group	Treatment Group
None	1	0
W23, W27, S56, S57	1	0
W28, W26, W25, W24	1	0
Classrooms (unable to expand)	1	1
Classrooms 1-11 (12)	0	3
Music rooms	0	3
Washroom	0	1
Art Room	0	1
Office	0	1
Workrooms	0	1
“Reading is Magic” poster	1	0
Pictures	Not Applicable	Treatment Group
Woman and man (washroom)		1
3 students/1 teacher		2
Instruments		2
Person working (media room)		2
Camera (Video Room)		1
Magazines (Media Center)		1
Book (Media Center)		1
Paintbrush (Art Room)		2
Do no enter (Media Center)		1
“Reading is Magic” poster		0
“Be kind” poster		1
Unable to remember any		1

Regarding signs, one participant in the control group said he could not remember any signs. Two participants in the control group had difficulty remembering more than four classroom signs each, and one of these participants remembered two classroom numbers, S56 and S57, wrongly. One participant remembered the “reading is magic” poster in the Media Center. A final participant remembered “classrooms” but was unable to expand on this.

In the treatment group one participant also remembered “classrooms” but was unable to expand on this. However, three other participants were able to remember classrooms signs 1 through 11, and one participant remembered classroom 12 (which he had gone past). Three participants remembered the washroom, art room, and workroom signs.

Participants in the treatment group were asked what pictures (pictograms) they remembered with the signs. Here again were a variety of answers and most of the signs had been remembered, including one, the video room, that the researcher did not call off in the script. This could indicate that children with ASD see different things but it could be that the same effect would be found in typically developing children. One participant was confident he could remember "pretty much every one" of the pictures. Only one participant in the treatment group said he could not remember any pictures.

Q11 When you go to a new place that you haven't been to before and you have to find your way around how do you feel? This question was asked to find out how children with ASD feel when they have to wayfind in an unfamiliar setting. Participants were asked to rate this question on the Likert scale from "very unhappy" to "very happy." After they answered, participants were asked a supplementary question *Why do you feel like that?*

Table 30

Feelings about Wayfinding Somewhere New

Wayfind somewhere new	Control Group	Treatment Group
Unhappy	1	1
Just ok	2	0
Happy	0	1
Very Happy	1	3

One participant in the treatment group said he felt "unhappy" as he did not like to go to new places by himself without his parents. In the control group, one participant expressed worry and unhappiness that in a new place "you don't know where you are, you don't know any places there, and (you could lose your parents)." Afterwards, on the way back to the classroom, it became apparent that he had been to Universal Studio the week before and had been worried about getting lost there. Of the control group participants who felt "just ok," one worried he might get confused next time and one that it would be ok if there was a map. One participant in the control group said she would feel happy as she likes going to new places.

In the "very happy" group, the control group participant was "very happy' because it was an adventure. Three participants in the treatment group said they would feel "very happy." One participant said he felt very happy because they were following the path and may have interpreted the question as asking how he felt about the wayfinding activity he had just completed. One treatment group participant felt that if he found where he was going he would remember it next time. The participant who attends the school felt "really confident I know where I'm going," at odds with her teacher's opinion.

Q12 Is there anything else you would like me to know about finding our way to the art room that we haven't talked about? This question was intended to capture any other information the participant wanted to share about their experience. However, instead of a discussion or providing additional information, the first four participants gave a negative answer.

Table 31

Anything else about the Wayfinding Experience

Anything else	Control Group	Treatment Group
No	3	1

After four participants this question yielded no information so it was amended to ask of the other five participants: *What is the main thing you remember about finding our way to the art room that we haven't talked about?*

Table 32

Main item Remembered about the Wayfinding Route

Main item	Control Group	Treatment Group
Media Center	0	1
Orange start point	0	1
Art Room door (blue)	0	1
Collecting the book	0	1
Shapes	1	0

The main thing the participant in the control group remembered was shapes and he had told the researcher he particularly remembered shapes. For one participant in the treatment group, the most memorable thing was the start point, including the color orange. For another it was the end point, the art room door, which she perceived as blue. The activity of collecting the book was the main importance for another, and for another it was the Media Center.

Observations

In this section interactions with participants are described, from in-class observations conducted by the researcher, to carrying out the wayfinding task at Stage 1 and Stage 2, to the post-study interview/questionnaire process. The experience of each participant is described individually in a case study basis. A summary at the end encapsulates each participant's experiences.

A phenomenological approach has been taken to describe the participants' actions while they were taking part in the study, based on researcher observations, including pertinent comments made about the route. In a phenomenological approach, "People describe their world . . . as they make sense of it," (Babbie, 2010, p. 334). For children with ASD the researcher tried to understand the world through their eyes. According to Babbie (2010) phenomenologists try to interpret participants "perceptions of the world" (p. 334), in this case, of the wayfinding study. Furthermore, this approach helps us understand the "lived experiences" of people (Creswell, 2013, p. 13; Bloomberg and Volpe, 2012, p. 32). Elements of the wayfinding study and the interview/questionnaire are reported to relate the lived experience of the participants. An active voice has been used for clarity and to convey the participatory nature of the study with children with ASD (Bloomberg & Volpe, 2012). All participants were assigned pseudonyms to ensure anonymity.

As a reminder about the procedure, on each occasion of the researcher's first observational visit, the teacher read the prepared script to the class introducing the researcher (see Appendix M). At a convenient point in class, the researcher read to the children so that participants would become accustomed to her voice and way of speaking. At the commencement of the study, the researcher went to the participant's classroom. First, the para who would be following the participant and the researcher along the route was given instructions. Then the researcher took the participant to the start point, in accordance with the relevant script, (Appendices I and J), and the wayfinding study began.

Adam's Experience (Control Group)

Adam is a slight boy with fair hair aged 8½. He is currently in Grade 2. Adam had been to the school more than 5 times before and is familiar with the layout. Adam is the first participant to take part in the study.

In-class observations. Adam was observed twice for approx. 1 hour each. Adam attended a class of seven, 4 males and 3 females with a teacher and 3 paras. Adam initiates and responds to communication from his teacher, paras, and classmates. At activity and reading times he shows good concentration, engagement, and enjoyment. He makes frequent eye contact with his teacher/para and has a good level of conversation. He is quick to respond when give instructions. He also has good listening skills. In a reading and writing task, Adam and his classmate are able to complete more work than others in the class, clearly engaged and ahead of his peers. The teacher later tells the researcher that Adam is very high-functioning and at times it is hard to tell his diagnosis of ASD, especially as compared to his peers in class.

Wayfinding Stage 1. When it is time to participate, the teacher has obviously reminded Adam about the study but he goes hesitantly with the researcher. The researcher stops outside the classroom door to explain the study. Adam is hesitant, avoiding eye contact. At the start point the researcher explains what they are going to do and Adam still avoids eye contact. Halfway through the explanation Adam takes off his shoe and says he has something inside it. The researcher waits for him then resumes. When asked if he understands he nods assent. The researcher leads the way with Adam at her left hand side. Sometimes he appears not to be listening and walking along without paying attention but when the researcher stops he stops. He is silent throughout.

Wayfinding Stage 2. On Adam's turn he sets off very hesitantly with the researcher following about 6' behind. This distance is maintained consistently throughout. If the researcher slows down to attempt to increase the distance between them, Adam also slows. Adam walks to the right hand side of the hallway close to the lockers. At the first set of double doors to the Media Center he slows in recognition and goes through. In this narrow hallway he slows, he is hesitant, looking around as he walks. He stops just before the library counter, hesitates, then appears to recognize where he is and passes behind the library counter (in the interview afterwards he narrates how he used the Periodical stable door with its "line through the door" as a landmark). Adam walks confidently to the double doors at the end of the Media Center and goes through. In the hallway he hesitates but then follows the correct route. As he walks, Adam looks around the hallway from left to right. Past the music rooms, he gets to the next decision point, pauses, then walks the correct way. He goes confidently to the Art Room.

During the exercise Adam makes no gestures or pointing (the pretest participant pointed out everything). He completed the task in silence, with no questions or comments. On occasions he is observed playing with his tee shirt, his hands up his tee-shirt as he carried out the task. This could have been a sign of concentration or nervousness.

Interview/Questionnaire. Adam says he feels happy finding the Art Room because he'd never done it before and now he knows where it is. He thought it was a little difficult because he'd never seen the Art Room before but finding the library helped him. He only remembers two things in the hallway, the door with the line across it (this is the Periodical room stable door) and the lockers. The only color he remembers seeing is "pinkish purple" at the library counter (but not the blue of the lockers he recalls). For shapes he remembers the "rectangular thing on the door that had words on it" (the door in the Media Center pointed out in the script) and a rectangular bookshelf in the library. Adam is unable to recall any signs. He feels "just ok" when he goes to a new place and has to find his way around and would like to have a map.

After the interview Adam is much chattier, he makes eye contact with the researcher, tells her he is going to be a scientist and is going to camp in three days and will take his notebook, the gift he received for participating, with him. He may have been nervous about the wayfinding task and what was expected of him to account for his previously quiet demeanor.

Summary. Adam successfully found his way to the Art Room in average time; he went directly and did not require any prompts. He appeared anxious throughout. He has struggled to find wayfinding cues in the environment to help him, mentioning a few shapes that acted as orientation clues, the stable door, the door in the media Center, and a bookshelf. The library counter appears to have acted as a landmark as he can recall its color but no other colors. Considering signage is a primary wayfinding cue, Adam cannot recall any signs along the route yet observation in class clearly shows he is very good at reading. This is an indicator that there is something unhelpful, unclear, or confusing about the existing signage.

Brad's Experience (Control Group)

Brad is a lively boy aged 9¼ currently in Grade 3 who identifies as a South Pacific Islander. Brad had attended the ESY Program before.

In-class observations. Brad was formally observed for one 2 hour session but he had made himself known to the researcher before then while she was observing another participant. On this occasion he became so excited when he realized the researcher was from England that he disrupted the class with his chatter and questions and inability to sit still. He is in a class of six other children, 1 female and 5 males, with 1 teacher and 2 paras. He is very enthusiastic and talkative in class making lively conversation with the teacher and his classmates. Twice, playing two different board games, he and his classmate adapt the games into battle games which become very noisy and the teacher has to tell them to stop. Brad has a vivid imagination and a good level of vocabulary as he talks constantly to his classmates and his teacher. Occasionally he initiates conversation with the researcher. At class question time activity, Brad becomes very excited, bouncing up and down on the floor, fidgeting, talking excitedly, sometimes over other classmates who become annoyed with him.

Wayfinding Stage 1. Brad is excited when he is collected from his classroom and tells the researcher on the way to the start point that he has a good long-term memory and likes doing navigational tasks. He has obviously been well prepped for the task by his parent/guardian and/or the class teacher. When the researcher leads the way it is hard at times to keep Brad on task and listening to instructions, a pattern of behavior he repeats in Stage 2. As they enter the Media Center Brad is impressed, “Wow,” and says he has never been there before. In this area particularly, Brad frequently points out details in posters, e.g. “What’s a lion . . .” When the researcher reads the signs Brad sometimes reads the details, the smaller text underneath, such as teachers’ names. He points out some of the doors the researcher intentionally did not refer to and notices the signs above the doors that the researcher again did not refer to. Brad visibly looks either side of the hallway for cues. Sometimes Brad goes ahead of the researcher and she has to call him back to look at a feature. Sometimes he says, “I know the way there.” At the library counter he repeats, “I know the way there,” and proceeds the wrong way, contradicting his earlier comment that he has been there before. The researcher calls him back.

Brad appears to be taking in a lot of information. Re-entering the Media Center on the return trip, he stops and says, “Wait, this smells like the clinic.” It is a subtle smell from the janitor’s cleaning several weeks ago but Brad has noticed it as different from the main hallway. At the library counter he interrupts the researcher to ask if the scanner works. The scanner is behind the library counter and was only visible on the return journey, what visibly calls it to attention is a small but bright red light which the researcher had not previously noted.

Wayfinding Stage 2. On his turn, Brad sets off very confidently, pointing out some small text, e.g. 4th grader, and the teacher’s name, Mrs. Snyder, on the doors at the start of the route that the researcher had not pointed out. He walks ahead and opens the Media Center doors but holds them open for the researcher saying, “After you.” He pauses again at the library counter to talk about the scanner. He quickly walks along the Media Center corridor, calling off doors with signs above including the doors the researcher did not call off, for example, he calls off the signed Fire Marshal. He notices posters of presidents on the wall and makes comments about several of them. Exiting the Media Center, he complains about the annoying music. In the distance, out of sight, janitors have a radio on, its volume barely perceptible to the researcher. Brad turns the correct way down the music room corridor. He goes confidently to S35 and says, “Art Room.” He appears perplexed when it is not, looks around, hesitates, then begins walking again. S35 is in the same orientation in the corridor as the Art Room so the mistake is understandable. Brad recognizes the music rooms then moves more confidently about 8′ ahead of the researcher. A caretaker passes by in the corridor but Brad ignores him. Brad pauses at the intersection in the hallway, looks back for the researcher, then turns right along the hallway and goes directly to the Art Room.

Interview/Questionnaire. Brad perceives the wayfinding study as an adventure, mentioning the word several times, and is very happy that we found, “Our goal . . . our treasure, the book.” He was not scared because the researcher was behind to ask directions of. He felt the task was very easy as he says he has a long term memory, is a good navigator, and can find places on his own. When asked what three things he can remember seeing in the hallway he refers to classrooms W28 and W27, which are correct, and then to S36 and S37, which are incorrect, there being no such numbers. He calls off other signs he remembers, such as the Work Room and the Audio Visual room. He mentions the library counter. He also refers to the “annoying music.” For colors he remembers seeing “grey doors,” a brownish library desk, and a book with brown fabrics (this is probably the book that was collected from the Art Room which was about fabrics). For shapes he calls off “gigantic rectangles,” the doors; tiny rectangles on the tops of D78 signs; square lockers; a square book; a desk that was half an “octangle”; and long shiny rectangular lockers. When asked what signs he remembers he cites W23, W27, S56, and S57. Again, W23 and W27 exist but there were no signs S56 and S57. Brad is very happy going to new places as “it’s another new adventure.”

Summary. In class observations and during the wayfinding task, Brad presented as a very active child. He is noted taking in a lot of information from his environment, he sees small details on posters and on signs; smells disturb him; noise annoys him; the light from the scanner diverts him. All these elements distracted him from his task. His senses seem to be bombarded. Regarding wayfinding cues, Brad has not been able to correctly distinguish colors along the route. He has a better remembrance of shapes but it is the smaller details he has noticed rather than the big picture. Again, similar to Adam, wayfinding signage that should have been helpful has not proved memorable to him. He remembered unnecessary details, such as the teacher’s name on the sign, which may have decreased his capacity to remember more important information.

Corey's Experience (Control Group)

Corey is aged 8½ years old and just completed Grade 2. He has never visited the school before.

In-class observations. Corey was observed in class on two occasions for approx. 1hour each. He is in a class of nine, 8 males and 1 female, with a teacher and two paras. Corey has a quiet demeanor in class. He plays appropriately with classmates and makes conversation. He listens to his teacher and paras attentively and complies with instructions promptly. He is patient and quiet in class even when others are slow to comply with the teacher's instructions and he has to wait for them.

Wayfinding Stage 1. When he is collected from class, Corey is shy with the researcher, talking quietly and hesitantly on the way to the start point. At the start point he listens intently to instructions, sometimes looking ahead, making little eye contact, but nodding in agreement or saying "ok" appropriately. He listens carefully to the researcher along the route, looking around appropriately, occasionally nodding or saying "ok" but otherwise is very quiet.

Wayfinding Stage 2. Corey starts off slowly about 6 ′ ahead. He points to W24 and says he remembers it. He follows the left hand side of the hallway closely. He points to W26 and W28 and two more. In the Media Center he slows, the researcher about 5′ behind. He looks around as if he is noting the environment. He points to the Audio Visual door, a door the researcher did not point out. He goes behind the library counter and looks around, slows, looking around. Corey walks the correct way. Out of the Media Center doors Corey shows no hesitation. At S34 he looks up. He is still keeping to the left hand side of the hallway, looking around. He comments he remembers the three doors and the washroom. He turns right and goes through the open doors. He is close to the wall looking left but turns to face right and walks to the Art Room door.

Interview/Questionnaire. Corey is happy he found the Art Room by himself, happy he found the book, and happy he did not get lost. He did not feel scared because he had been shown the room once so knew where it was and could remember. He felt confident he could lead the class if they needed to go someday. The three things he remembered seeing in the hallway were the bathroom, the library, and the music room. Corey remembers colors, the gray of the washroom sink (it is stainless steel); white on the walls (probably the Media Center walls); and blue on the lockers. He remembers square walls, not the hard brick, (again probably the Media center walls); the rectangle desks in the classroom which he got to see (probably the Art Room), on desk, and the "circle where you wash your hands" (the communal sink which he observed in the restroom area before the Art Room corridor). He struggles to remember any signs, recalling the library "read notice" and the classroom. He feels "just ok" when he has to go to a new place as if he is by himself he could get confused.

Summary. Corey is quiet and attentive in class and showed the same attitude during the wayfinding study. This helped him reach the Art Room directly with no distractions in an average time that was below the average participant. Corey has particularly remembered the washroom sink off the corridor, recalling its color, gray, its shape, circular, and citing it as one of three things he remembered. For him, although it

was off the main study route, it has acted as a landmark. The washroom was located just before the Art Room so he has used this as a cue to help him reach his destination. Notably, he selected this cue as a wayfinding strategy for himself as it was not something that the researcher had pointed out. Corey also remembered blue lockers but it is unlikely they would have helped him wayfind as their location was not discriminate. Again, as with previous control participants, existing wayfinding signage
has not helped him navigate.

Ian's Experience (Control Group)

At 10¼ years old Ian is the oldest participant in the study and has just completed Grade 4. He identifies as a white male. Ian has attended the school for previous ESY Summer Programs.

In-class observations. Ian was observed for a 1 hour period. He was in a class of seven, 6 males and 1 female with a teacher and two paras. Ian sits quietly, engaged in playing a game with classmates who are all more talkative. He makes eye contact with his teacher and appears relaxed. Ian carries out instructions promptly, listens attentively, and is engaged with reading activities. He is quiet compared to his talkative classmates but is engaged and interested in what they are saying while he is generally silent. In class discussion Ian shows quiet, sensible behavior, sitting on the floor, listening to his classmates attentively but does not himself volunteer answers or participate.

Wayfinding Stage 1. When he is collected for the study, Ian appears cautious leaving the classroom with the researcher. He answers her general questions in short sentences or monosyllables but seems to be listening attentively. Ian listens intently as the researcher explains the task, nodding occasionally in appropriate places. As the researcher begins, Ian walks beside her, occasionally walking on before she has completed the script about the signs but pauses then to listen. At W23 and W24 he nods that he can see these doors.

On the return trip down the music corridor, Ian walks slightly ahead of the researcher. He is silent throughout the journey but appears to be listening and is looking around appropriately.

Wayfinding Stage 2. At Ian's turn he starts confidently about 6′ ahead of the researcher. He points to the blue lockers on the right and says he remembers the numbers on the lockers (they have small numbers on colored discs). He also points to classroom W27 and says "shapes on the door" (perhaps the vision panel). Between classrooms W28 and W26 he points and says, "Bulldog picture." It is a poster featuring a bulldog.

Ian does not hesitate as he goes through the Media Center door. He walks confidently about 8′ ahead of the researcher. He slows at the library counter, looks around as if contemplating, before moving more quickly behind the counter. Along the right hand corridor towards the Media Center exit doors he points out plaques on the wall. Out in the main hallway he pauses, looks down and says, "Big shape." He points the correct direction and walks on but he is slow as he looks at classrooms S34 and S35. At the music rooms he slows more and appears unsure. Ian continues walking. At the final decision point along the route he again appears unsure, looks around, then turns to the researcher and says again, "Big shape." He seems to recognize where he is and moves off the big square quickly at first but then slows and appears unsure. Walking slowly he finds the Art Room.

Interview/Questionnaire. Ian says he felt ok with the researcher leading because he felt he could usually remember numbers, shapes, names, and colors. He felt happy when it was his turn, and thought it would not be that hard to do and that he would try to remember what he saw. He appears to have understood what he needed to do and employed strategies to himself remember. He felt the experience was scary because he got lost (this must have been at the last decision point). What made him realize he was in the correct place was seeing the 5th grade sign on the door (probably classroom W29 adjacent to the Art Room). Ian thought the task was a little difficult because there were all kinds of twists and turns and doors to go through. He is the only participant to really articulate the route. He did not think finding it was easy. If he had to find the Art Room on his own he felt "just ok" but was unable to articulate further.

The three things Ian remembered in the hallway were the dog picture (the bulldog he had pointed out earlier) and "people next to the Art Room," (possibly framed pictures on the wall outside the restroom). Ian remembers colors, lockers which had circles of blue, yellow, and green. He has failed to see the blue lockers in general but has noticed small details on the lockers which had individual numbers and labels on to help identify them. This is another example of the common trait of children with ASD unable to see the big picture. Ian remembers the big shapes on the floor (that the researcher had pointed out), the lockers, and a plaque on the wall with a dog (in the Media Center). This was the same plaque that had been noted by Freya the previous day. It may have stood out against other things on the wall because it was three-dimensional.

When questioned, Ian cannot remember seeing any colors (although he noted colors when asked what three things he remembered). For shapes he remembers an oxygon, “a picture of an oxygon with a person in it that was a picture that would help me remember.” The researcher is unsure what picture he is referring to. Squares are remembered, big squares and squares on the floor in blue (although he could not remember the color blue in the previous question). He remembers a rhombus on the ground. When the researcher asks where he explains the square was in it. He was describing the large squares which when viewed from certain angles could be perceived as a rhombus.

Regarding signs, Ian vaguely remembers W28, W26, W25, and W24, some of the first doors referred to. The written text was not helpful to this participant. When asked how he feels in a new place he said he felt unhappy, and explained that at universal it’s a big area and you don’t know where you are. The researcher realized later as Ian talked to her as she took him back to his classroom that he had been referring to Universal Studios as he had been on a recent family vacation to California.

Summary. Ian found the Art Room directly and in the quickest time. This may have been due to the fact that he was the oldest and maturity made him more confident. Surprisingly, though, by he own admission, he “got lost.” He is obviously worried about getting lost in the environment and has fresh experience of this from his time in Universal Studios. Colors have not helped Ian to navigate and he has not remembered any of them. What has helped him is that he has perceived complex shapes which helped him to remember his way and provided key navigational aids, squares, oxygons, rhombus, circles, a three-dimensional shape, and the shape of a bulldog. Like the other three participants in the control group, the existing signage did not help Ian to navigate.

Danny's Experience (Treatment Group)

Danny is the youngest participant, just turned 8 years old and has just completed 2nd Grade. He has never visited the school before. Danny is the first participant in the treatment group. He is observed to have an awkward gait as he walks.

In-class observations. Danny was observed on two occasions for approx. 1 hour each. He is also in the class of nine, 1 female and 8 males, with a teacher and two paras. During the first observation, Danny is playing a game with a para and other classmates but he is disengaged, not talking, not participating in the game. When the teacher is talking Danny appears momentarily engaged then loses interest, looking around, moving his body. When he moves to another table to play a different game he is again disinterested, refusing to participate until the para finally persuades him to join in.

During the second observation period, Danny has refused to cooperate with his teacher. He spends the whole time standing or sitting in the hallway outside his classroom as a para stands nearby to keep watch over him, occasionally talking to him. He is silent, refusing to make eye contact, and does not respond or talk to her when, for example, she suggests getting a snack or gives him a paper and pencil to draw with.

Wayfinding Stage 1. As the researcher explains the study to Danny in class it is unclear how much attention he is paying. He makes no eye contact and looks around but nods in acquiescence that he is ready to go. During the walk to the start point there is little conversation, Danny avoids eye contact and walks close to the left hand side of the corridor. At the start point the researcher explains what they will be doing but is unsure how much Danny has comprehended. She begins walking and reading the script. At the mention of the first signs Danny's face suddenly lights up and he points and reads the signs. It is as if he has the realization that he can do the activity. The researcher explains the pictures accompanying the signs. Danny starts to read all the signs, pointing at them as he goes. Sometimes he walks in front of the researcher, sometimes he reads the signs ahead of the researcher's script.

In the Media Center Danny reads signs on some of the doors that the researcher did not point out in the scrip but interestingly ignores the two existing pink doors that have not had wayfinding aids applied. Danny confidently reads all the signs in the yellow corridor. Out of the Media Center onto the big red square Danny automatically turns right to follow the red squares on the floor ahead of the researcher and before she has been able to draw his attention to the other possible routes. Continuing on the route, the researcher calls Danny back to look at the three red music signs and explains the pictures. Danny continues, automatically following the green squares without considering the other possible route, about 8′ ahead of the researcher throughout. Danny reaches the Art Room ahead of the researcher and reads Art Room and Classroom 11. The researcher explains the Art Room is their destination and reads the rest of the script.

On the return trip Danny continues to read the signs, pointing out ones that were passed earlier, usually walking ahead of the researcher, often moving past things before the researcher has got to the script, including passing through the red doors into the

Media Center.

Wayfinding Stage 2. As Danny sets off on his turn he reads all the signs, pointing as he goes, including the washroom sign at the start point. He is about 8′ in front of the researcher. He enters the Media Center and moves fluidly down the yellow corridor reading all the signs, unhesitatingly walking correctly behind the library counter. He recalls the magazine picture. He has no hesitation out of the red Media Center doors and follows the red corridor. He reads all the music rooms signs and claps at the music classroom, maybe in delight he has remembered or in recognition of music. At the green washroom sign he points out the picture of children. He walks ahead of the researcher at the green corridor, goes directly to the Art Room and waits outside for the researcher. He is told to go in and collect the book.

Interview/Questionnaire. Danny is very happy that he found the book inside the Art Room. He thought it was easy even though the lights were off, i.e., the lights were off inside the classroom so it was relatively dark but he was still able to find the book. Danny says he would be very happy finding the Art Room on his own because he went on the green path, his favorite, as green is his favorite color. When asked what three things he can remember in the hallway, Danny immediately recalls all four colors, orange, yellow, red, and green. When probed he cannot remember any objects or things seen in those colors. When asked what colors he remembers seeing, Danny repeats the four colors in the same order. He does not recall any other colors when probed. Danny is asked what shapes he remembers and recalls, “Squares, orange squares, and squares, squares leading us to the Art Room.”

Regarding signs, Danny calls off every classroom sign in order, Classroom 1-11. The numbers appear to have helped him. When asked about pictures he remembers the washroom woman and man; the classroom sign with three students and a teacher; instruments; and "the media guy in the office." In answer to how he feels when he goes to a new place and has to find his way around, Danny says he feels very happy because we were following the path. He seems to be referring to the wayfinding activity and does not understand the actual question when pressed.

Summary. Danny found the Art Room directly. He had the second slowest time due to his awkward walk and to the fact that he stopped at every sign to call it off. In class and on first introduction Danny presented as a taciturn child reluctant to engage with peers or adults. Seeing the coloured signs which he could read by himself had a profound effect on Danny. Not only could he read and comprehend them himself but when explained he understood the pictures and how they related to the signs. He was able to put the two elements together to help him find his way around.

Danny was also able to discriminate and remember all four wayfinding colors, particularly the shapes on the floor. He did not refer to the door colors so it is unclear how much they helped individually or whether they just contributed to the overall perception of the color scheme. Interestingly the blue predominant in the existing color scheme was not noted by Danny at all.

Danny clearly enjoyed the wayfinding activity and felt a sense of achievement that he found the Art Room. There was a look of delight on his face that he could read the signs. He was enthusiastic, especially in contrast to his taciturn demeanor walking to the study start point. As the first participant in the treatment group it was also unexpected that he would read the signs ahead of the researcher and follow the colors instinctively.

Edward's Experience (Treatment Group)

Edward is ten, older than all but one of the other participants, and has just completed 5th Grade. He has never visited the school before.

In-class observations. Edward was the only participant who the researcher had not been able to directly observe in class. However, he had been in class on a number of occasions when she was present, had heard her reading, and had introduced himself to her. He appeared mature in comparison to his peers.

Wayfinding Stage 1. On the way to the start point, Edward exhibits quite sophisticated language with good conversational ability and is keen to know what we will be doing and how he can find his way around. On the researcher's turn, as they begin, Edward quickly walks along the corridor pointing out signs and naming rooms without waiting for the researcher. In the yellow corridor he calls off rooms ahead of the researcher. At the library counter he asks if the room on the left is a computer room and is pointed to the sign which he reads. Often Edward walks ahead of the researcher and she has to call him back to point out pictures on the signs. The researcher misses out some of the script because of this behavior. In the red corridor, at the large red square, Edward says, "And red ahead," and immediately starts to follow the red corridor without stopping to look at other possible routes. Edward reads all three music room signs ahead of the researcher, the furthest away one first as that is the one he sees first since the doors are recessed. In the green hallway, Edward pauses to listen to the researcher's script and recognizes that the green corridor terminates in the orange corridor where the route began.

On the return journey, at Classroom 9 and Classroom 10, Edward comments they are 5th grade classrooms (he has seen teacher's name and grade class behind the vision panel on one door).

Wayfinding Stage 2. When it is his turn, Edward walks off confidently about 8′ in front of the researcher, pointing and calling off the classroom signs as he walks. After Classroom 2, he points out lockers on the right hand side which the researcher had not mentioned. At the yellow doors into the Media Center, he holds open the door for the researcher. In the yellow corridor, Edward moves quickly, providing a running commentary on the wayfinding aids, imitating the researcher's script. He calls off the colors, the yellow circles, noting that all the doors are yellow, and mentions signs such as the Media Work Room 1, Magazines, and the No Entry door. He also notes the poster of presidents on the right hand side of the hallway.

Often Edward paraphrases the researcher's script, describing the alternative routes they could take in the red corridor, for example. This delays his time. At the large green square he imitates the script and says they would rather take the green hallway. Interestingly, turning into the green corridor, he refers to the green lockers (they are blue and were not referred to by the researcher). So absorbed and quick is Edward that he calls off the Art Room sign but continues walking, calling off the next door signs, Classroom 11 and Classroom 12. Edward knows that he is in the corridor he started in so perhaps he is naturally heading back to the start point. At Classroom 12, the researcher reminds Edward of his task and he immediately stops and goes back to the Art Room to collect the book saying, "I did find it."

Interview/Questionnaire. Edward felt very happy when the researcher led so he would know how to find his way there and happy that he was able to find the Art Room and remembered to get the book. He found finding the Art Room easy because of the yellow color and you could easily see a big square on the floor which usually meant the gym or the Media Center. The three things that Edward remembered were a couple of classrooms, going through the Media Center, and passing the Music Office, the Music Store, and the Music Classroom. Edward can remember seeing yellow, red, orange, and green. Yellow seems to have particularly stood out for him as he refers to it a couple of times. Regarding shapes, Edward remembers squares on the floors and the library shelves, circles as yellow, and rectangles, very long tables in the library holding two chairs (chairs were stacked on shelving in the Media Center).

Regarding signs, Edward easily and accurately recalls all the classrooms (up to and including Classroom 12 which he went to), the music things, and the Art Room. When asked what pictures he saw, he remembered the Art Room with the paintbrush; the Video Room with the camera (the camera was his own observation of the pictogram as the researcher did not mention this and Edward did not mention it during the study); the Media Center with the library/book; the Media Work Room with a person working; and the classroom signs with the teacher teaching kids. Edward reports that he feels very happy going to a new place if he finds where he's going. At the conclusion, Edward thanked the researcher for allowing him to help with the study.

Summary. Edward found the Art Room directly with no prompting along the way. He made the second fastest time and would doubtless have been faster if he had not stopped to imitate the researcher's script. So confident was he along the route that he forgot what his task was and had to be prompted and go back to the Art Room. Like the first participant, Edward went ahead of the researcher at Stage 1, automatically following the colored wayfinding aids and reading the signs. This was an unexpected effect. Edward had no difficulty finding his way around and was happy and confident carrying out the task. He used colors, shapes on the floor, colored doors, signs, and pictures with the signs to find his way around. Moreover, he clearly remembers what he saw and can describe the wayfinding aids. For Edward, the combination of wayfinding aids has helped him navigate.

Freya's Experience

Freya is 9½ years old and has just completed Grade 3 in school. She currently attends the school in the part of the school reserved for younger age groups, home classroom A24. Her teacher for the ESY Summer Program is her Special Education (SE) Teacher in school. She tells the researcher that Freya was unable to find her way to the Special Education classroom, a few classrooms around the corner from her classroom. Only in the last six weeks of school was she able to go the short way to the restroom on her own which was on a direct route. A para had to take her from the bus to the class in the mornings and she has to be escorted again from the classroom to the bus when class has finished. The SE Teacher puts this partly down to her anxiety. She may have been to the Media Center although her class age group has their own Media Center and Computer Lab but the SE Teacher is very skeptical that she could get there on her own.

In-class observations. Freya was observed on two occasions for approx. a 1 hour and a ½ hour period. She is in a class of 9, 3 males and 6 females, with a teacher and two paras. She initiates conversation with her classmates and raises her hand to answer the teacher's questions. She makes frequent eye contact with the teacher. The class moves to the Computer Room and here Freya is observed working well with a partner, talking and interacting with her, in a calm and quiet manner. Back in the classroom, Freya is attentive, carries out instructions promptly, and interacts well with her teacher, classmates and paras. She appears relaxed and is often smiling.

Wayfinding Stage 1. The researcher is concerned that Freya may be reluctant to accompany her due to her anxiety. The researcher enters the classroom and waits while the children finish their task. Freya sees the researcher and tells her para she has to go. The researcher says she'll wait until she finishes but Freya has difficulty concentrating and is keen to go with the researcher. On the way to the start point Freya is observed to walk with an awkward gait on her tiptoes. This is likely to affect her speed.

At the start point, Freya walks beside the researcher, listening and looking around. In the yellow corridor, Freya reads, "Video Room," a room the researcher did not refer to. Further along the corridor towards the red doors, Freya says, "Presidents." She has noticed pictures of the presidents on the right hand side of the corridor. At the big red square Freya says she has been to this school before (using the past tense). The actual Art Room of two in the school is to the left but Freya shows no recognition of this when a right turn is made to follow the red squares. It is unlikely that she would have been to this Art Room anyway as it is for upper grades. Outside Classroom 7 and Classroom 8, Freya points to a long black scrape mark on the floor. She comments on the green corridor before the researcher does.

On the return trip, Freya comments on the same black scrape on the floor outside Classrooms 7 and 8. At the big red square she comments on the blue square ahead (the existing squares in the floor). In the yellow corridor, she again comments on the presidents she passed earlier. Proceeding down the yellow corridor towards the yellow doors, Freya comments on a crocodile on a poster on the right hand side, then a fish poster, then a space poster on the opposite wall. She has been observing posters in the corridor, focusing on small details. Back at the start point, Freya points out another black scrape on the floor nearby to the researcher.

Wayfinding Stage 2. At the start point Freya notes Classroom 1 and Classroom 2 and tells the researcher, "I told you I know the way." She is about 4′ ahead of the researcher but looks back, hesitant to leave. The researcher reassures her she's right behind her and she becomes more confident. Freya calls off all the signs in the orange corridor. She has no hesitation going through the yellow doors into the Media Center, now about 6′ in front of the researcher. In the yellow corridor she recalls posters of fish, the crocodile, and a cat (she had not referred to the cat before). She does not call off either sign to the Video Rooms, which the researcher did not refer to, and also misses the Media Work Room 1, (but remembers the cat poster).

Freya does not hesitate to turn behind the library counter, more confident at about

8′ ahead of the researcher. She points out "presidents" and "more presidents" in the corridor. She describes the red double doors as two old doors. Moving out of the media Center, she has no hesitation, pointing as she walks in the direction of the red squares on the floor, calling off Classrooms 7 and 8. She pauses at the music rooms to read all the signs. At the big green square she does not hesitate, she moves quickly, without looking at Classroom 9 and 10, and goes straight to the Art Room. There is a look of delight on her face as she turns to the researcher and says, "I made it to the Art Room."

Interview/Questionnaire. Freya felt happy with the researcher leading but nervous on her turn because she thought she was not going to make it but afterwards felt "very, very, very happy." Freya thought finding the Art Room was easy because she goes to school and could remember (although we know she could not have remembered that route). She feels confident she could find the room again because she remembers everything about the school as she used to go there (again using the past tense). The three things she most remembers are Classroom 1 and 2, the presidents, and the crocodile. Freya can remember all the colors, red, orange, yellow, and green. For shapes, she remembers squares; big squares with triangles (probably the large squares in the hallway with the existing triangles apparent); rectangles; and circles. She cannot remember, when asked, what the rectangles and circles were on but says she has trouble remembering sometimes. She remembers an oval in the Media Center (maybe the library counter).

Freya has excellent recall of the signs, calling off the magazines, the office, the music rooms, naming each in order of the route, all the classrooms in numerical order, and the Art Room. When asked about pictures, she specifically recalls the "No Entry" sign and the paint brush. Freya says she feels really confident going to a new place as she knows where she's going. The main thing she remembers is the orange square at the start point.

Summary. Freya found the Art Room directly with no prompts required. She took the slowest time due to the difficulties she had walking.

The colors of the wayfinding aids helped Freya to find her way around. She remembered different shapes. The signs and the pictures accompanying the signs proved very memorable in helping her to wayfind and she was able to accurately recall them. Interestingly she also frequently ignores the bigger picture to focus on small details that help her wayfind, a black scrape on the floor, a cat on a poster, pictures of presidents. She has used multiple cues from the environment to help her find her way around, both the applied wayfinding aids and other cues she found to help herself. In all that, she has also been able to focus on the wayfinding task at hand; memorable to her is the orange square at the start point and the paintbrush symbol at the destination point.

We know that during the normal school year Freya was anxious about finding her way around and had only recently gained enough confidence to find her way the short distance and direct route to the rest room. Freya admits that she was nervous to start with finding her way to the Art Room but the happiness and confidence she felt when she achieved her goal was evident. For her, the wayfinding aids and the activity had a profound effect.

Gemma's Experience (Treatment Group)

Gemma is an 8½ year old girl and has completed Grade 2. In addition to ASD, she needs fine motor support during the school year. Gemma has attended the school for previous ESY Summer Programs.

In-class observations. Gemma was observed in class on two occasions for approx. 1 hour each. She was the only female in a class of eight males, with a teacher and two paras. Gemma played with other children in class, initiating and responding to conversation with them and with her teachers. She listens to her teacher and responds appropriately to questions in class. Occasionally she fidgets in her seat. She appears manually dexterous playing with small game pieces and with a modelling compound. The main observation about Gemma is that she constantly needs reminding by teaching staff to put things away, e.g. to put her book back, to pick up her toys, to push her chair in. Once she is reminded she complies straight away as if she has forgotten rather than that she is being obstinate or deliberately non-compliant.

Wayfinding Stage 1. Gemma is reluctant to accompany the researcher, she avoids eye contact, facing the wall as she walks. She has been on vacation the previous week so she has not seen the researcher for a while. Gemma is noted to walk with an awkward gait. At the start point, the researcher has difficulty getting Gemma to concentrate as she reads the instructions. Gemma does not pause to listen when walking past the first set of orange doors and the researcher has to call her attention to point out the classroom picture. Gemma turns naturally towards the Media Center doors following the wayfinding aids. She asks irrelevant questions, her mind not on the task. She stops in the Media Center corridor to look at a poster of planets. She walks ahead of the researcher along the yellow circles on the floor and has to be called back to look at the No Entry door. Gemma is distracted when she sees the Computer Lab walls and guesses it might be a computer room. She walks past the library counter to look at the Computer Room door. The researcher has to call her back to focus on the task and leads them behind the library counter. Gemma notices the poster of presidents in the yellow corridor and talks about Abe Lincoln. She also notices a poster about reading on the opposite library wall "reading is magic" and says how she likes it.

The researcher gets Gemma back on task. In the red corridor, Gemma naturally follows the red squares on the floor. She walks ahead of the researcher who calls her attention to the Classroom 7 and 8 signs. Gemma walks ahead and reads the three music signs. The researcher stops her to explain the pictures. At the green corridor, Gemma is distracted by the janitor's equipment in the restroom area off the corridor. She then becomes focused on whether this part of the school is a middle school or a high school and this distracts her for some time. Also, framed pictures of children in this part of the corridor distract her. In the green corridor, Gemma recognizes the orange corridor and the start point are ahead and asks if they have nearly finished. The researcher calls her attention back to the Art Room. She has missed some parts of the script because Gemma is talking about something else and asking questions unrelated to the study.

On the return trip, Gemma is again very distracted talking about other things. She looks at the poster of presidents and touches a tactile, raised emblem of a badge on a plaque. In the yellow corridor, she stops for a long time looking at and naming all the planets on the poster before the researcher is able to get her back on task. Gemma also complains she is tired.

Wayfinding Stage 2. When it is her turn, Gemma talks about other things. She walks passed Classrooms 1 and 2 with no hesitation. She pauses at Classroom 5 and 6 and the researcher reminds her of her task. She enters the yellow corridor and is once again distracted by the planets poster. Gemma continues about 6′ ahead of the researcher, she is looking around and does not appear to be concentrating but has no hesitation in following the yellow circles behind the library counter. She comments on the presidents again. She does not read aloud any of the wayfinding signs but clearly can read well. She goes through the red doors out of the Media Center and has no hesitation following the red corridor although she does not appear to be paying attention. At Classroom 7 and 8 she pauses to talk and the researcher reminds her of her task at which she runs a little way along the corridor as if she knows where she is going. She shows no hesitation walking down the green corridor, past the green doors, appearing to be focused on getting back to the start point which she knows is ahead. At Classroom 12 the researcher reminds Gemma what her task is. She immediately remembers and goes straight back to the Art Room to collect the book.

Interview/Questionnaire. During the interview process Gemma interrupts the researcher several times to ask how many questions there are. She is anxious to finish. Her focus is that the exercise was a lot of walking so she rates the first question “just ok” with the researcher leading as it “was a lot of walking.” She was happy when she was leading because she wanted to lead the researcher. She felt the task was “ok” scary and when pressed explained this was because the Art Room was dark and the book was boring. She also thought it was "kind of difficult" because her feet hurt. She thought finding the Art Room was not easy, "a little bit easy," but recognized in herself, "I kind of lost track," and passed the Art Room. Gemma felt it was "just ok" finding the Art Room without directions as it was "a little bit difficult" and her feet were tired. Her physical condition has had an effect on her view of the task.

Regarding the three things she saw, Gemma remembers the Media Center with books, the poster about magic, and the washroom sign. Distracted from the interview she randomly tells the researcher the odd numbers are blue and the even numbers are red – she has noticed a frieze of numbers above the blackboard opposite the desk she is sat at. For colors she remembers orange, yellow, and green (but not red). She also remembers squares and circles in a straight line on the floor. For signs, she remembers instruments and the teacher teaching kids but cannot recall the words that accompanied the signs. When she goes to a new place she says she feels a little bit happy wayfinding as she likes to go new places. Finally, Gemma is asked what the main thing is she remembered. She replies without hesitation, "The Art Room door was blue with a lot of cool colors." The researcher thinks she is confused, (the door was green), but goes back to check and, applied to the vision panel, is a blue film with patterns on. No-one else, including the researcher, had noticed this.

Summary. Gemma completed the task in the slowest time, taking over twice as long as the fastest participant, not surprising given her constant interruptions to talk about other things that she saw in the environment rather than concentrating on the task in hand.

The researcher had to remind her nine times to focus on the task. The difficulties Gemma had walking were also reflected in the slower time. So distracted was she that she found the Art Room but carried on walking past it and had to be reminded of the task.

The colored floor aids notably helped Gemma to navigate and she remembers shapes and color along the route. Considering she is able to read well she does not read any of the signs during the study and she cannot recall any of the signs afterwards. Some of the pictograms were more memorable for her. Instead, Gemma focusses on small details in the environment to help her navigate, Abe Lincoln on a poster, images of planets on a poster, and words on a poster.

Gemma had the ability to know that it was important in the task to find a cue to help her remember where the Art Room was. She failed to use the big picture, the Art Room sign, the picture of the paintbrush, the green door, but instead focused on the small detail, the vinyl material applied to the vision panel.

Gemma did not enjoy the wayfinding task because she did not like the walking component. Also she was anxious to finish the task and the interview which may have been a combination of boredom or anxiety to get back to her classroom.

Harry's Experience (Treatment Group)

Harry is 9½ years old and has just completed Grade 4. He identifies as a Black male.

In-class observations. Harry was observed on two occasions for approx. 1 hour periods. He was in a class of seven with 6 males and 1 female, with a teacher and two paras. He was talkative in class, both to his classmates and responding to the teacher's questions. He complies with instructions. On the second observation, Harry had a glove on his hand which distracted him for much of the class, flicking his gloved hand in front of his face, not listening to the teacher, disengaged with a reading activity. He lacked concentration and engagement in other class activities and fidgeted, swaying backwards and forwards, banging the back of his head on the desk a few times, clicking his fingers, playing with the glove, and playing with a piece of ribbon.

Wayfinding Stage 1. Collecting him from the classroom, Harry is wary of the researcher. It is hard to get him to talk on the way to the start point. He has been on vacation the previous week so has missed seeing the researcher. At the start point, he listens intently to instructions, nods assent, but makes no eye contact. He walks unusually close to the researcher for a child with ASD. He is silent on the route. In the yellow corridor, Harry walks ahead of the researcher looking around to observe. The researcher calls him back to point out the Media Work Room 1 sign. Harry moves ahead again but is silent. At the turn into the red corridor and the turn into the green corridor Harry is ahead of the researcher, automatically following the wayfinding aids.

On the return trip, Harry nods at the three red music doors. In the yellow corridor he is about 2′ ahead. He often looks back, at one time hearing the door close behind by the para who is following. He seems aware of her presence but says nothing. He looks anxious, slightly ahead down the orange corridor, but still close to the researcher.

Wayfinding Stage 2. At his turn, Harry starts off quickly without waiting for the researcher to finish the script, about 8′ ahead, silent. He enters the Media Center, looks around confidently, then looks back for the researcher but he is still about 8′ ahead. He quickly walks behind the library counter without hesitation. At the big red square he is about 8′ ahead, hears the para coming through the door, and looks back. He pauses to look at Classroom 7 and 8 as if to remember but does not look at the three red music doors.

At the big green square Harry pauses, facing the direction of the green corridor and says, “Which way?” The researcher asks which way he thinks. He points towards the green route and says again, “This way?” seeking reassurance from the researcher. She asks if he remembers anything about that way, if it looks familiar. He looks around, points again, and walks down the green corridor. Harry walks slowly past the first two green classroom doors, looking at them intently, then speeds up walking as if he has remembered, about 8′ ahead of the researcher he finds the Art Room.

Interview/Questionnaire. Harry is the only participant who expresses he was “a little scared,” worried they were going to get lost. He felt “just ok” when he was leading but was unable to expand on why he felt like that. Harry is the only participant who said the exercise was scary and that he thought they were going to get lost. He did not find the task difficult, he thought it was easy following the colors orange, green, and red (though he had given no verbal clues as he went along). When questioned how he would feel if he had to find the Art Room on his own he said “unhappy,” when pressed because he had already done it. He seemed to be expressing because he had already done it he did not want to be asked to do it again.

The three things Harry remembered from the task were doors, colors, and signs.

He recounted all four colors, orange, green, red, and yellow. For shapes he remembers yellow circles on the floor and squares on the floor. He remembers signs for classrooms and workrooms but cannot remember any of the pictures that accompanied them. Harry feels unhappy when he has to go to a new place by himself without his parents or someone he knows. The main thing he remembers is collecting the book.

Summary. Harry found the Art Room in the median time for all participants. He went directly to the Art room though he did need a verbal prompt. Throughout the wayfinding task Harry presented as an anxious child which was not how he appeared in class. In the interview afterwards he expressed his fear of getting lost and dislike of going to new places. For him, finding his way around the school environment was an anxious task.

Despite the fact that Harry was using all the colored wayfinding aids, referring to doors, colors, and signs, he still lacked confidence and needed verbal reassurance that he had chosen the correct route down the green corridor. While he remembers words on the signs, the pictures had not helped him.

Summary

This section presented the findings of the research study, including demographic information, description of the physical school environment, the data analyses to answer the research questions, individual observations about the participants and the interview process. The researcher conducted the study in an ethical manner, checking back on what the participants said in their interviews to correlate them with the environment. Regarding the research questions, the results did not err in favor of the hypotheses.

However, the statistical data only tells part of the story and the observational and interview data about individual participants is perhaps more illuminating and tells us more about the behavior of children with ASD when they are wayfinding to a destination than statistics can. From observational and interview data collected, children with ASD varied widely in their actions and what they used to help them wayfind during the wayfinding task, probably more that in the general population. This would not be surprising given that children with ASD differ so widely along the spectrum of their condition. The following chapter discusses the implications of the findings.

CHAPTER 5: CONCLUSIONS

This exploratory research study was designed to answer the question of whether wayfinding aids applied along the corridors in a school would increase the ability of children with ASD to find their way without or with minimal verbal or physical assistance. In addition, the study wanted to find out what children with ASD thought about this wayfinding experience and what information they used from the environment to help them navigate. Nine participants took part in the experiment and the conclusions represent the quantitative and qualitative data collected.

Effect of Wayfinding Treatment on Children with ASD

According to the quantitative data collected, the provision of wayfinding aids did not enable the participants to find their way to the destination more often than participants who had to find their way to the same destination without wayfinding aids. Both groups reached the destination with equal success. However, the wayfinding aids did enable all children in the treatment group to find their way directly to the destination as opposed to the control group where one child found the destination but indirectly.

Despite the quantitative data from this small sample indicating that the wayfinding aids had insignificant statistical effects, the qualitative data collected indicates that they had a positive effect. Both the observational and interview data showed that the provision of wayfinding aids had a noticeably positive effect on some children with ASD. Some children followed the colored aids instinctively at Stage 1 when it was the researcher's turn to lead without waiting for the researcher to provide instructions in wayfinding. The positive effect of wayfinding aids in the environment is also supported as the children in the treatment group were able to recall colors and shapes with more frequency than participants in the control group. The findings suggest the addition of wayfinding aids had a positive effect on children with ASD although, for a variety of factors, we cannot say that they found their way more often to a destination than children who found their way without wayfinding aids. This has implications for researchers in that, although the results are encouraging, a larger study would help test this theory further and allow the results to be generalizable.

These results also have implications for designers involved in the construction and refurbishment of schools and the commissioning bodies of these buildings. Application of wayfinding aids were shown to have a positive effect on cognition of children with ASD which likely helped them find their way around the school more effectively; no negative effects due to the addition of wayfinding aids were identified. Moreover, wayfinding aids help the general population so their application would benefit everyone in the school and not negatively impact students with ASD. However, without positive results from a larger sample, it could be difficult to persuade designers and commissioning bodies to commit resources to retrofit such aids in an existing school. What is practical is to persuade designers to provide aids such as the ones used in this study in a new build or at the time of refurbishment. Installing different colored aids would be at no additional cost compared to installing uniform colored features throughout, such as the same colored doors or the same colored signage.

Effect of Individual Wayfinding Aids on Children with ASD

One of the aims of the study was to find out what cues in the interior environment provided memorable wayfinding information to participants in the experiment, specifically the overall color of the wayfinding aids, the colored doors, colored shapes on the floor, and signage.

Color. Color clearly had a great effect on participants in the treatment group. Some participants automatically followed the wayfinding aids even before the researcher could instruct them in Stage 1 of the study. All participants in the treatment group perceived all four colors and were able to remember them afterwards. Some recalled what form the colors took, e.g. yellow circles on the floor. By contrast, participants in the control group had difficulty remembering colors in the existing environment which must have made their wayfinding task more difficult. They also had difficulty recalling what features in the corridor colors had been applied to. The fact that all the corridors looked the same probably accounted for the fact that one participant in the control group initially went to an incorrect destination. This effect would likely have been more pronounced if the route had been longer or more complex.

In this study, color was applied to a small area in the school. A designer involved in implementation of a wayfinding strategy for a new school or refurbishment of an existing school would need to consider how to apply color over more extensive areas so that it made cognitive sense with the layout of the building.

Colored doors. Although some participants in the treatment group commented on the colored doors others did not mention them specifically but they likely contributed to the overall impression of color in the corridors. Participants in the control group, however, did not remember any doors with the exception of one participant who remembered the unique feature of the stable door. In designing a new school or refurbishing an existing school colored doors would be beneficial to enhance the overall effect of color in the corridor. However, at transition times, when many doors would be open, the colored effect would be less visible. This is one of the limitations of the study in that all doors were closed and therefore more noticeable. Children with ASD may need wayfinding training in both situations when doors are closed and open. As an alternative, in this particular school, and others designed similarly, static lockers could be colored to become wayfinding aids. Although lockers were not studied as a variable here, they may have a similar effect of providing a colored wayfinding aid in corridors.

Colored shapes on the floor. For participants in the treatment group, colored shapes on the floor provided a wayfinding cue which several participants automatically wanted to follow. They perceived not only the colors but the two different shapes, squares and circles. Some participants in the control group were able to recall existing shapes in the floor but because the same shape and color combinations were present throughout the route they provided no distinct wayfinding cues. Designers could provide different colored shapes in the floor to help children with ASD find their way around. This is difficult to do in an existing school unless an extensive refurbishment and renewal of floor covering is planned but is certainly practical in a new build. Creating shapes in the floor is more expensive for a flooring contractor to fit; ironically, the school where the experiment took place had gone to the expense of installing shapes in the floor but, because they were all the same color, they provided no distinct wayfinding aid.

Signage. The signage had a great effect on participants in the treatment group.

Most participants were able to remember the majority of signs, calling off the room names afterwards. Room names had been simplified to aid participants and confusing numbering systems eradicated. Signs in different colors stood out in the corridors helping participants to identify rooms. By contrast, because there was no logical labelling or numbering format perceptible in the existing signs and they were all the same color, participants in the control group had difficulty remembering them. In a new school or refurbishing an existing school, designers should be mindful to apply signs that are logical for children with ASD rather than applying signs that have little meaning or that they may not understand.

If a numbering system is used this should also be simple and logical. In this study this was achieved by omitting numbers altogether if they were unique rooms, e.g. Music Room or Computer Room. Where there were several rooms with the same name, e.g. classrooms, doors were numbered sequentially in the order they were perceived, counting up or down depending on the direction of travel. Numbers used were single or double digits only with no additional letters. Color combined with the number provided additional identification, e.g. Classroom 1 on an orange and a green sign. If facilities management staff required specific door numbers these could be applied in small text at the top of the door to avoid confusing users. In practice, signs would need to comply with ADA guidelines so would need to be tactile raised and in Braille but their appearance would not differ markedly from the signs applied in the wayfinding study.

Pictograms used in combination with text made the route more memorable and supported the written word for children with ASD in the treatment group. In future designers could use pictograms to support text on signs wherever possible as children with ASD are often taught using pictures. This method would not only help children wayfind but would also support their classroom learning.

Effect of a Combination of Wayfinding Aids

At the outset of the study, the decision was made to test a combination of wayfinding aids rather than the normal research practice of testing each aid individually and comparing their effects. The results of this study showed that participants in the treatment group did reference different aids to a greater or lesser extent likely due to the variation in characteristics of children with ASD. For example, some children used the signage with text and pictograms while some recalled the text but had difficulty remembering the pictograms. Although the sample was small, it indicates that this population varies so much in their characteristics that a combination of wayfinding aids is likely to support a greater number of children. This has implications for designers in that they may need to specify a number of combined aids and, for commissioners of such designs, that they will need to fund several aids rather than just one.

Variation in use of Wayfinding Aids/Cues by Children with ASD

An interesting outcome from the study was discovering what participants in the control and treatment groups used as wayfinding aids or cues. In this context, aids were the colored doors, colored shapes on the floor, and signage, and cues described other features in the environment. Many participants, in both groups, remembered posters, or specific parts of posters, that helped them find their way around. For example, Ian remembered a picture featuring a dog, Freya noticed a crocodile on a poster, and Gemma perceived individual planets on an astronomy poster. Regarding other wayfinding cues used, Freya, in the treatment group, noticed small rubber scrape marks on the floor that stood out for her against the overall look of the corridor. Brad, in the control group, used smell to help orientate himself, being aware of the odor of polish in the Media Center. Gemma failed to see the Art Room door with large scale colored wayfinding aids but saw the small scale patterned film applied to the vision panel in the door. For Danny, in the treatment group, signs had a profound effect whereas Gemma, also in the treatment group, could not remember the words on the signs. Ian, in the control group, found his way by perceiving and remembering complex shapes in the environment. If more participants had taken part they may have used different cues. This reinforces how children with ASD differ in their characteristics; this variation in use of aids/cues would probably not have been found in the general population or in a wayfinding experiment with typically developing children.

From the above, the conclusion can be drawn that children with ASD use a variety of wayfinding cues in the environment. This means that applying several aids simultaneously, e.g. colored doors, colored shapes on the floor, and signage, including text and pictograms, could help a greater number of children. If a teacher or para were to take a child with ASD individually on a wayfinding activity, such as the one in the study, and questioned them afterwards, they may be able to find out what the child saw and used while wayfinding, including any unique or unexpected wayfinding cues. This could be implemented as a strategy to help that child find their way around.

Wayfinding as an Evidence-Based Design Intervention for Children with ASD

Although the wayfinding aids provided as a treatment were colored doors, colored shapes on the floor, and signage, the wayfinding scripts read by the researcher were a variable in the study. Nothing in the literature anticipated the effect of the wayfinding scripts, although, as previously noted, there is an absence of literature directly related to wayfinding experiments with children with ASD. The constant variable in the two study groups was that both groups received individual instruction in wayfinding, showing them cues or aids in the environment to help them navigate. After this instructional intervention, participants in both groups were able to find their way to the destination point. This finding suggests that children with ASD, when given detailed wayfinding instructions, may be able to find their way to a given destination in an untreated corridor and a corridor treated with wayfinding aids.

This has implications for educators who could use wayfinding as an interventional strategy to help children with ASD find their way around. For example, educators could take learning opportunities to teach children about wayfinding cues in the existing environment which could help them find their way from their classroom to the playground or from the bus to their classroom, etc. As this study demonstrated, wayfinding intervention is possible even in an existing environment that has not been treated with wayfinding aids. Moreover, it is an inexpensive and easy intervention to administer with no specialist training. Teachers could instruct children individually and also in a group, letting children take turns leading. For example, during the ESY Summer Program where the study took place, it was common practice for children to line up in the classroom and for the para or teacher to lead the way to the restroom, playground, etc. If the class were given instruction, individuals could then be asked to lead the class to their destination, expanding educational opportunities beyond the classroom.

This method could also be applied to ABA style training, where children with ASD are given intense, individual instruction, to learn how to wayfind in an environment as an EBD intervention. Furthermore, the majority of students in this study enjoyed rather than resisted the process. A further study measuring anxiety pre-and post-treatment could indicate if wayfinding and experiencing success in completing a goal has an effect on anxiety.

Wayfinding as an intervention could also be useful to clinicians who diagnose and treat children with ASD. For example, clinicians could develop a wayfinding route in a building, lead the child with ASD around, and question them afterwards to gain an understanding of their cognitive ability and how they perceive the environment. They may find out, for example, such as this study did, that Brad is affected by light, and sound, and smells, and that Gemma is distracted by many things in the environment, particularly visual images. This could possibly enable clinicians to tailor interventions and design treatment plans dependent on how the child views the world.

Wayfinding as an EBD intervention for children with ASD has implications for other people and other places. Although this study only took place in a school environment it may apply to other environments. Parents could try using wayfinding strategies to help their child with ASD become more familiar with environments outside the home and school. This is particularly relevant as children with ASD are often uncomfortable or anxious in unfamiliar environments. In this study, Harry expressed his anxiety about new environments and getting lost. Ian was fresh from his experiences at Universal Studios and his fear of getting lost there. Freya was known to be an anxious child unable to find her way from the bus to the classroom or from her classroom to the special education room on her own. Parents could, for example, use a wayfinding intervention in a supermarket and select wayfinding cues to help their child find their way to their favorite food. Or they could use a wayfinding intervention that may help their child find their way to the doctor's office in a clinic, a commonly visited setting. Again, this would be a simple intervention for parents to administer that may lessen anxiety and increase independence.

Assistance Required by Children with ASD in a Wayfinding Task

It had been anticipated that participants in the study would need a range of assistance methods to complete the wayfinding task, such as verbal and physical reminders, from the researcher. In the field, the researcher did not need to administer any physical reminders and administered only one verbal reassurance to a participant to confirm they were going the correct way. This is promising as the lack of prompts needed by children in the study is an indicator that some children with this level of ASD, having received instruction in wayfinding as an intervention, may be able to find their way ultimately without anyone accompanying them.

The researcher did, however, need to administer frequent reminders to several participants to keep them on task and remind them where they were going. Conversely, it may be that some children, even with this high-functioning level of ASD, may never be able to wayfind independently; they may always need the presence of a teacher or para just to keep them on task. A longitudinal study would be required to test the short and long term effects of these interventions.

Emotional Effects of Wayfinding on Children with ASD

One of the aims of the study was to find out what children with ASD felt about the task of wayfinding. Participants in the control group reported on their experience wayfinding in a school corridor using existing wayfinding cues and participants in the treatment group reported on their experience with the application of wayfinding aids, colored doors, colored shapes on the floor, and signage. Overall, participants in both groups enjoyed their experience wayfinding. This is encouraging because it implies that children with ASD would enjoy doing this type of activity as part of their individual education plan to learn new skills. For participants who expressed a particular fear of getting lost in the environment, helping them develop wayfinding strategies by using cues from their environment could enable them to feel more confident and less stressed when they have to interact with the physical environment. Wayfinding is an important skill they could learn and potentially take from elementary school to high school and beyond into adulthood.

We know from the literature review that many people with ASD reported difficulties finding their way around school and for some that caused anxiety and a sense of being different compared to their peers. One of the outcomes of this study, noted through observation of the children carrying out the wayfinding activity and by their comments in the interview afterwards, was that children expressed a sense of achievement and pride in being able to navigate to a destination. These feelings are important to foster in all children but particularly in children with ASD who often face many challenges. Successful wayfinding could also increase self-esteem. Children with ASD in this study were successful at a task which they had probably never been asked to do before – lead the way to a destination.

Applicability of Person-Environment Fit Theory to Experiments with Children with ASD

This study investigated several theories to find the one most applicable to wayfinding with children with ASD. Many theories were considered but some promising theories were untested. P-E Fit Theory was selected because it had been tested in many previous studies, though none with children with ASD that could be found. The premise of P-E Fit Theory, that by altering the environment to suit humans they will have a better experience, was applicable to this research. For participants in the treatment group the wayfinding aids in general helped them find their way around more easily and more confidently. For some, the manipulation of the wayfinding aids did not go far enough to adapt the environment to suit them. For example, Gemma in the treatment group was distracted by extraneous information in the environment, particularly posters, and found it difficult to concentrate on the task making it more difficult for her to find her way around in a timely fashion. Removing all the posters from the environment might help her concentrate more but it would also remove important wayfinding cues that she and other participants, both in the control and treatment group, used to navigate.

Another example is Brad in the control group. One of the reasons he had difficulty focusing on the task was because of his hypersensitivity to the environment, the smell of polish, distant noises, and light. It would be impractical and probably impossible to remove everything that could be a stimulus to him. For children with ASD with these types of characteristics and sensitivities, designers may never be able to tailor the environment enough to fit them perfectly. However, based on this study, P-E Fit Theory can be held as an appropriate theory to guide further research in wayfinding studies with children with ASD.

Applicability of Lynch's Elements of Legibility to Experiments with Children with ASD

In this study a combination of wayfinding aids were tested. Aids were applied in accordance with Lynch's Elements of Legibility (1960). Colored doors became landmarks or edges, colored shapes in the floor acted as paths, and signage provided legibility. The library counter acted as a node and a landmark; participants were told to "remember this place" and most participants referred to it. Although Lynch's framework had not been found cited previously in environmental research with children with ASD it proved appropriate. Participants purposefully followed the colored paths, perceived the doors on the edges of the route, read the signs, and recalled the library counter as a landmark. The study also highlighted some limitations of Lynch's theory, that one child particularly took auditory and olfactory information from the environment to use as a wayfinding cue which Lynch did not include in the Elements of Legibility framework. The findings suggest the importance of expanding consideration of elements in the environment because the children with ASD in this study mentioned sensitivity to a broader range of elements.

Demonstration of Weak Central Coherence Theory

One of the characteristics of children with ASD highlighted in the literature review is their inability to see the big picture but instead to focus on small details, known as Weak Central Coherence Theory (Baron-Cohen, 2008; Frith, 2003). Baron-Cohen (2008) linked this to stimulus in the environment and stressed the importance of sensitive environmental design. In this study, the manifestation of weak central coherence and hypersensitivity to the environment were evident in many of the children with ASD. For example, Brad was clearly overwhelmed by visual, olfactory, and auditory information, even personifying Baron-Cohen's stress caused by "radios playing even at a distance" (p. 56). Freya saw details on posters and small scrapes on the floor. Gemma also saw details on posters. Ian noticed not large expanses of color on the lockers but small colored shapes applied to the lockers. Corey remembered a washroom sink seen in his peripheral vision off the main corridor. Despite these behaviors, all the children in the study were also capable of seeing the big picture in that they were able to perceive and navigate the whole route and find the destination point. The implications for clinicians and educators are that the information gathered from this study supports Weak Central Coherence Theory as applied to an interior environment. For designers, this knowledge could help them consider ways of designing corridors in schools to reduce the number of distractions for children with ASD. This study did not set out to test Weak Central Coherence Theory but it was a surprising finding, a demonstration of what may occur in fieldwork designed to better understand children with ASD.

Demonstration of Hyper- and Hyposensitive Behaviors in the Environment

In tandem with weak central coherence discussed above, participants with ASD in the study in both the treatment and control groups clearly demonstrated hyper- and hyposensitivity to the environment. The extent to which they were affected and what caused their sensitivities varied between participants. Brad experienced hypersensitivity to the environment; distractions were everywhere, in visual, olfactory, and auditory information. Gemma was particularly hypersensitive to visual information, pictures and words easily distracted her. By contrast, Danny demonstrated a hyposensitivity to the internal environment. He showed no interest in the environment until he saw the visual color in the corridors which clearly animated and engaged him. These findings suggest the importance of understanding the interactions between individual students with ASD and their school environment. A larger group of participants is likely to demonstrate additional elements in the interior which hyper- or hypostimulate students with ASD.

Documenting an EBD Experiment with Children with ASD

One of the drivers for this study was the current lack of EBD research into the design of the environment suitable for children with ASD. By documenting in detail the steps taken to conduct the research it was hoped to lay a foundation that other researchers could use in similar experiments. Accordingly, the study documented in detail each phase and what had to be done to ensure a robust experiment that also protected the child participants. This included: selection of participants; approval and consent process; setting up the school site for the experiment; design, procurement, manufacture, and application of wayfinding aids; writing wayfinding scripts; pre-testing the wayfinding route; recruitment of participants and reminder process; pre-study observations; instructions to teachers; data collection methods; post-study interview/questionnaire process; concluding the study; and description of measurement variables. In short, the study details all the steps to enable other researchers to conduct their own similar research. A timeline is also included to alert others that an experiment of this nature can be a lengthy process and to plan accordingly. The approvals that needed to be secured from the relevant school district and the Institutional Review Board required time-consuming negotiation and much paperwork. The number of participants was small and the findings of the study are not generalizable but the process to conduct the study can be adapted and used elsewhere.

A point to note for future studies, the decision was made to use typically developing children in the pilot test for reasons outlined in Chapter 3. Post-study we support this view since the findings indicate that children with ASD varied so much in their wayfinding behavior all foreseen circumstances could not have been identified.

Collecting Quantitative and Qualitative Data in a Wayfinding Experiment with Children with ASD

In this study, both quantitative and qualitative data were collected to provide a balanced combination of metrics to interpret the results. In a small study such as this, nine participants, the quantitative data is not generalizable but collecting it is no less valid. The production of quantifiable data, usually considered the epitome of research, also helps to drive the interior design profession forward. However, this study found that the individual characteristics of children with ASD had an extrinsic effect on the data and made it difficult to draw direct comparisons between groups. Even in a larger sample, a similar effect may be found. Quantitative data collected for a larger sample (30 is usually considered generalizable) is likely to give stronger quantitative results but alone would miss important qualitative data.

The qualitative data collected opened a window into the cognitive processes of children with ASD and their perceptual abilities. Quantitative data would not have captured this valuable information. In short, with the variation in characteristics of this particular population, children with ASD, collecting both quantitative and qualitative data in a study such as this is considered important and likely to give more relevant results.

Design of Elementary School Corridors

Research in the literature review indicated that a clearly signed, legible environment is easier for all users to find their way around. Although no previous studies were found that used children with ASD as participants in a wayfinding experiment, the literature review indicated that children with ASD would benefit from clear wayfinding as much as the general population. In this study, participants in both groups were all able to find their way around the corridors with just one participant in the control group initially going to the wrong room. It was evident, however, that the colored wayfinding aids made it easier and more memorable for children in the treatment group to find their way around; they could remember colors, shapes, and pictures and words on signs. The importance of color in wayfinding was evident. It is therefore a recommendation that in future designers consider implementing these types of wayfinding aids when they are designing or refurbishing corridors in elementary schools. Costs are generally the same whatever colors are used so this is not a limiting factor. Use of color in wayfinding will help all users to find their way around not just children with ASD. Sometimes, for the designer working to a budget, color is the only aesthetic available.

Wayfinding as a Tool to see a Child with ASD's Perspective

By using a wayfinding script, taking a child with ASD on a route, and conducting a questionnaire process afterwards, educators, designers, and clinicians could gain an understanding of how a child with ASD perceives their environment. This could help designers suggest design strategies for children. For example, if we know that children like Brad and Gemma are unduly distracted and overwhelmed by sensory information in the environment, designers could consider how to create suitable educational environments for them, such as individual work cubicles. It could also help educators find out learning preference styles for children with ASD. For example, we know that Ian sees shapes in the environment. Educators could link this to teaching methodology to help him learn. They could adapt and personalize educational tools for children with ASD who may see details in the environment, or colors, or signs. It might also help clinicians recommend interventional treatments based on how the child perceives their environment. This is all further work that needs to be tested but this study provides a foundation.

Limitations

The main limitation of this study is that a small number of participants took part, nine, meaning there is insufficient quantitative data to make assumptions and generalize the findings. Other limitations were fully discussed in Chapter 3. Another limitation noted here is that the research took place when the school was not in general session so participants were not disturbed by other users as they would potentially be during normal passing times in the school corridors. Some children are likely to be distracted by other users and some to be sensitive to the noise, proximity, and even smell of other users, which may affect their ability to wayfind. Educators often scaffold the learning of children with ASD so for some wayfinding could begin with the child accompanied on a route in a quiet corridor, then on their own in a quiet corridor, and progress to wayfinding in a corridor at passing times when they are busier. Further research would be needed to test this.

Future Research

This study took place in a particular school along a particular route with a limited number of participants. As such, the results are not generalizable. However, the procedure used to conduct the study is transferable to similar wayfinding research in other buildings with children with ASD. This could include not only other elementary schools but also middle and high schools and even colleges. Wayfinding could be tested with participants from different age groups. It could be particularly effective for older youth in high school or adults in college who are more aware of their difficulties finding their way around and on whom there is more societal pressure to be independent in this task. Wayfinding could be used as a strategy to help them. Additionally, wayfinding research could be tested in other environments which children with ASD use regularly with their families, such as clinics or supermarkets. Particularly in larger environments, pointing out wayfinding cues to help them find their way around could help children with ASD feel less stress.

It would also be interesting to conduct this research as a longitudinal study, testing participants to find out whether they could remember the route the next day, the next month, etc. Also, it would be interesting to find out what would happen if participants were asked to undertake the second stage of the wayfinding task independently without the researcher in attendance, how would they fare and how would they feel? These tests would tell us more about the cognitive processes of children with ASD.

Another continuation of this study would be to test wayfinding aids as an EBD intervention with children with lower functioning levels of ASD. In this case educators could work one-on-one with a child using an ABA treatment approach. Educators may need to enforce the wayfinding over many weeks or months to test whether children with lower functioning levels of ASD could find their way around more independently.

Dissemination of Results

The researcher afterwards felt it a great privilege to have been able to share the wayfinding experience with the participants, children with ASD, and for that period of time to be able to see the environment through their eyes, to see what they see. The researcher has a responsibility to share that information with other researchers, with designers and educators, which the participants cannot do. To date presentations have been accepted to the annual conferences of the Interior Design Educators Council and the Environmental Design Research Association.

Summary

This research aimed to find out whether wayfinding aids applied in the school environment could help children with ASD to navigate. It also aimed to find out what children with ASD remembered and perceived about the environment as they were wayfinding. The results indicated that children with ASD at this functioning level can be taught to find their way around a school and that wayfinding aids are beneficial to cognition and perception. One frustration the results raised for this researcher as a designer is *how can I design for a population who is aware of elements in the environment that I am not aware of?* Those small details, smells, and sounds affected them but not me. This exploratory study also aimed to start to fill the void in EBD research into the environment with children with ASD by employing a robust experimental methodology. Although it represents only a small study, using a particular element in the environment, it is hoped it will stimulate additional much-needed research.

Perhaps one of the most important results of the study was that it also found what others have stated, that children with ASD have a unique way of viewing the world and that the designed environment has a strong effect on them. The interpretation of qualitative data in this study possibly provides the first insight of its kind for others into a previously unexplored world inhabited by a small number of children whose needs should be better understood and provided for. The more research such as this that is conducted the more designers will be able to find out how children with ASD perceive the world and how they can design environments to support them. The time the researcher spent with the children in the study and had the opportunity to see the world through their eyes was a privilege and provided an insight into this unique and special population.

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Appendix A. Selection Criteria

Aids to Support Children with Autism Spectrum Disorder (ASD)

Screening Criteria will be administered by ESY Program Administrator/Lead Teacher at Northern Elementary School, North Metro School District (NMSD).

Eligible participants will be identified through NMSD database as follows:

- Child has registered to attend the Extended School Year's Summer Program 2016
- Child has been assigned a place at Northern Elementary School
- Child has a diagnosis of ASD as recorded on their IEP
- Child is aged 8-11
- Child is able to communicate verbally in simple words or sentences
- Child is able to follow simple instructions and accompany the researcher during the study

Participants will be identified as ineligible if:

- Child currently attends Northern Elementary School as their neighborhood school
- Child has challenging behavior indicator/Crisis Prevention Intervention

If the child is eligible to take part in the study the Recruitment Pack (containing a Parental Consent Form, a Child Assent Form and a stamped addressed envelope) will be enclosed and mailed out to parents with ESY Summer Program information from NMSD.

Appendix B. Parental Consent Form

Aids to Support Children with Autism Spectrum Disorder (ASD)

Dear Parent/Guardian,

Your child is invited to be in a research study about school design. North Metro School District (NMSD) has identified that your child would be a suitable participant based on the study criteria. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

Background Information:
The purpose of this study is to find out whether changes in the design of the school interior could help children with ASD. NMSD has given approval to conduct this study during the Extended School Year Summer Program 2016 at Northern Elementary School.

Procedures:
If you agree for your child to be in this study, we would ask him/her to do the following things:

- Be assigned to a group
- Be observed in class to get to know them
- Walk with the paraprofessional and the researcher from one room in the school to another and back again
- Walk on their own from one room in the school to another; the paraprofessional and researcher will follow and provide assistance as needed
- Be videotaped and audiotaped during the study
- Answer a few short questions about their experience
- The anticipated length of participation is up to one hour during one class period

We would ask you to do the following:

- Explain the study to your child
- Consent for NMSD to provide demographic information about your child to the researcher to inform the study, i.e. child's gender, date of birth, ethnicity. primary language, intellectual disability, and any visual impairment, hearing impairment or motor disability.
- Complete a short questionnaire at the end of this form
- Discuss your child's participation with him/her a few days prior to the study and on the morning of the study in order to ease any anxiety

Risks and Benefits of being in the Study:
The study has several risks: your child could become visibly upset or frustrated during the study. The likelihood of the risk will depend on your child's characteristics but should this happen the researcher will terminate the study. A paraprofessional will be present at all times during the study to assist your child.

The benefits to participation are: First, your child may enjoy the experience; Second, your child could help further knowledge about the design of the school interior for children with ASD.

Compensation:

Your child will receive payment: a certificate congratulating him/her for taking part in the study; a small gift with the University of Minnesota logo. Your child will receive this payment for taking part in the study even if the study is terminated for the reasons noted above. No payment will be received if the child is withdrawn from the study

Confidentiality:

The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify your child. Research records including video/audiotapes will be stored securely and only researchers will have access to the records. Study data will be encrypted according to current University policy for protection of confidentiality and securely destroyed one year after the date of the study.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota or NMSD or any school operating under NMSD. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:

The researcher conducting this study is: Julie E. N. Irish. If you have any questions **you are encouraged** to contact me at College of Design, University of Minnesota, 240 McNeal Hall, 1985 Buford Ave., St. Paul, MN 55108; (763) 951 3771 or e-mail irish026@umn.edu. You may also contact my adviser Dr. Barbara Martinson, University of Minnesota, via e-mail bmartins@umn.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

If you would like to learn more about this opportunity, there is going to be an Optional Informational Meeting at Northern Elementary School on June 15th 2016 at 5pm where I will outline the study and answer any questions. Representatives from NMSD will also be present.

I appreciate your willingness to allow your child to help me in this research effort.

Yours sincerely,

Julie E. N. Irish, Doctoral Candidate, University of Minnesota

Consent Forms and Pre-Study Questionnaire

Please return the completed forms by June 17th 2016 either by e-mail to irish026@umn.edu (please scan in the form with your signature on), or by post in the stamped addressed envelope provided, or hand to me at the Optional Informational Meeting. Please sign only the consent forms that you agree for your child to participate in. Leave blank the consent forms that you do not consent for your child to participate in.

1) Statement of Consent: Participation

I have read the above information. I have asked any questions and received answers. I consent for my child *(insert child's name)* ________________________ to participate in the study.

Signature of parent or guardian:_____________________________

Date: __________________

Signature of researcher:____________________________________

Date: __________________

2) Statement of Consent: Disclosure of Demographic Information

I have read the above information. I have asked any questions and received answers. I consent for the researcher to obtain my child's demographic information from North Metro School District. I consent for North Metro School District to disclose my child's *(insert child's name)* _______________________ demographic information to Julie E.

CONSENT TO DISCLOSE INFORMATION	Parent/guardian initial permission **YES**	**NO**
Gender		
Date of Birth (as there may be a difference between younger and older children)		
Ethnicity (as there are reports of a higher incidence of ASD in some populations)		
Primary language (as the child may have more difficulty understanding the researcher)		
Intellectual disability none, borderline, mild or moderate (as this may be an indicator of understanding the researcher)		
Visual, hearing, or motor disability (so that the researcher can make accommodations)		

N. Irish.

Signature of parent or guardian:____________________________

Date: __________________

Signature of researcher:___________________________________

Date: __________________

3) Statement of Consent: Videotape

I have read the above information. I have asked any questions and received answers. I consent for my child *(insert child's name)* ________________________ to be videotaped during the study.

Signature of parent or guardian:_____________________________

Date: __________________

Signature of researcher:____________________________________

Date: __________________

4) Statement of Consent: Audiotape

I have read the above information. I have asked any questions and received answers. I consent for my child *(insert child's name)* ________________________ to be audiotaped during the study.

Signature of parent or guardian:_____________________________

Date: __________________

Signature of researcher:____________________________________

Date: __________________

You will be given a copy of this information and the signed consent forms to keep for your records.

Please also answer the following questionnaire:

Pre-Study Questionnaire to Parents/Guardians

How familiar is your child with Northern Elementary School, Northern, Minnesota?

Please put an X in the box that applies (are true). You can check more than one box if they apply.

My child has:

- ☐ Never visited the school.
- ☐ Visited the school occasionally 1-3 times (for example, for an orientation day or for a brother’s, sister’s, or friend’s activity).
- ☐ Visited the school more than 3 times (for example, for a summer transition program).
- ☐ Visited the school more than 5 times and is familiar with the layout of the school.
- ☐ Attended the school previously for Extended School Years (ESY) Summer Program

Receiving Further Information:
If you would prefer to receive further correspondence about this study (such as results) direct from the researcher by mail or e mail rather than via the school district please provide your address or e mail below:

Name of parent or guardian: ____

Mailing address: ____

____

____

____

E mail address: ____

Appendix C. Child Assent Form

School Study

(This form may be read by or read to potential participants)

Hello,

I am a researcher at the University of Minnesota. I am asking if you are willing to help us in our research study because we are trying to learn more about kids your age.

Your mom or dad or the person that cares for you has said it is ok for you to be in this study.

If you agree to be in this study we will ask you to take part in a fun activity. We will ask you to do this at school during the summer program. The researcher will be with you to tell you what to do and to help you.

Your teacher has said it is ok for you to take part in the study during the day so you won't be tardy or in trouble because you have missed lesson time.

If you agree to be in this study, we will ask you to do something that involves walking around the school. During the study the researcher will video you and record what you say. Being in this study is totally up to you, and no one will be mad at you if you don't want to do it.

You can ask any questions that you have about this study. If you have a question later that you didn't think of now, you can ask later.

Signing here means that you have read this paper or had it read to you and that you are willing to be in this study. If you don't want to be in this study, don't sign. Remember, being in this study is up to you, and no one will be mad at you if you don't sign this or even if you change your mind later.

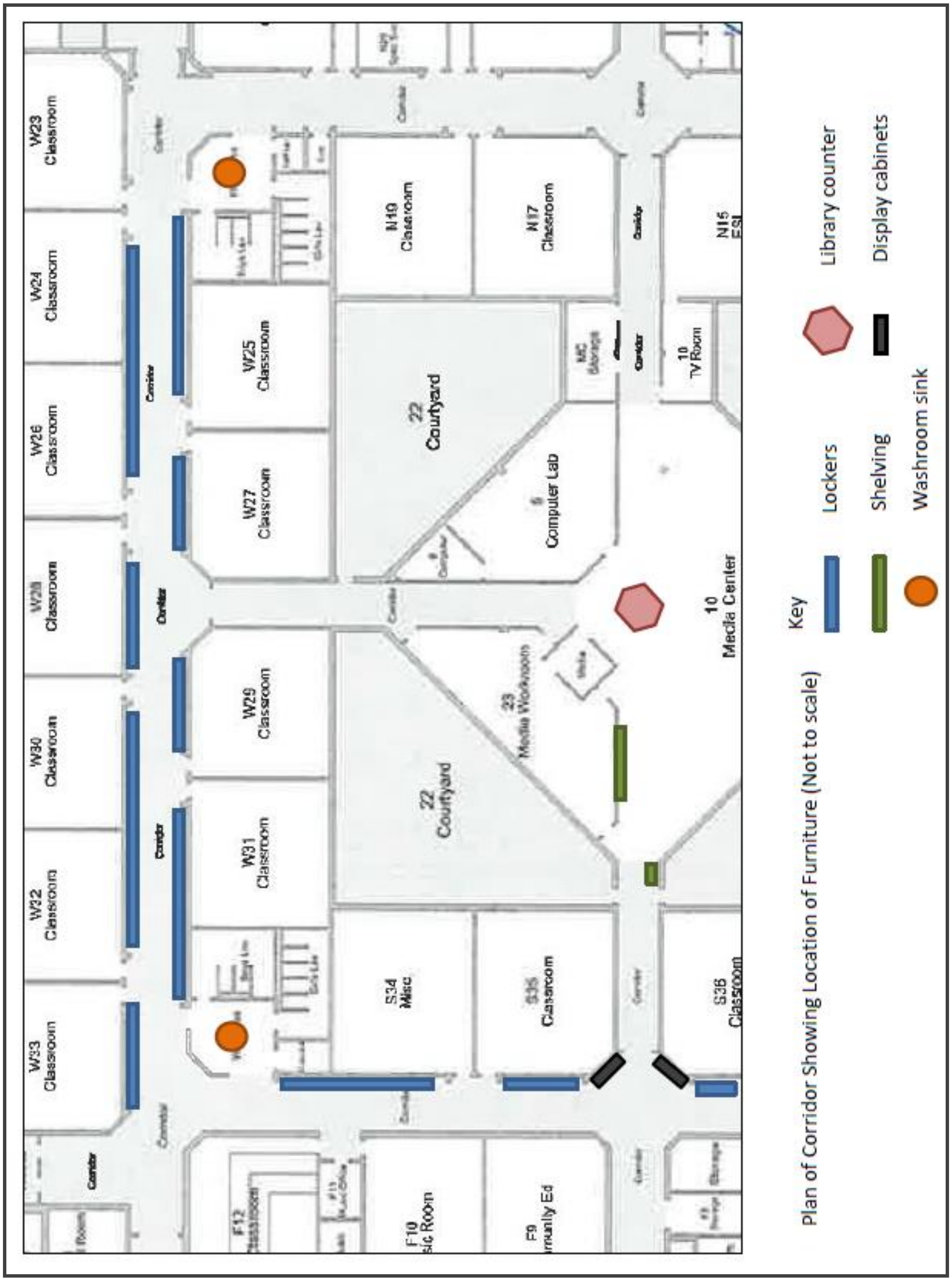
Signature of participant____

Name of participant____

Signature of person explaining study_____________________________

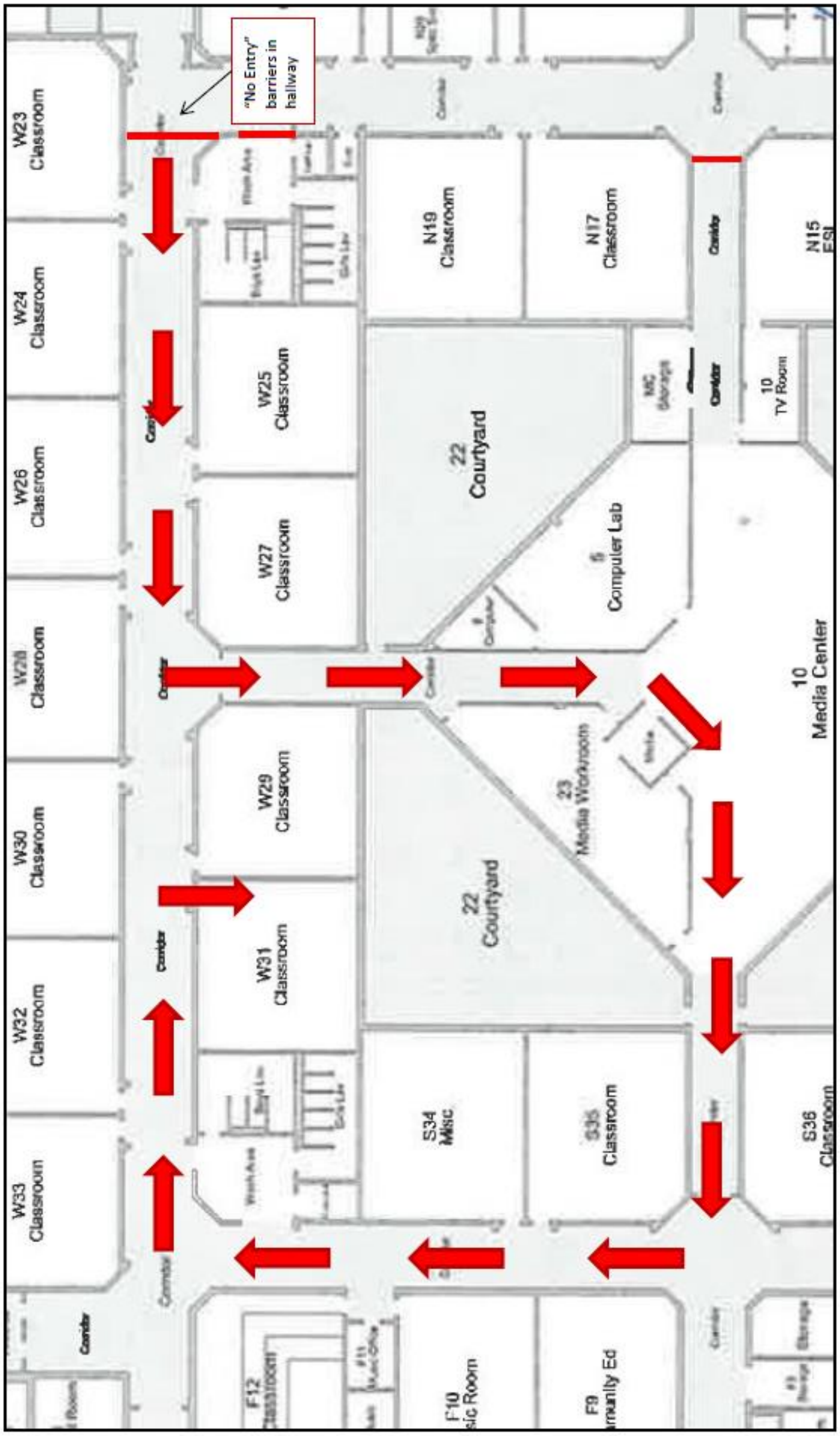
Date_______________________

Appendix D. Plan of the Corridor

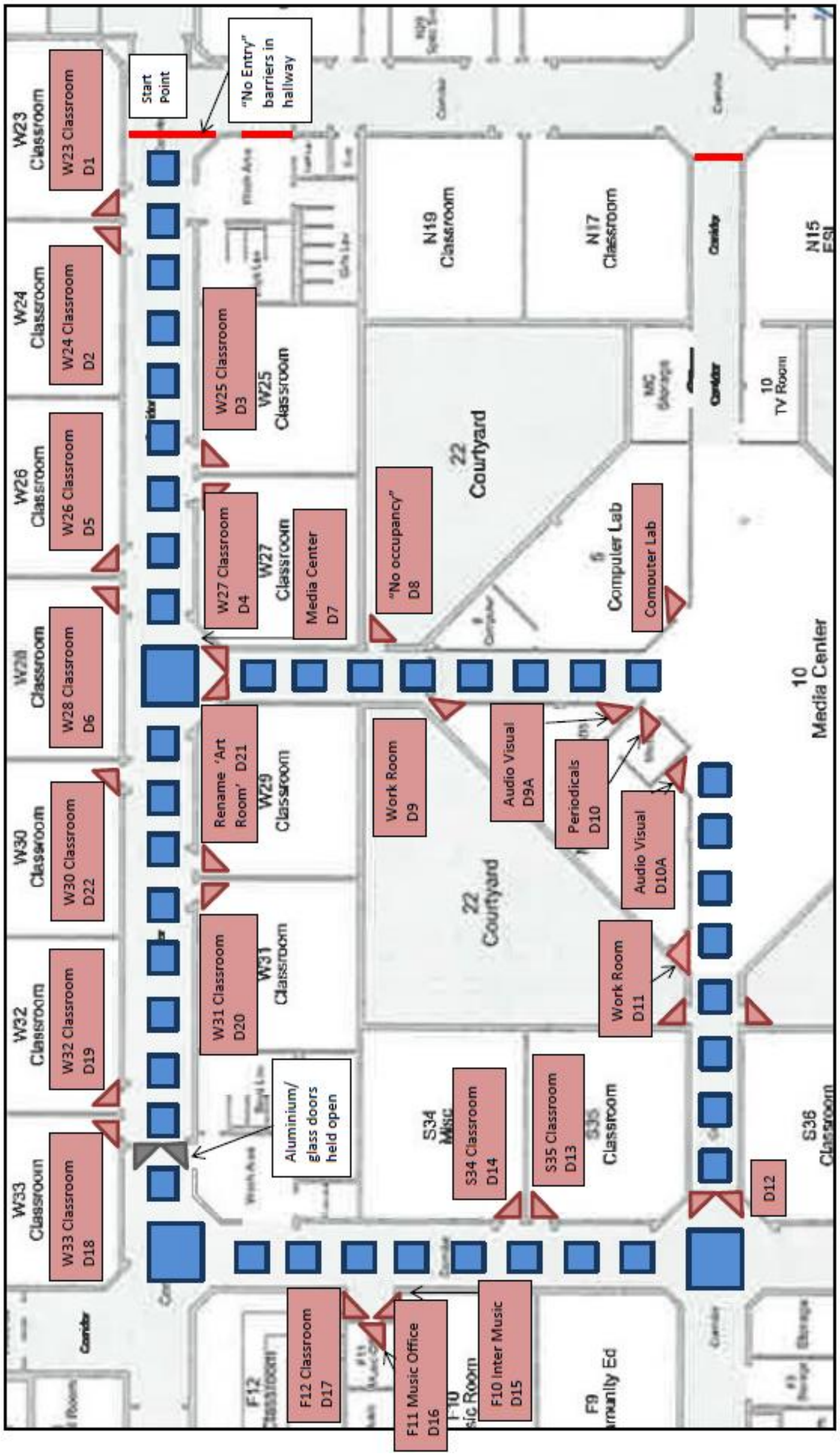


Plan of Corridor Showing Location of Furniture (Not to scale)

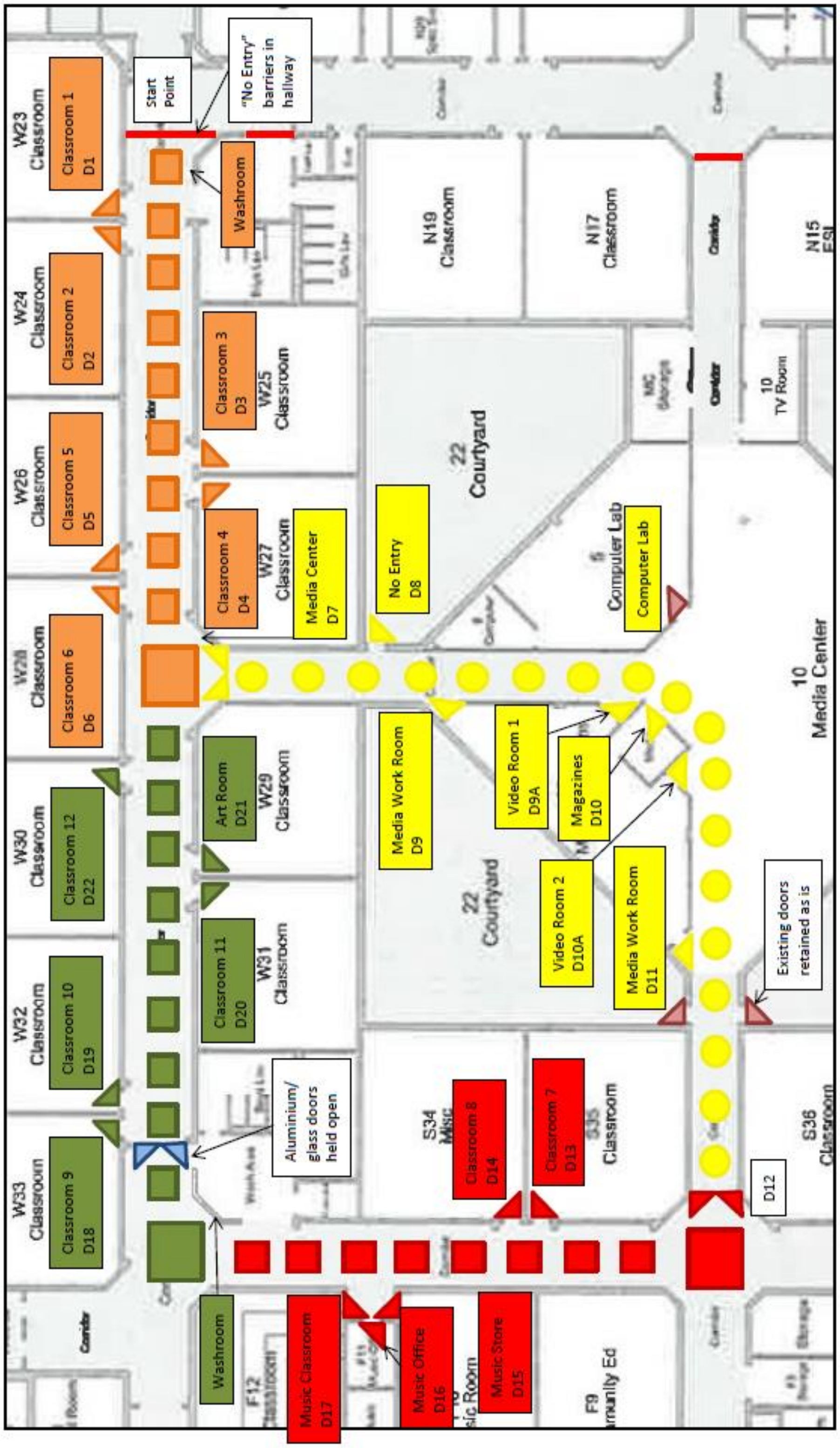
Appendix E. Plan of Designated Route



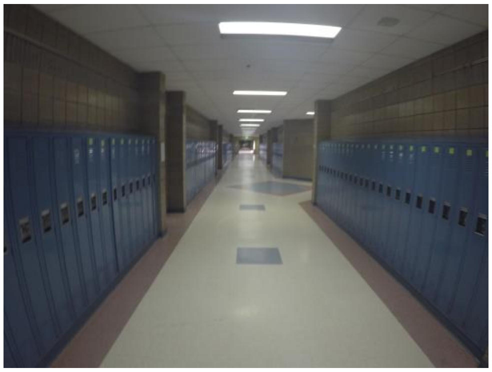
Appendix F. Plan of Existing Wayfinding for Control Group

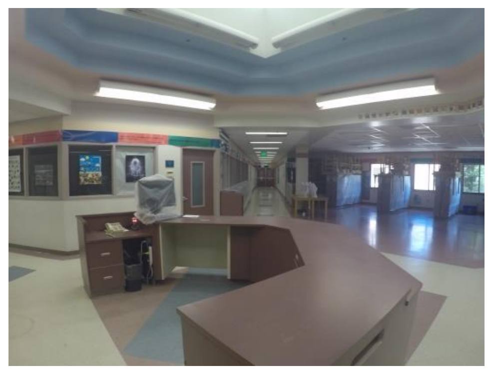
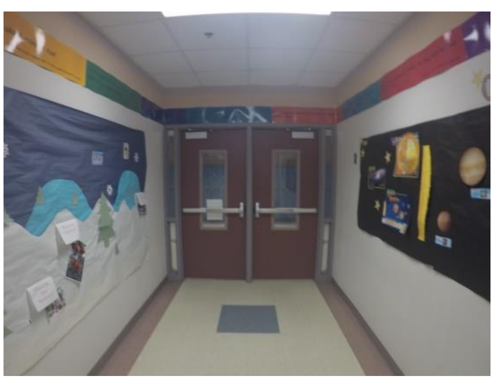


Appendix G. Plan of Wayfinding Aids for Treatment Group



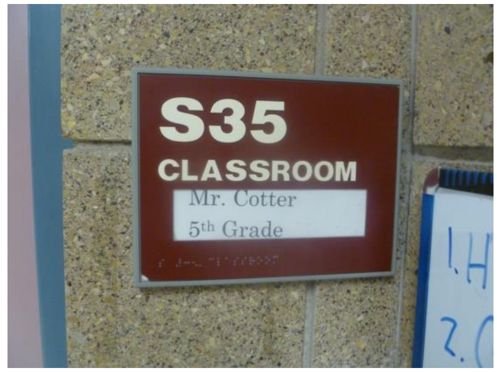
Appendix H. Photographs of Control Route





W29
CLASSROOM
Ms. Myers
5th Grade


S35
CLASSROOM
Mr. Cotter
5th Grade


EXIT

Appendix I. Script for Participants in the Control Group

Participant name: **Rm. no:**

Camera ref. no: **Audio ref. no:**

Para: Please follow us discreetly behind about half a hallway length behind us so you can see us but you are not obvious to us

(In the classroom)

Hello ________________, I'm Miss Julie you've seen me in your class. It is time for us to do the fun study together. Are you ready? The teacher has said it is ok for you to leave the classroom. Come with me and we'll get started!

(Walk to start of route. Carry out casual conversation to help participant feel at ease).

How old are you?

When's your birthday?

What grade will you be in when you go back to school in September?

What school will you be going to in September?

(Arrive at start of route).

We are allowed to go under this barrier because we are in the research study together.

(Stand on a blue square on the floor).

Ok, we've arrived at our start point. Listen while I tell you what we are going to do. We are going to find our way to the Art Room as we need to collect a book from the Art Room.

First, I am going to lead the way to the Art Room. I'll show you things along the way to help us find the way there. Then I'll lead us back here to the start point (indicate blue square).

Next, I am going to ask you to lead the way to the Art Room. Try to remember what you see along the hallway the first time I lead you to help you find your way there when you are leading. When you are leading I'll be walking just behind you. Don't worry if you forget the way you can ask me for help. I know the way so we won't get lost.

Afterwards I'll ask you some questions about what we did.

Don't worry, I'll remind you what to do as we go along.

Are you ready? Do you have any questions? Then let's go!

(Start walking along the control route).

We are leaving the start point here (indicate down) by this wall (indicate left). We are going to walk down this hallway (indicate the direction).

Notice there are two doors here (indicate right). Can you see the signs here W23 Classroom and W24 Classroom (indicate right)? We will walk past them.

There are two more doors here (indicate left). One has a sign W25 Classroom and the other has a sign W27 Classroom (indicate left). We will walk past them.

And here's another set of doors. They have signs W26 Classroom and W28 Classroom (indicate right). Let's continue walking.

Now we have got to this big area in the hallway. We are going to turn here (indicate right) and go through these big doors into the Media Centre (indicate left).

We'll open these doors now and go through.

Can you see the hallway ahead? We will follow this hallway (indicate forward).

There is a door and a sign with writing on the door (indicate left). We will walk past that.

We are going to walk past another door here (indicate right). Let's keep walking.

We have come to the library counter in the Media Center. Look up and remember this place. We could walk that way (indicate left), or that way (indicate ahead) but we are going to walk this way (indicate right). We are going to walk behind the library counter and keep following the hallway this way (indicate right).

The library counter is by another door here (indicate left). Let's walk past it.

We are heading towards those big doors (indicate ahead).

There's another door here (indicate right) (*Work Room*). Let's keep walking.

We've got to the big doors. We have to open these doors. Now we are in another big hallway.

We can walk straight ahead, we can turn that way (indicate left) or we can turn this way (indicate right). We are going to walk this way down this hallway (indicate right).

There are two more doors here (indicate right) and signs S35 Classroom and S34 Classroom. We will walk past these.

Now we have got to a place with three doors (indicate left). They all have different signs by the doors (indicate right). F10 Inter Music, F11 Music Office and F12 Classroom. We will walk past them.

We are at another big area in the hallway. It is by the washroom (indicate right).

We could turn that way (indicate left), we could walk over there (indicate left ahead) but we are going to turn this way along this hallway (indicate right). So remember we walked along that hallway (indicate behind) and now we are going to turn this way down this corridor (indicate directions).

Can you see there are two doors here with signs W33 Classroom and W32 Classroom (indicate left)? We will walk past them. We will keep walking.

Now we have got to two more doors (indicate right). One has a sign W29 Classroom and the other has a sign Art Room (indicate right). The Art Room! That is the room we are looking for! We have found it!

(Pause at Art Room)

We won't go in the Art Room now but next time we will go in to collect the book. Now remember I am going to lead us back to the start point back the way we came and then it will be your turn to lead the way to the Art Room.

Ok, let's go back to the start point. I will lead us back to the start point and remind you of some of the things we saw on the way here to help you lead the way next time. Next time you will be leading us to find the Art Room and we will need to go inside the room so we can collect a book from inside the room.

(Return from Art Room to Start Point along control route)

So now we are heading back to the start point. We are starting off in this hallway, outside the Art Room.

We are going back past the doors with the signs W32 Classroom and W33 Classroom (indicate right).

We have got to the washroom (indicate left).

Now we have got to the big hallway.

There is another hallway straight ahead but we will turn this way (indicate left) and keep walking back along this hallway.

Remember these three doors (indicate right)? We are walking back past them.

We are also walking back past the doors with the signs S34 Classroom and S35 Classroom (indicate left).

Now we have got back to the big place in the floor (indicate down). We can go straight ahead or we can go down there (indicate right) but we are going to turn this way (indicate left) towards those big doors that we walked through before.

We will open the doors. Now we are back in this hallway. Let's walk on.

This is the door that we passed earlier (indicate left) (*Work Room).*

We will walk back along this hallway. Remember we passed this library counter? We walked behind the library counter.

We walked passed this door (indicate left) *(periodicals).*

We are going to turn here (indicate left) and keep following this hallway back the way we came.

There is the door with the sign on the door (indicate right) that we walked past earlier. Let's keep walking.

Now we have got to the big doors. We will open the doors and go back out of the Media Center.

We're back in the hallway again. There is a hallway that way (indicate left) but we are going to turn this way (indicate right) and go back down the hallway. This is the hallway we started in.

Remember we passed these two doors with the signs W28 Classroom and W26 Classroom (indicate left)? We are going to walk back past these.

Then we passed these two doors with the signs W27 Classroom and W25 Classroom (indicate left).

We also passed these two doors with the signs W24 Classroom and W23 Classroom (indicate right)? We are going to walk back past these.

Now we have arrived back here at our Start Point (indicate right).

(Pause at Start Point)

Now you are going to lead us back the same way to the Art Room. I'll be right behind you. If you don't remember the way don't worry you can ask me for help. I know the way so we won't get lost.

As we walk along the hallway tell me if you see anything that you remember from when we walked along it the first time. Tell me if you remember seeing any colors that we walked past. Tell me if you remember any shapes that we walked past. Tell me if you remember any signs that we walked past. Tell me anything else that you remember seeing from the first time. Remember you are trying to find the way to the Art Room as we need to collect a book from inside the room.

Let me just get ready.

TURN CAMERA ON

TURN RECORD BUTTON ON

RECORD START TIME: ________________________

GET OBS PLAN READY

Are you ready? Do you have any questions? Then let's go!

(Participant leads the way to the Art Room along the control route)

Contingency comments if participant is unsure of route:

Do you need some help?

Do you think you are going the right way?

You are going the right way.

You are not going the right way. We walked past this door/shape/sign. Carry on and try again.

Do you remember we walked past this door/shape/sign?

Do you remember which way to go now?

(On arrival at the Art Room).

Well done you've found the Art Room! Let's go inside and you can collect the book.

RECORD FINISH TIME: ________________________

TURN RECORD BUTTON OFF

TURN CAMERA OFF

(Go inside the Art Room and collect the book. Researcher carries the book).

Now I will take us back to the start point. I have a few questions to ask you when we get there. Let's go.

(Walk back along the control route to the Start Point . Carry out casual conversation to help participant feel at ease).

What is your favorite subject in school?

Do you have any brothers or sisters?

Do you like sports?

What sports do you play?

(Arrive back at the Start Point. Ok we are back at the Start Point. Now we will go into my room so I can ask you some questions.

(Go to a room/area by the Start Point to administer the questionnaire).

We will just go in here and sit down so I can ask you some questions.

(Administer interview/questionnaire).

Thank-you for helping me with my study. You've been really helpful. Here is a certificate and a small gift to thank you for helping.

(Hand over certificate and gift).

Now I will take you back to your classroom.

(**Take participant back to their classroom).**

End.

Appendix J. Script for Participants in the Treatment Group

Participant name: **Rm. no:**

Camera ref. no: **Audio ref. no:**

Para: Please follow us discreetly behind about half a hallway length behind us so you can see us but you are not obvious to us

(In the classroom)

Hello ________________, I'm Miss Julie you've seen me in your class. It is time for us to do the fun study together. Are you ready? The teacher has said it is ok for you to leave the classroom. Come with me and we'll get started!

(Walk to start of route. Carry out casual conversation to help participant feel at ease).

How old are you?

When's your birthday?

What grade will you be in when you go back to school in September?

What school will you be going to in September?

(Arrive at start of route).

We are allowed to go under this barrier because we are in the research study together.

(Stand on a blue square on the floor).

Ok, we've arrived at our start point. Listen while I tell you what we are going to do. We are going to find our way to the Art Room as we need to collect a book from the Art Room.

First, I am going to lead the way to the Art Room. I'll show you things along the way to help us find the way there. Then I'll lead us back here to the start point (indicate blue square).

Next, I am going to ask you to lead the way to the Art Room. Try to remember what you see along the hallway the first time I lead you to help you find your way there when you are leading. When you are leading I'll be walking just behind you. Don't worry if you forget the way you can ask me for help. I know the way so we won't get lost.

Afterwards I'll ask you some questions about what we did.

Don't worry, I'll remind you what to do as we go along.

Are you ready? Do you have any questions? Then let's go!

(Start walking along the treatment route).

We are leaving the start point here at this orange square (indicate down) by this wall with the orange sign washroom and the picture washroom (indicate left). We are going to walk down this hallway with the orange squares (indicate the direction).

Notice there are two orange doors here (indicate right). Can you see the orange signs here with the words Classroom 1 and Classroom 2 and the picture of a classroom with the teacher and children (indicate right)? We will walk past them.

There are two more orange doors here (indicate left). One has an orange sign Classroom 3 and the other has a sign Classroom 4 and they have the picture of the classroom (indicate left). We will walk past them.

And here's another set of orange doors. They have signs and pictures Classroom 5 and Classroom 6 (indicate right). Let's continue walking.

Now we have got to this big area in the hallway with the big orange square on the floor. We are going to turn here (indicate right) and go through these big yellow doors into the Media Centre (indicate left). See the yellow sign Media Centre with the picture that looks like a book in a library.

We'll open these yellow doors now and go through.

Can you see the yellow circles in the hallway ahead? We will follow these yellow circles (indicate forward).

There is a yellow door and a yellow sign with the words and picture no entry on the door (indicate left). We will walk past that.

We are going to walk past another yellow door here (indicate right). It has a yellow sign Media Work Room 1 and a picture that looks like someone working at a desk. Let's keep walking.

We have come to the library counter in the Media Center. Look up and remember this place. We could walk that way (indicate left), or that way (indicate ahead) but we are going to walk this way following the yellow circles on the floor (indicate right). We are going to walk behind the library counter and keep following the yellow hallway this way (indicate right).

The library counter is by another yellow door here with a sign and a picture Magazines (indicate left). Let's walk past it.

We are heading towards those big yellow doors (indicate ahead).

There's another door here with a sign Media Work Room 2 and the same picture of someone working at a desk (indicate right). Let's keep walking.

We've got to the big yellow doors. We have to open these doors. Now we are in another big hallway with a big red square on the floor.

We can walk straight ahead, we can turn that way (indicate left) or we can turn this way down the red hallway (indicate right). We are going to walk this way down this hallway with the red squares on the floor (indicate right).

There are two more red doors here (indicate right) and signs and pictures Classroom 7 and Classroom 8. We will walk past these.

Now we have got to a place with three red doors (indicate left). They all have different red signs by the doors to do with music (indicate right). Music Store with pictures of musical instruments; Music Office, with pictures of a music note and someone working in an office; and Music Classroom with pictures of musical notes. We will walk past them.

We are at another big area in the hallway with a big green square on the floor (indicate down). It is by a green sign Washroom and a washroom picture (indicate right).

We could turn that way (indicate left), we could walk over there (indicate left ahead) but we are going to turn this way along this green hallway (indicate right). So remember we walked along that red hallway (indicate behind) and now we are going to turn this way down this green hallway (indicate directions).

Can you see there are two green doors here with signs and pictures Classroom 9 and Classroom 10 (indicate left)? We will walk past them. We will keep walking.

Now we have got to two more green doors (indicate right). One has a green sign Art Room and a picture of a paintbrush and the other has a green sign Classroom 11 (indicate right). The Art Room! That is the room we are looking for! We have found it!

(Pause at Art Room)

We won't go in the Art Room now but next time we will go in to collect the book. Now remember I am going to lead us back to the start point back the way we came and then it will be your turn to lead the way to the Art Room.

Ok, let's go back to the start point. I will lead us back to the start point and remind you of some of the things we saw on the way here to help you lead the way next time. Next time you will be leading us to find the Art Room and we will need to go inside the room so we can collect a book from inside the room.

(Return from Art Room to Start Point along treatment route)

So now we are heading back to the start point. We are starting off in this green hallway, outside the Art Room with the sign with the picture of a paintbrush.

We are going back past the green doors with the green signs Classroom 10 and Classroom 9 (indicate right).

We have got to the green sign and the picture Washroom (indicate left).

Now we have got to the big hallway with the big green square on the floor.

There is another hallway straight ahead but we will turn this way (indicate left) and keep walking back along this red hallway.

Remember these three red doors with the red signs to do with music with music notes and musical instruments (indicate right)? We are walking back past them.

We are also walking back past the red doors with the red signs Classroom 8 and Classroom 7 (indicate left).

Now we have got back to the place in the floor with the big red square (indicate down). We can go straight ahead or we can go down there (indicate right) but we are going to turn this way (indicate left) towards those big red doors that we walked through before.

We will open the doors. Now we are back in this yellow hallway with the yellow circles on the floor. Let's walk on.

This is the yellow door that we passed earlier with the yellow sign and picture Media Work Room 2 (indicate left).

We will walk back along this yellow hallway with the yellow circles on the floor. Remember we passed this library counter?   We followed the yellow circles and walked behind the library counter.

We walked passed this yellow door with the yellow sign Magazines and the picture of magazines (indicate left).

We are going to turn here (indicate left) and keep following the yellow circles in this hallway back the way we came.

There is the yellow door with the yellow No Entry sign on the door (indicate right) that we walked past earlier. Let's keep walking.

Now we have got to the big yellow doors. We will open the doors and go back out of the Media Center. Remember the yellow sign Media Center with the picture that looks like a book in a library (indicate right)?

We're back in the orange hallway again with the big orange square on the floor. There is a hallway that way (indicate left) but we are going to turn this way (indicate right) and go back down the hallway with the orange squares. This is the hallway we started in.

Remember we passed these two orange doors with the orange signs and pictures Classroom 6 and Classroom 5 (indicate left)? We are going to walk back past these.

Then we passed these two orange doors with the orange signs Classroom 4 and Classroom 3 (indicate left).

We also passed these two orange doors with the orange signs Classroom 2 and Classroom 1 (indicate right)? We are going to walk back past these.

Now we have arrived back here at our Start Point the orange square on the floor with the orange sign and picture Washroom (indicate right).

(Pause at Start Point)

Now you are going to lead us back the same way to the Art Room. I'll be right behind you. If you don't remember the way don't worry you can ask me for help. I know the way so we won't get lost.

As we walk along the hallway tell me if you see anything that you remember from when we walked along it the first time. Tell me if you remember seeing any colors that we walked past. Tell me if you remember any shapes that we walked past. Tell me if you remember any signs that we walked past. Tell me anything else that you remember seeing from the first time. Remember you are trying to find the way to the Art Room as we need to collect a book from inside the room.

Let me just get ready.

TURN CAMERA ON

TURN RECORD BUTTON ON

RECORD START TIME: ________________________

GET OBS PLAN READY

Are you ready? Do you have any questions? Then let's go!

(Participant leads the way to the Art Room along the treatment route)

Contingency comments if participant is unsure of route:

Do you need some help?

Do you think you are going the right way?

You are going the right way.

You are not going the right way. We walked past this door/shape/sign. Carry on and try again.

Do you remember we walked past this door/shape/sign?

Do you remember which way to go now?

(On arrival at the Art Room).

Well done you've found the Art Room! Let's go inside and you can collect the book.

RECORD FINISH TIME: ________________________

TURN RECORD BUTTON OFF

TURN CAMERA OFF

(Go inside the Art Room and collect the book. Researcher carries the book).

Now I will take us back to the start point. I have a few questions to ask you when we get there. Let's go.

(Walk back along the treatment route to the Start Point . Carry out casual conversation to help participant feel at ease).

What is your favorite subject in school?

Do you have any brothers or sisters?

Do you like sports?

What sports do you play?

(Arrive back at the Start Point).

Ok we are back at the Start Point. Now we will go into my room so I can ask you some questions.

(Go to a room/area by the Start Point to administer the questionnaire).

We will just go in here and sit down so I can ask you some questions.

(Administer interview/questionnaire).

Thank-you for helping me with my study. You've been really helpful. Here is a certificate and a small gift to thank you for helping.

(Hand over certificate and gift).

Now I will take you back to your classroom.

(**Take participant back to their classroom).**

End.

Appendix K. Recruitment Advert for Paraprofessional

Job Opportunity

Do you know someone who would be interested in working with a graduate student from the University of Minnesota and gaining experience in special education?

I am a doctoral candidate at the University of Minnesota and will be conducting research this summer. I am seeking a paraeducator assistant to help in classrooms with children with Autism Spectrum Disorder (ASD).

a. The minimum requirements for a paraeducator during the summer are:
i. Must be a high school graduate
ii. Must be willing to lift with no restrictions
iii. A plus would be experience working with special education students (but not required)
iv. Must be willing to work with students on functional skills and some behaviors
v. Toileting of students may be required

b. Attendance will be required:
i. From 8.45am-12.15pm, Tuesday July 5th- Friday July 15th, 2016
ii. Attend a work day on Wednesday June 15th to become familiar with the staff and the routines

c. Must be able to travel to location at Northern Elementary School, Northern, MN

d. Must go through the application process for North Metro School District and employment will be through North Metro School District

e. Rate of pay is $13.63/hr.

Appendix L. Follow-up Letter

Dear Parent/Guardian,

I am an interior designer from the United Kingdom studying for a PhD at the College of Design, University of Minnesota. I recently wrote to you asking if you would consent to allow your child to help me with my research study. The purpose of my study is to find out whether changes in the design of the school interior could help children with autism spectrum disorder (ASD).

The original letter and consent forms are enclosed again for your convenience. Please consider allowing your child to take part in this study.

If you have any questions please contact me by telephone (763) 951 3771 or by e-mail irish026@umn.edu. You may also contact my adviser Dr. Barbara Martinson, University of Minnesota, via e-mail bmartins@umn.edu.

If you choose to participate in this study please return the completed forms to me by *insert date* either by e-mail (please scan in the form with your signature on), or by mail in the stamped addressed envelope provided.

I appreciate your willingness to allow your child to help me in this research effort and thank you for your consideration.

Yours sincerely,

Julie E. N. Irish, MSc
Doctoral Candidate
College of Design
University of Minnesota
240 McNeal Hall
1985 Buford Ave.
St. Paul, MN 55108

Appendix M. Script for Teacher

Name of Teacher:

Name of Participant:

Date:

General Class introductions:

This is Miss Julie. She is a researcher from the University of Minnesota. She is going to be in class with us this week. She will be doing some reading in the class. Some of you will be helping her learn how we find our way around the school next week or the week after.

Date:

The week before:

______________________I have heard that you are going to be helping Miss Julie with her research study next week. That sounds like fun. I'll remind you about it again next week.

Date:

Two days before:

________________________Remember you are going to be with helping Miss Julie with her research study in two days' time at _______________. Don't worry if you miss class time. You will be back in class in time for the next lesson/to get the bus home. I'll remind you about it again tomorrow.

Date:

The day before:

____________________________Remember you are going to be helping Miss Julie with her research study tomorrow at ___________________. Don't worry if you miss class time. You will be back in class in time for the next lesson/to get the bus home. I'll remind you about it again tomorrow.

Date:

The day of the study:

____________________________Remember you are going to be taking part in a research study with Miss Julie today at _____________________. Don't worry if you miss class time. You will be back in class in time for the next lesson/to get the bus home. Miss Julie will come and get you when it is time, and the paraprofessional will also come.

Appendix N. Reminder to Parents/Guardians

Dear Parent/Guardian,

Your child is due to take part in the research study about school design on

____

Please discuss your child's participation with him/her a few days prior to the study and on the morning of the study in order to ease any anxiety

Thank-you!

Julie E. N. Irish, Doctoral Candidate, University of Minnesota

Appendix O. Pre-Study Observation Sheet

Name of participant: Date: Rm no.:

Behavior/Frequency:

Time Interval:	Verbal communication (response or initiate) to T/P/C	Makes eye contact with T/P/C	RRB/Plays with object(s)/ other distraction(s) RRB/O/D	Carries out teacher's instructions Y/N/P
9.00-9.15				
9.16-9.30				
9.31-9.45				
9.46-10.00				
10.01-10.15				
10.16-10.30				
10.31-10.45				
10.46-11.00				
11.01-11.15				
11.16-11.30				
11.31-11.45				

Key

T = Teacher
A = Paraprofessional
C = classmate

RRB = restricted repetitive behavior
O = plays with object/s
D = affected by other distraction/s e.g. light, noise

Y = yes
N = no
P = needs prompts

Appendix P. Post-Study Interview/Questionnaire to Participants

Name of participant:

I will ask you some questions and I want to know how you feel in answer to the questions.

Please circle the best answer from the smiley faces:

☹☹	☹	😐	☺	☺☺
Very unhappy	**Unhappy**	**Just ok**	**Happy**	**Very happy**

Q1 How did you feel about finding the (art) room with me leading?

☹☹	☹	😐	☺	☺☺
Very unhappy	**Unhappy**	**Just ok**	**Happy**	**Very happy**

Q2 How did you feel about finding the (art) room when you were leading?

☹☹	☹	😐	☺	☺☺
Very unhappy	**Unhappy**	**Just ok**	**Happy**	**Very happy**

Q3 Did you think finding the (art) room on your own was scary?

YES / NO

Why did you think it was scary?

Q4 Did you think finding the (art) room on your own was difficult?

YES / NO

What made it difficult?

Q5 Did you think finding the (art) room on your own was easy?

YES / NO

What made it easy?

Q6 How would you feel if you had to find the (art) room on your own?

☹☹	☹	😐	☺	☺☺
Very unhappy	**Unhappy**	**Just ok**	**Happy**	**Very happy**

Why would you feel like that?

Q7 What three things can you remember seeing in the hallway when you were finding your way to the room?

Q8 Can you remember seeing any colors in the hallway when you were finding your way to the room?

If you did, what colors do you remember seeing?

Q9 Can you remember seeing any shapes in the hallway when you were finding your way to the room?

If you did, what shapes do you remember seeing?

Q10 Can you remember seeing any signs (pictures with words) in the hallway when you were finding your way to the room?

If you did, what signs or pictures or words do you remember seeing?

Q11 When you go to a new place that you haven't been to before and you have to find your way around how do you feel?

☹☹	☹	😐	☺	☺☺
Very unhappy	**Unhappy**	**Just ok**	**Happy**	**Very happy**

Why do you feel like that?

Q12 (Original) Is there anything else you would like me to know about finding our way to the art room that we haven't talked about?

Q12 (Amended) What is the main thing you remember about finding our way to the art room that we haven't talked about?

Thank you for answering these questions! ☺☺

Thank-you for helping me with my study. You've been really helpful. Here is a certificate and a small gift to thank you for helping.

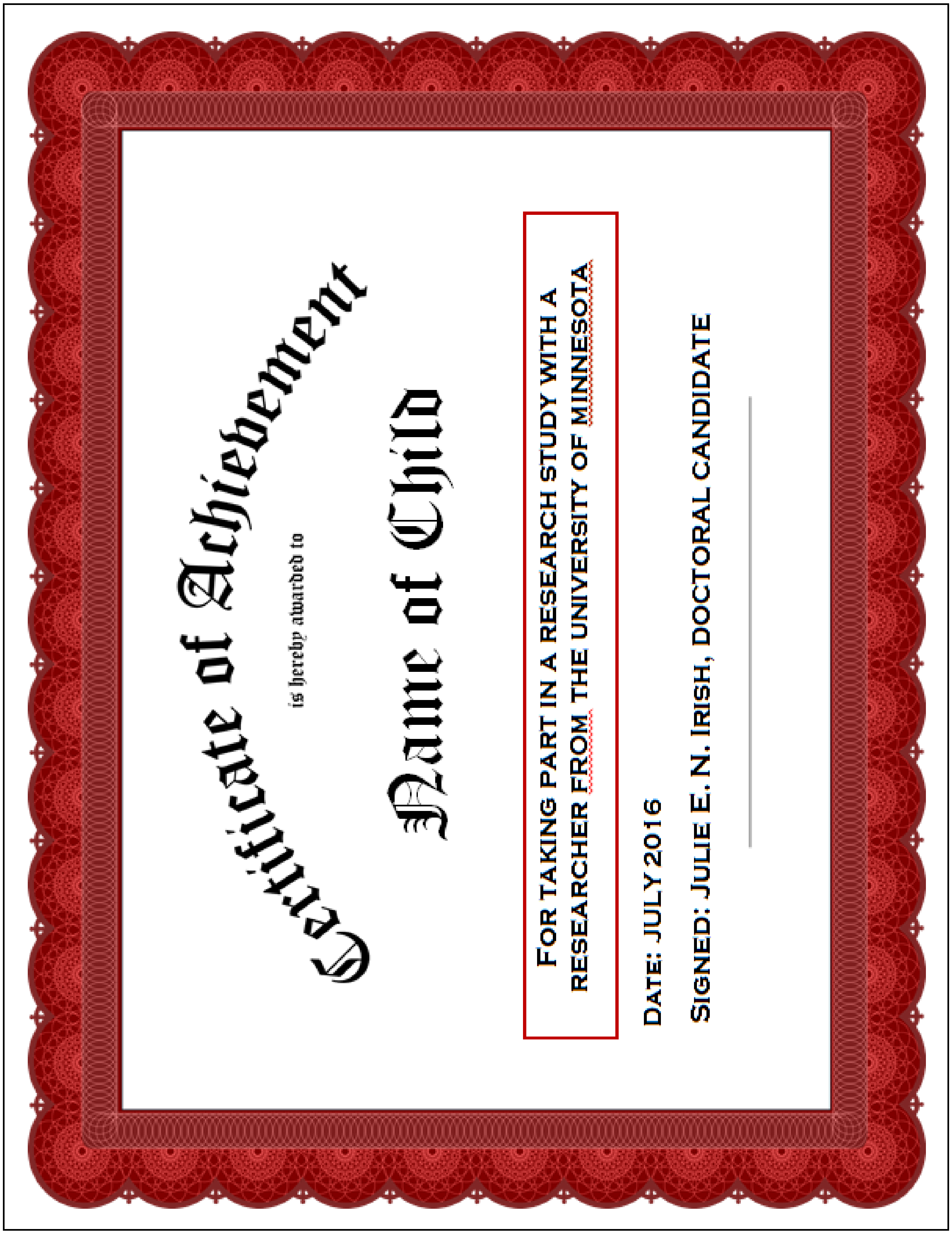
*** HAND OVER CERTIFICATE AND GIFT**

Now I will take you back to your classroom.

(**Take participant back to their classroom).**

End.

Appendix Q. Certificate to Participants



Certificate of Achievement

is hereby awarded to

Name of Child

FOR TAKING PART IN A RESEARCH STUDY WITH A RESEARCHER FROM THE UNIVERSITY OF MINNESOTA

DATE: JULY 2016

SIGNED: JULIE E. N. IRISH, DOCTORAL CANDIDATE

Appendix R. Thank-you Letter to Parents/Guardians

Dear Parent/Guardian,

I am writing to thank you for allowing your child to take part in my research study to find out whether changes in the design of the school interior could help children with autism spectrum disorder (ASD).

Without your generosity I would not have been able to conduct this study so I am extremely grateful. If you would like the results of the study, I will send them early in 2017.

We recently changed the protocol for the study so I am also pleased to enclose a $20 gift card for your child.

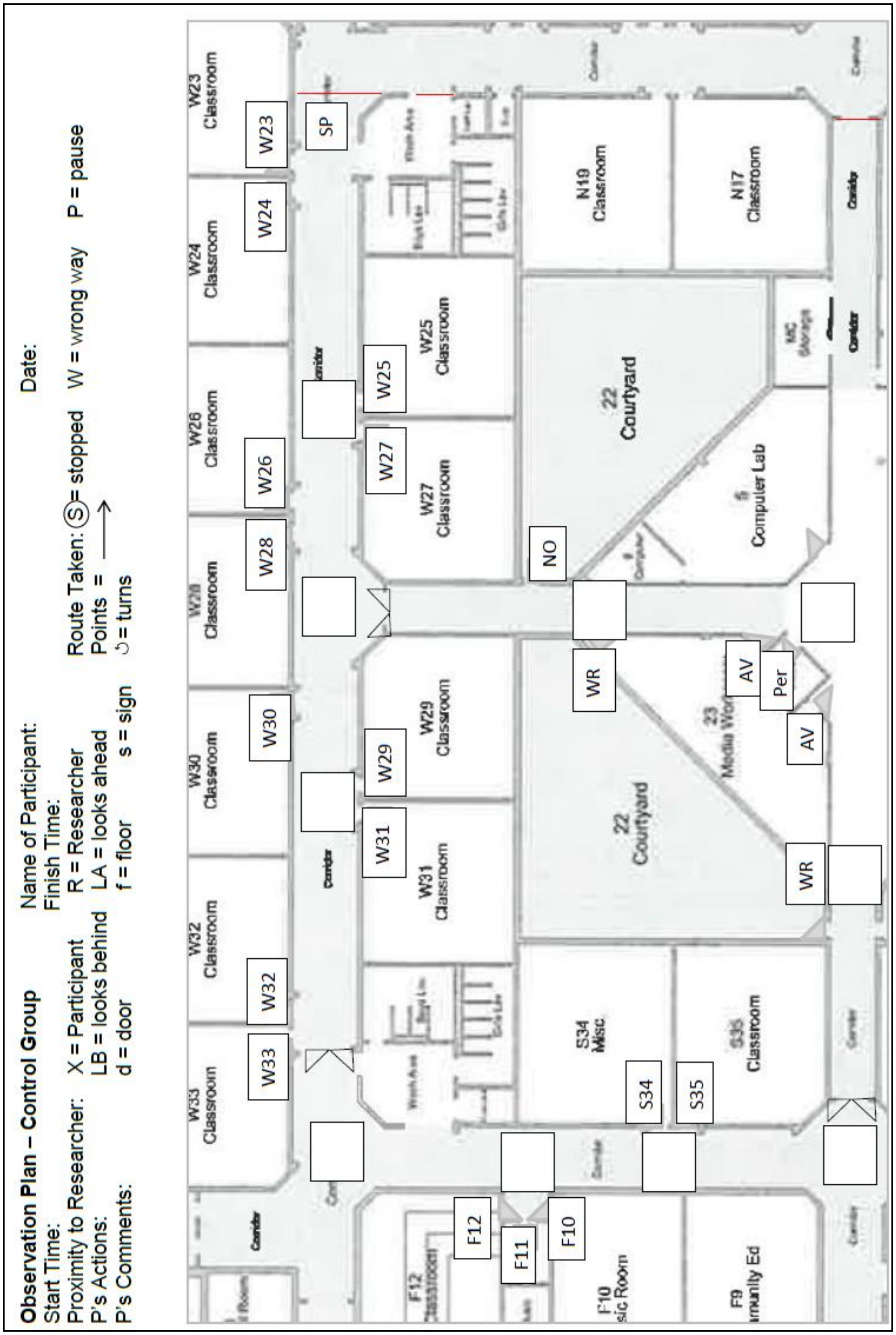
If you have any questions please contact me by telephone (763) 951 3771 or by e-mail irish026@umn.edu. You may also contact my adviser Dr. Barbara Martinson, University of Minnesota, via e-mail bmartins@umn.edu.

Once again I appreciate your willingness to allow your child to help me in this research effort.

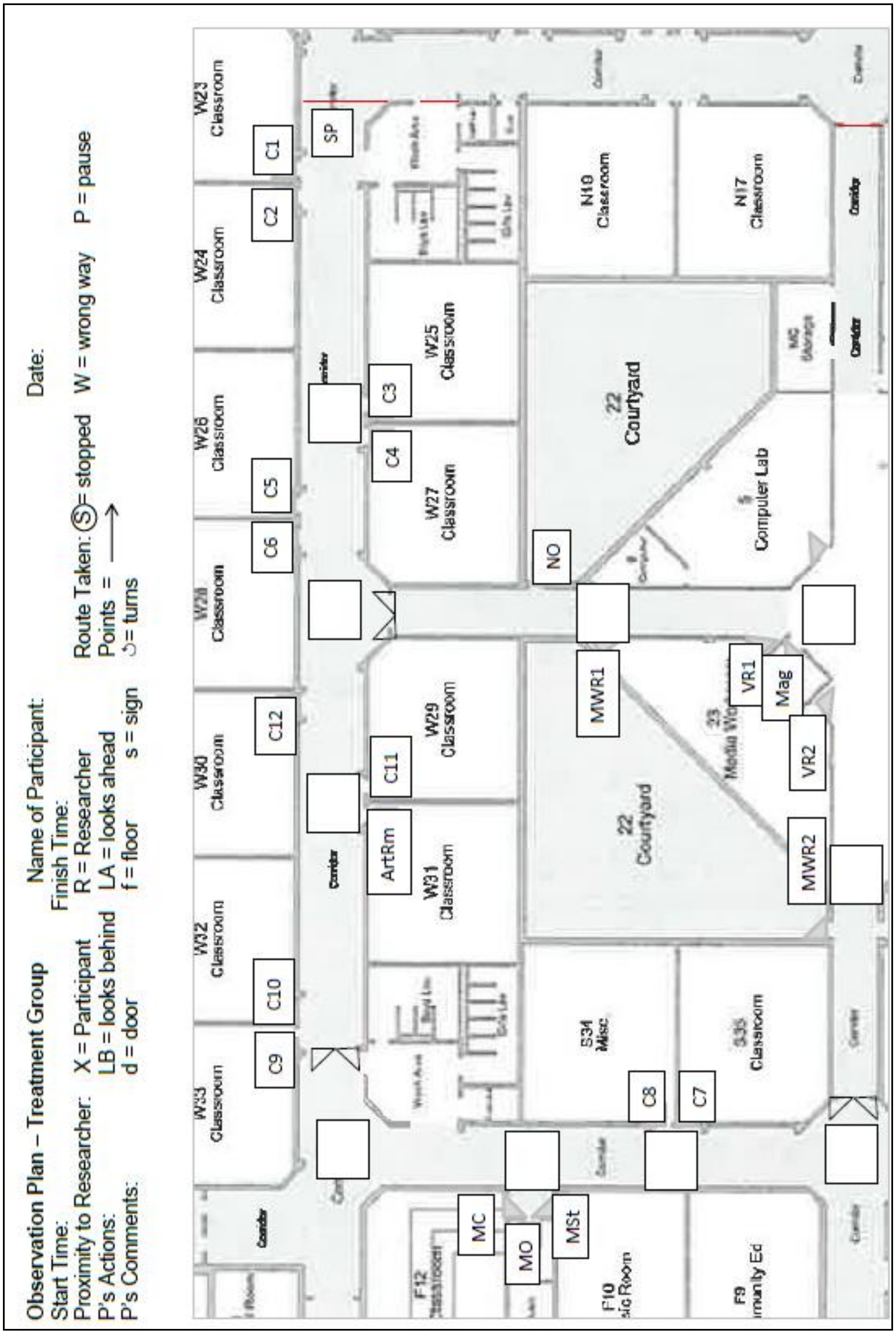
Yours sincerely,

Julie E. N. Irish, MSc
Doctoral Candidate
College of Design
University of Minnesota
240 McNeal Hall
1985 Buford Ave.
St. Paul, MN 55108

Appendix S. Behavioral Map for Control Group



Appendix T. Behavioral Map for Treatment Group



Appendix U. Light and Sound Recording Sheet

LIGHT AND SOUND RECORDING SHEET

LOCATION	DATE	TIME	LIGHT	SOUND
1				
2				
3				
4				
1				
2				
3				
4				
1				
2				
3				
4				

Appendix V. Pre-Study Checklist

DAILY CHECKLIST: ON SITE
All

- Check all lights are on
- Check aluminium doors are open
- Check Media Centre Doors x 2 are closed
- Check light levels
- Check sound levels
- Check book is in Art Room
- Take barriers down during study

Control

- Check Art Room sign is in position

Treatment

- Check all wayfinding aids are in position *
    * NB no orange squares on floor until pupils are in classrooms

DAILY CHECKLIST: PRE SITE

- Take study schedule/ list participants
- Take observation plans
- Take behavioral maps
- Take scripts
- Take interview questionnaires
- Take notebook
- Take video camera
- Take tape recorder
- Take additional adhesive tape
- Take certificates
- Take gifts
- Take spare matboard
- Take light meter
- Take sound meter

DAILY CHECKLIST: POST SITE

- Download video data
- Download tape recorder data
- Collate behavioral maps
- Charge video recorder
- Charge tape recorder