School of Built Environment

Spatial Design in Schools: Impacts on Learning Potential of Children with Learning Disabilities

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007)—updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number HR 154/2008.

Signature: …….

Date: ……...

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List of Abbreviations

ABS	Australian Bureau of Statistics
ADD	Attention deficit disorder
ADHD	Attention deficit hyperactivity disorder
ARCH	Australian Architecture Database
ART	Attentional restoration theory
ASD	Autism spectrum disorder
CCA	Constant comparative analysis
CEFPI	Council of Educational Facility Planners International
CELE	Centre for Effective Learning Environments
DET	Department of Education and Training
DI	Direct instruction
EBD	Evidence-based design
EBR	Environment–behaviour research
FSFL	Full-spectrum fluorescent light
HREC	Human Research Ethics Committee
MBD	Minimal brain dysfunction
MLD	Motor learning difficulties
OECD	Organisation for Economic Cooperation and Development
POE	Post-occupancy evaluation
SAD	Seasonal Afflictive Disorder
SIPT	Sensory Integration and Praxis Test
SIT	Sensory integration theory
UNICEF	United Nations Children's Fund
US	United States
UV	Ultra-violet
WHO	World Health Organization

List of Definitions and Terminologies

Term	Definition
School environment	School environment includes all spaces within a school campus, ranging from built to natural environmental attributes and their influence on learning abilities and sense of well-being (Clark and Uzzell 2006; Walden 2009). These include interiors and classroom spaces, furniture, colour, light, thermal comfort, noise acoustics, site and natural settings.
Built environment	Built environment refers to man-made environments.
Learning, physical and school settings	Learning, physical and school settings are used interchangeably to refer to the organisation of space by educators in terms of learning equipment (e.g., study materials, stationery, books) and furniture (e.g., desks, chairs, seating arrangements) for effective learning to take place, and to meet teaching and learning objectives (Shalaway and Beech 1998). Setting is used interchangeably with environment to refer to positive behaviour-building actions such as giving students verbal encouragement (Moos 1979). This thesis uses physical/school settings to distinguish from the physical environment as used in environmental psychology and design.
Physical environment	Physical environment is a broad term from an environmental psychology perspective and includes urban, built and natural surroundings of organisms (Gifford, Steg and Reser 2011). However, in this thesis, it refers to the built and natural surroundings of users.
Spatial design	Spatial design refers to the design of built (architecture and interiors) and natural (landscape and exteriors) environments.
Teaching process	Teaching processes are tasks or activities that are undertaken to facilitate learning—for example, to impart skills or knowledge in specific subject areas (Mangal 2009).
Learning process	Learning processes are the ways in which children gain new skills, knowledge, attitudes and values (Gredler 2001), such as experiential (Kolb 2014), perceptual (Gibson 1969; Adolf and Kretch 2015), cognitive, emotional and verbal processes, some of which can occur simultaneously (van Merriënboer 2016).

Learning outcomes	Learning outcomes are statements identifying skills, abilities and knowledge that learners should be able to demonstrate at the end of a course or syllabus (Donnelly and Fitzmaurice 2005).
Inclusive education	Inclusive education is an educational practice in which children with diverse abilities and backgrounds are welcomed to learn in conventional educational settings. As defined by Cologon (2013, 6): > Inclusive education requires recognising and upholding the rights of all children and adults and understanding human diversity as a rich resource and an everyday part of all human environments and interactions. Inclusive education is an approach to education free from discriminatory beliefs, attitudes and practices, including free from ableism.
Children	In this thesis, children are those aged under 10 years who are studying in mainstream primary schools.
Experiential learning	Experiential learning refers to experience as a source of learning. It is based on experiential learning theory and derives from Dewey, Lewin and Piaget's (Kolb, Boyatzis, Mainenelis 2001; Kolb 2014) holistic pedagogical models. This thesis hypothesises that a school's architectural settings—including formal and informal spaces, interiors and exteriors, built and natural—play a role in providing opportunities for positive learning experiences.
User-centred design	User-centred design is derived from product design theory and is based on human factors and ergonomics. It refers to the idea that 'the needs of the end-user should constantly drive the design' (Cornell 2002, 35).
Child-centred(ness) in education	Child-centred (ness) in education is a concept that evolved from early schooling history based on developmentalism in the United States (US) (Chung and Walsh 2000). It refers to placing the child at the centre (e.g., their activities and experiences) of the schooling process to facilitate moral, intellectual and mental development through education (Chung and Walsh 2000).
Child-centred design	Child-centred design is rooted in the concept of user-centred design and the notion of child-centredness from early schooling history based on developmentalism in the US (Chung and Walsh 2000). It refers to architectural designs developed with a focus on the spatial needs of primary users (children) in their school environment. These needs include perceptual, behavioural and physical

	necessities to make learning spaces more accessible and provide better spatial opportunities to facilitate learning for children.
Mainstream schools	Mainstream schools in Australia refer to regular schools such as primary and secondary schools (government and non-government schools). These schools provide support for special needs students by providing special classes (Australian Bureau of Statistics [ABS] 2009), including children with diverse learning abilities and following inclusive educational practices as per the United Nation's (2006) Conventions on the Rights of Persons with Disabilities and Commonwealth of Australia, Disability Standards for Education (2005).
Alternative schools	Alternative schools are those that take an alternative philosophical approach to education (e.g., Steiner and Montessori).
Traditional schools	While mainstream schools are also referred to as traditional schools, in this thesis, the term refers to schools that follow the teacher-driven direct instruction approach to education (Johnson and Johnson 2001; Novak 1998).
Perception and Cognition	The terms perception and cognition have been used interchangeably by experts from different disciplines (e.g., geographers, psychologists, social scientists), making it difficult to distinguish between the two terms. Both terms refer to processes that enable inferences to be drawn and new knowledge to be processed. This study distinguishes between the two terms based on Downs (2005, 314) distinction, where perception: > refers to the process that occurs because of the presence of a new object and results in the apprehension of that object by one or more senses and temporally linked to immediate surroundings and immediate behaviour whereas cognition may not be linked to immediate behaviour and is a term that includes perception, problem solving and the organisation of new information and ideas.

Abstract

This thesis explores links between school designs and learning potential based on the space–behaviour hypothesis that the environment can influence human behaviour and performance depending on the opportunities for interaction offered to users (Canter 1974, 1975, 1977; Gibson 2014; Lang and Moleski 1974; Proshansky 1987; Sommer 1967; Walden 2009). The key idea is to recognise whether it is possible to enable children—specifically, those with learning disabilities—to maximise their learning potential by developing specific combinations of environmental factors in mainstream school design. This thesis seeks to identify overlaps between architecture, education environment psychology and behavioural sciences with the objective of developing knowledge of what works and what does not work in the context of mainstream school design. Identifying the interdisciplinary overlaps will help designers to create 'inclusive' school environments that respond to the needs of those with learning disabilities in mainstream school settings.

The key theories that form the theoretical framework are the person–environment fit theory (Parsons 1909), theory of affordances (Gibson 2014) and theory of environmental stress (Bell, Fisher and Loomis 1978). Based on these theories, existing literature in the field of school design and education is examined to evaluate the relationships between the built and natural aspects of school environments, including colour, illumination, furniture arrangement and landscape, and perceptions and experiences of primary school children. The methodology involves critical analysis of literature from the disciplines of architecture, education, environmental psychology and environment–behavioural sciences, supplemented by case studies in three primary schools in Perth. The case studies examine specific aspects of children's spatial preferences, interactions with and perceptions of spaces they occupy, with the objective of understanding what defines their spatial choices and whether these definitions, if applied to design, could help them to maximise their learning potential.

The findings of this study highlight the role of spatial design in meeting the needs of children with learning disabilities in mainstream school settings by responding to their psychological, perceptual, sensorial and behavioural propensities in the context

of learning. This study is highly significant because it bridges both interdisciplinary and intradisciplinary gaps within architecture and education, thereby establishing a nexus between behaviour and spatial qualities in the context of mainstream school environments and the learning potential of children with learning disabilities.

Chapter 1: Introduction

1.1 Introduction

This thesis explores the space–behaviour[1] nexus in the context of *children's* (see List of Definitions and Terminologies) space and their behaviour. It aims to determine whether *spatial design* (see List of Definitions and Terminologies) can contribute to school-based and non-medication interventions to improve learning potential for children with learning disabilities (LDs). The study highlights the need to develop a child-centred approach by considering the uniqueness of children's perceptual and behavioural needs in the design process. It draws upon interdisciplinary perspectives by analysing theoretical, documentary and empirical literature in the fields of spatial design, environmental psychology, environment–behaviour sciences and education to provide an understanding of the spatial needs of children with LDs (see Figure 1.1). The methodology involves a comprehensive analysis and discussion of children's spatial needs in *school environments* (see List of Definitions and Terminologies) and is supplemented by case studies to provide insights into how to purposefully design spaces to support the needs of those with LDs in *mainstream schools* (see List of Definitions and Terminologies).

This study does not advocate treating LDs for students via school design; rather, it studies the physical conditions of school environments that could support the spatial needs of children with LDs, thus enabling them to maximise their learning potential in mainstream school environments.

To lay the foundation and provide an understanding of the relationship between school designs and learning potential, this chapter begins with a discussion of the role of the *physical environment* (see List of Definitions and Terminologies) in influencing human behaviour, *perception* (see List of Definitions and Terminologies)

[1] This thesis considers Bell et al.'s (1996) definition of environmental psychology, which is a study of the relationships between behavior and the built and natural environments. Grounded in this definition, this research is based on the space–behaviour link hypothesis that spatial design can influence behaviour and performance positively or negatively depending on the opportunities for engagement and experiences afforded by the environment.

and performance. It also provides a brief outline of LDs and the concept of including children with diverse LDs in mainstream schools.

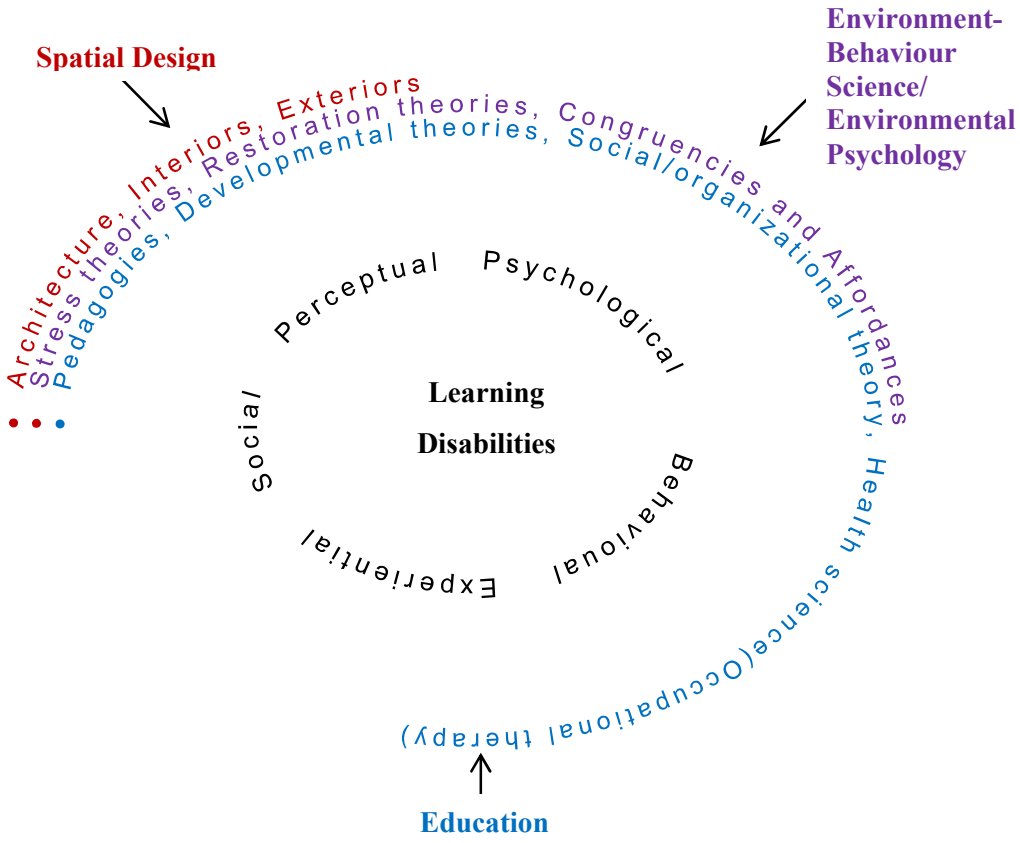

Figure 1.1: Interdisciplinary examination of literature

In this thesis, children with LDs will be referred to as such, whereas children with no LDs will be referred to as those from a non-LD group.

1.1.1 Role of the school environment in facilitating learning

> Winston Churchill once said we shape our buildings and then they shape us. If this is true, and it is the author's belief that it is, then there is no designed environment that needs immediate attention more than does the school facility. (Conners 1983, 15)

A growing number of researchers have examined the role of physical environments in affecting children's development (David and Weinstein 2013), peer socialisation (Simkins and Thwaites 2004), behaviour (Ahrentzen et al. 1984; Shabha 2006) and sense of well-being (Lackney 1999; Schneider 2002; Woolner et al. 2007), finding that school environments significantly affect children's learning and motivation to

learn. These aspects are linked to students' performance and academic outcomes, but they receive limited attention when solutions are being designed for educational projects (Maxwell 2016).

The attributes of physical environments (e.g., architecture, interiors, urban) have been linked to children's long-term health, well-being and cognitive development (Cosco and Moore 1999; Johnson 2007), and they contribute to children's mental health and learning (Barrett et al. 2013; Caplan and Van Harrison 1993; Evans 2003). From environment and behaviour perspectives, researchers have acknowledged the relationship between human behaviour and environments (Evans and Lepore 1997). For example, studies have highlighted the effect of environmental variables, such as space and colour (Read, Sugawara and Brandt 1999), furniture (Knight and Noyes 1999; Linton et al. 1994) and playground design (Pellegrini and Davis 1993), on children's behaviour and performance in schools. Negative effects of environmental attributes have also been noted, with stress, aggression and a decrease in pro-social behaviour linked to thermal discomfort (Anderson 2001; Lagacé-Séguin and d'Entremont 2005). This implies that physical environments can support or impede behaviour, health and well-being, and therefore learners' ability to learn efficiently.

Natural environments have been associated with restorative effects on learners, with positive influences observed on stress levels, recovery from cognitive fatigue and attention span among children (Hartig et al. 2003; Hartig 2004). In children with attention disorders, opportunities to engage with natural environments have been shown to increase attentional capacities, decrease aggression and reduce the need for medication (Taylor, Kuo and Sullivan 2001). Natural elements of school spaces provide opportunities for interactive play and development and facilitate social dimensions of learning (Cosco 2007; Wood, Christian and Martin 2011). They positively affect students' behaviour and sense of well-being (Kaplan 1995; Taylor, Faber, Kuo and Sullivan 2001) and contribute to better *learning outcomes* (see List of Definitions and Terminologies). Thus, this study recognises the role of school environments in supporting children's behavioural needs and their physical and mental health, thereby resulting in better learning outcomes.

Multiple factors affect learners' behaviour and achievement in schools; thus, it cannot be said that there exists linear and causal relationships between school design

and achievement and to claim that environment defines behaviour (Maxwell 2016; Walden 2009). Consequently, this thesis examines these relationships by conducting an interdisciplinary review of the literature in the fields of spatial design, environmental psychology and education (see Figure 1.1). The physical environment forms an overlapping area of enquiry between spatial design and environmental psychology. Theoretical constructs from environmental psychology provide a foundation to understand the relationship between physical environments and users, including perceptions, effect on socialisation, behaviour, experience and well-being. These aspects form part of the *learning processes* (see List of Definitions and Terminologies) through which learners gain knowledge (Gredler 2001); thus, they overlap with education. This thesis reviews empirical, theoretical and documentary literature in the education field with a focus on children with LDs and their learning processes. It examines various theoretical perspectives (e.g., pedagogical, social/organisational and developmental) to determine how learning occurs for children with LDs and the strategies for which the physical environment formed part of the solution to support the needs of the LD group in mainstream schools.

1.1.2 Key theories applied for the exploration of school environments and learning

Theory of affordances

Gibson (1986) used the term 'affordances' to describe the perceived qualities of an object, feature or change in the immediate surroundings that comprises both natural and built aspects of the environment (Johnson 2007). This concept has influenced many works in areas of study related to behaviour, perception and cognition towards physical environments. The theory of environmental affordances (Gibson 1986) posits that users' perceptions of and responses towards their environment are governed by their reading of the environment and the opportunities they receive to use their abilities. As Clark and Uzzell (2006, 178) explained, 'at the centre of Gibson's theory lies a transactional belief about people-environment reciprocity…assuming that the individual and the environment coexist and jointly contribute to the meaning and nature of the situation'. This theory was relevant to explore the transactional relationships between children and their school

environments and to examine the functional role of design in facilitating these transactions for better learning abilities.

Person–environment fit theory

Parsons' (1909) person–environment fit theory (matching individuals' skills to their job) was elaborated by Holland (1997), who suggested that people search for environments that provide agreeable challenges, job fulfilment, opportunities to complete tasks as per their abilities, and that enable them to express their values and strengths. Altmaier and Hansen (2011, 132) added that when such a congruence is achieved between person and environment, 'individuals are more likely to make better work choices and be better adjusted'. In the context of this study, Parsons' (1909) person–environment fit theory is essential to analyse what types of student–environment fit are required for school designs to be *inclusive* (see List of Definitions and Terminologies).

Environmental stress theory

The theory of environmental stress[2] refers to those environmental attributes as sources of environmental stress or stressors which prompts negative response (behavioural, emotional or psychological) from users (Bell, Fisher and Loomis 1978). In the context of school environments, environmental stressors can also be theorised as a 'lack of congruence between individual needs and goals with the opportunities and constraints afforded by the school setting. When environmental constraints directly or indirectly thwart such goals or expectations, the individual attempts to cope with the stressful situation' (Ahrentzen et al. 1982, 224). When the stress theory is interpreted with the concept of affordances and person–environment fit transactions, it indicates that the interpretation of environmental attributes as constraining or supportive stimuli depends on learners. It is vital to explore the nature of these perceptual, cognitive and behavioural sensibilities for learners with LDs in the context of learning environments. This will enable the design of

[2] Many definitions of stress have been used in various types of stress research models. Zimring's (1982) definition of stress is considered for this study, as it resonates with the theoretical lens used to understand the issues that occur when there is a misfit between individual needs and capabilities and environmental attributes.

approaches that seek to acknowledge that school environments—whether built or natural—have both positive and negative transformative influences on users.

Thus, this thesis examines the potential of enabling children with LDs to maximise their learning potential through spatial design (see Figure 1.2).

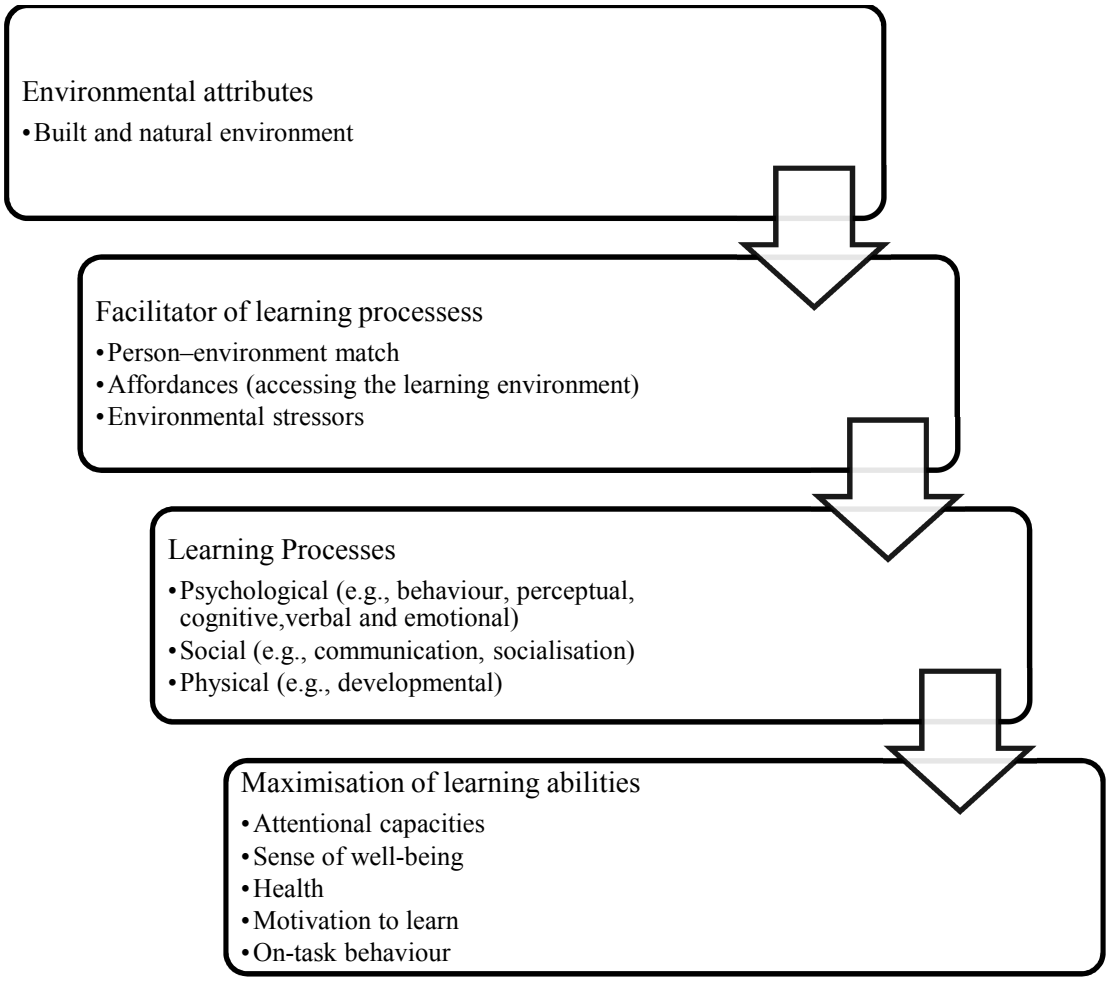

Figure 1.2: Pathway to maximisation of learning abilities via spatial design

As stated previously, learning involves processes such as *experiential* (see List of Definitions and Terminologies), social and perceptual. From an environmental psychology perspective, the motivation of an individual to engage in tasks is linked to motivation to learn in education (Weiner 1990). Researchers in education also recognise that motivation to learn is one of the three fundamental factors for consideration in instructional design, where the objective is to create enriched experiences so that learning is more appealing and effective (Saritas and Akdemir 2009). As learning depends on new experiences, including those that occur by interacting with physical environments, motivating children to engage and learn from

the environment facilitates their learning processes. Learners' ability to engage with the social and physical dimensions of learning environments has been shown to positively influence their learning potential (Ramey and Campbell 1991; Ramey and Ramey 2004). Environmental attributes prompt engagement with the physical environment in children depending on how interactive, meaningful and pleasant their spaces are perceived to be (Moore 1986; Walden 2009).

1.2 Issues with Current Approaches to School Design

The hypothesis of this study resonates with current ideas of modern educational thinking on linking space with learning outcomes. From a higher educational context, Oblinger (2006, 1) acknowledged the relation between space and learning and argued that:

> Space—whether physical or virtual—can have an impact on learning. It can bring people together; it can encourage exploration, collaboration, and discussion. Or, space can carry an unspoken message of silence and disconnectedness. More and more we see the power of built pedagogy (the ability of space to define how one teaches) in colleges and universities.

The idea of *built environments* (see List of Definitions and Terminologies) as a pedagogical construct can also be found across younger groups of students in primary schools. However, general architectural practices for primary schools are largely inclined towards facilities, procurements and budgets (Gallaher et al. 2004; Knapp 2007; Lackney 2015; Lippman 2010a; Walden 2009). While modern educational standards differ from older monitorial school models, children's perspectives and teachers' pedagogical needs are also important aspects that require consideration, thus responding to these new trends in educational practice. As Oblinger (2006, 1) explained, 'learning spaces often reflect the people and learning approach of the times, so spaces designed in 1956 are not likely to fit perfectly with students in 2006'. In recent advancements in educational research, there has been a trend for spaces to be more interactive and engaging. However, a combination of mismatches between architectural approaches (functionalism or form follows function, and determinism or functions follow form) and operational concerns of efficiency and economy (Halpin 2007 quoted in Bland and Sharma-Brymer 2012)

has resulted in school buildings lacking key qualities that would enable educators to articulate their pedagogies effectively.

Children vary in their perceptions and associations of built environments (Bachelard 1994). Their understanding of space and the nature of experience may differ from that of adults (Matthews 1992). This suggests that spaces created for their use should not only appeal to their levels of perception and aestheticism, but also complement their ideas of what constitutes enriched spaces for learning. However, the process of school spaces is largely conceptualised, created and managed from an adult perspective (Koralek and Mitchell 2005), raising the question of how such spaces (discounting children's sensibilities) work for them as efficient and nurturing spaces for learning.

As schools today move towards matching the technological advancements of this century, it is essential to recognise that while it is important to provide design solutions that accommodate new learning technologies such as smartboards (Walden 2009), it is also important to recognise the human element of design. This consideration refers to responding to the heterogeneous nature of learners in mainstream settings (Forlin 1998) linked to diversities in their learning abilities (Lyon et al. 2001). Further, school designers and architects must recognise that children will spend a significant number of their developmental years in these structures (Ahrentzen et al. 1982; Dillon 1976; Linton et al. 1994; Savanur, Altekar and De 2007; Wingrat and Exner 2005). These buildings could leave an imprint on their health, behaviour and sense of well-being, which they could carry into their adult life. Consequently, the key questions for this thesis are grounded in exploring mainstream school design from the perspective of children, with a focus on their spatial needs related to the learning and pedagogical prerequisites of educators who are the organisers of their *learning settings* (see List of Definitions and Terminologies).

1.3 Rationale for Study

A growing number of studies in neuroscience and education concur with progressive educators' views of learning as an experiential process. Neurons are the basic components connecting spaces called synapses within the brain (Zull 2002). The

brain creates new synapses when presented with information that is inconsistent with older memories (Caine and Caine 1994; Zull 2002). Therefore, learning occurs when synapses change with new experiences (Goldberg 2002; Zull 2002). Neuroscientists consider that learning occurs when neurons communicate with each other when presented with new information or experiences (Hannaford 1995). These ideas concur with constructivist pedagogies, which value experience as a source of learning and consider that human responses to their environments are unique in the learning process (Fosnot 1996; Glasersfeld 1996, 2005). This new understanding of learning as a social, situational and experiential process has influenced a new wave of international education reform, with mainstream education approaches shifting from traditional transmission models of learning to constructivist collaborative and/or experience-based learning (Whitehouse 2009). 'Mainstreaming' and 'inclusion' policies have been introduced as part of these educational reforms, which see students with diverse learning abilities sharing the same school facilities. This new trend in international education reform has inspired the re-emergence of discussions on the transformative qualities of architecture (Whitehouse 2009) and a corresponding paradigmatic shift in the way schools are being designed. The new reforms require spaces that offer flexibility and adaptability to respond to the diversity of learners sharing the same facilities or school spaces. The current study contributes to the emerging knowledge bank on design strategies that respond to current educational policies of inclusion and mainstreaming.

Schools in most developed countries such as Australia work on the policy of 'inclusiveness'(Commonwealth of Australia, Disability Standards for Education Act, 2005), where children with LDs are integrated into mainstream education (Forlin 1998). They receive special needs support as per inclusion policies (Forlin 1998; United Nations Education, Science and Cultural Organization [UNESCO] 1994, 2005) for meeting their academic goals. Further, diversities in learning abilities exist among children with and without LDs in mainstream schools, and this is a broad and complex subject (Lyon et al. 2001). Responding to this diversity is one of the key criteria for meeting educational policies of inclusion in mainstream schools (Cologon 2013). It also requires a corresponding design response for mainstream schools to be inclusive such that it supports the spatial needs of children with LDs and enables

educators to organise settings to articulate academic support or intervention strategies for this group.

Mainstream educational policy reforms therefore require a corresponding architectural response. However, there is an absence of literature and clear guides on how to proceed once building 'standards' of physical environments have been met due to the multiplicity and interplay of factors involved in evaluating the influence of physical environments (Higgins et al. 2005). To fill this gap, this study investigates children with LDs in mainstream schools by examining their perceptions of their school environments and what they mean for school design. In doing so, the knowledge generated will bridge the gap between design practice and education, thereby enabling designers to respond to current education reforms that promote inclusiveness policies for children of diverse abilities.

1.4 How Learning Disabilities Are Understood

LDs are defined as disabilities in seven areas related to reading, language and mathematics, and they can co-occur with other disorders (e.g., behavioural, emotional) and social skills deficits (Lyon et al. 2001). Kavale and Forness (2000) defined it as difficulties in learning to read, write and/or calculate. Within this group, there are those who can learn 'normally' and those who learn with educators' support due to a co-occurrence of the learning disability with other issues, such as physical, sensory and behavioural disorders, which further affect their academic achievements. LDs become intensified when co-occurrence occurs. For example, children with a reading disability and a co-occurrence of attention deficit disorder (ADD) have an intensified reading disability and are more resistant to intervention (Lyon et al. 2001). Studies also show that 80% of children with attention deficit hyperactivity disorder (ADHD) have underachievement or LDs (Cantwell and Baker 1991). Such convergences between LDs and other disorders can also occur among those who have autism spectrum disorder (ASD) and no developmental disorders, but non-verbal LDs (Klin et al. 1995).[3] Further, Schworm and Birnbaum (1989, 35) explained

[3] Klin et al. (1995, 1130) defined nonverbal LDs (NLDs) on 'the basis of a cluster of deficits affecting the nonverbal aspects of the child's functioning including deficits in tactile perception, psychomotor coordination, visual–spatial organization, nonverbal problem-solving, and appreciation of incongruities and humor'. School designers should consider the visual–spatial skills deficit aspect when creating inclusive school environments, as the deficit makes it difficult for these children to

that despite some differences between children with LDs and ADHD (e.g., greater inattention when engaged in visual tasks than hyperactive students), 'distinguishing children with hyperactivity from children with other learning and behaviour disorders is often difficult because of an overlap in symptom expression'. Based on this understanding of convergences, this study comprises children with LDs and includes those with co-occurring disorders.

LDs cover a broad range of symptoms arising out of each type of disability (e.g., cognitive and perceptual), which can pose difficulties in learning depending on the severity of the symptoms. For some of these children, such as those with ASD, negotiating and accepting the built environment can be an overwhelming experience (McAllister 2010). When forced to make extra efforts to make sense of their built environments, these individuals find spaces alienating, which triggers stereotypical behaviours (repetitive gestures and movements) (Sánchez, Vasquez and Serrano 2011) as part of their coping mechanisms. Similarly, environmental factors such as unwanted ambient noise can pose difficulties in focusing on tasks for children with ADHD (Zentall and Shaw 1980; Zentall 2005). These issues with perception and responses to environmental attributes raises the question of what can be done from the perspective of mainstream school design to ensure that school environments are inclusive and respond to educators' and children's needs for 'inclusive learning'.

1.5 Research questions

The key research questions are focused on understanding:

1. How learning processes (experiential, behavioural and perceptual) are understood? How should these affect mainstream school design?
2. What does it mean to be in a mainstream school with an LD? How does it affect learning processes for these children?
3. What are the specific differences in the nature of experience for children with LDs and those without LDs in mainstream schools? What are the implications of these experiences for creating an inclusive school design?

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remember what they see and understand of their spatial settings, which in turn makes it challenging to negotiate and respond to available spatial affordances for learning.

1.6 Research Aims and Objectives

The main aims of this thesis are to:

4. identify whether school design strategies can be aligned with the concept of 'inclusion' in education for mainstream schools with a focus on most commonly used spaces, including classrooms and play areas, but not excluding other informal and formal spaces used as part of routine school sessions
5. determine whether a school's environmental attributes can be designed purposefully to contribute to school-based (non-medication) interventions to accommodate needs for those with LDs that involve inattention, impulsivity and sensory processes.

The objectives of this study are to:

1. understand how children's preferences in relation to school environments influence their response and behaviour towards school environments (e.g., via better motivation to learn)
2. determine whether these preferences are relevant when developing 'inclusive' design strategies for mainstream schools and, if so, make recommendations to enable designers to design 'inclusive' spaces for schools (by incorporating an integrated approach focused on the needs of children with LDs).

A series of secondary objectives aim to:

1. Explore the nature of learning experiences for children with LDs: To understand the type of student–environment fit that must occur to facilitate learning, it is essential to first understand the nature of learning experiences for children with LDs to identify how they could influence school design.
2. Understand and analyse the links between learning processes (experiential, behavioural and perceptual) and environmental attributes in the context of children with LDs: The objective is to identify the type of spatial affordances required and the congruencies that must occur with the spatial needs of children with LDs to facilitate learning. This would consequently inform questions of how these could be interpreted in terms of spatial design.

The knowledge obtained from this evaluation will enable designers to design solutions that are inclusive and child-centred.

1.7 Significance

A prerequisite of designing a response to mainstreaming practices in education (of including learners of diverse abilities, including those with LDs) is that spaces must respond to diversity of learning abilities among those with and without LDs. Despite the emerging nature of knowledge on LDs and co-occurring disorders, there is a crucial need for design solutions in the present that can successfully mesh the needs of both typical students and those with LDs. This study is therefore significant because it contributes to the emerging knowledge such that innovative strategies can be developed based on the understanding of school design and its effect on children with LDs.

Further, this thesis aims to merge the disparate areas of spatial design and education by studying the influence of the school environment on the behaviour and learning of children with and without LDs. The results will provide architects and interior designers with data on the importance of mainstream school design for LDs, such that designed spaces blend seamlessly with pedagogical objectives of addressing the needs of children with and without LDs.

1.8 Thesis Structure

The thesis is structured into ten chapters, beginning with Chapter 1, which introduces the reader to the contextual underpinnings and rationale for conducting this study.

Chapter 2 describes the research methods and outlines the theoretical framework and key theories that are used as a lens to analyse and link the theoretical component with its supplementary case studies. It details the path of enquiry and explains how the two theories of affordances and person–environment fit help to answer the key research questions. The chapter outlines the factors that formed the rationale for selecting primary school children, the process of sample selection and the tools applied to conduct case studies in Perth schools. This is followed by a discussion of the data analysis techniques used to assess the qualitative data from the case studies.

Chapter 3 examines the environment–behaviour nexus in schools based on insights from environmental psychology and neuroscience. It examines interdisciplinary themes from schools' spatial design and education perspectives, with a focus on the themes of environment and behaviour relationships. The aim is to examine literature that furthers an understanding of the transformative influences of physical environments, which can then be applied to better understand the relationship between school environments and learning processes (behavioural, sensorial, perceptual and experiential), specifically for children with LDs.

Chapter 4 presents an overview of the evolution of school design. By tracing the path of school design, it furthers an understanding of how space has developed to define what is learned. It examines *alternative*[4] *school* (see List of Definitions and Terminologies) pedagogies based on notions of *child-centredness* (see List of Definitions and Terminologies) (such as Steiner and Montessori) to examine how pedagogical differences between *traditional* (see List of Definitions and Terminologies) and alternative models influence spatial design, and whether these differences affect children's learning processes. The alternative models are based on the 'constructivist' learning theory, which posits that 'learners acquire knowledge from their engagement in the built and natural environment' (Lippman 2010a, 131) via participation and discovery. This notion of 'constructivism' suggests potential overlaps between school design and education grounded in the environment–behaviour nexus. This concept from various pedagogical perspectives is further analysed to identify links between spatial design and education, and to further understand how spaces can support the processes related to learning.

Chapter 4 then examines how learning occurs from various disciplinary perspectives, including constructivist, developmental and neurological, with an emphasis on the role of school environments in facilitating learning. It provides a deeper understanding of the nature of experiences for children with LDs in mainstream

[4] Australian educational systems are divided into public or government schools (educating two-thirds of Australian students) and private or independent schools (20% Catholic schools; the rest are non-religious schools such as Montessori and Steiner) (Dearden, Ryan and Sibieta 2010). Non-religious models of schooling, which use 'child-centred' pedagogy, emphasise the environment's role in the learning process. Chapter 3 explores these two models to determine the overlap between environments and learning from a theoretical perspective, with the aim of bridging the gaps between education, behaviour and school design.

schools from both the social and physical environmental dimensions of school environments. This is necessary to build a foundation for developing child-centred, inclusive school designs.

Chapters 5 and 6 review the literature from the built and natural environmental perspectives respectively to explore their role in influencing learning processes. These include spatial organisation, furniture, colour, light, noise and thermal comfort from the spatial design perspective, as well as elements such as nature, site and landscape features from the exteriors of the school environment. This is necessary to identify aspects of the physical environment that positively and negatively affect the learning processes of children with LDs.

Chapter 7 examines the literature to identify interdisciplinary gaps and issues with current design approaches to understand the factors that limit the creation of designs that are inclusive for children with LDs. It introduces the concept of the 'one-size-fits-all' approach in school design and critiques it by suggesting strategies that designs can implement to mesh the needs of both groups. The key idea is that these strategies should support users with and without LDs to fulfil the aims of inclusiveness, while also enabling educators to create the relevant settings to respond to the diversity of learning needs in the classroom.

Chapter 8 presents three case studies conducted in Perth schools and details the qualitative data collected from surveys, field notes and observations. It discusses the responses and inherent meanings based on the theoretical foundations set by the previous chapters. The insights from the students, including those with LDs, provide valuable information on children's preferences and sensibilities towards their school's physical environment. The aim is to determine specific aspects that could help designers develop strategies for the design of school environments that are sensitive to the needs of young children (specifically those with LDs of inattention and impulsivity). Towards this aim, comparisons are drawn between traditional and alternative school models to determine the similarities and differences between children's spatial preferences and perceptual sensibilities.

Chapter 9 presents findings from the case studies regarding children's understanding of space and learning environments and it evaluates these findings against those of

previous studies. It presents common themes from the case studies and literature to derive what needs to be addressed in the design of school environments to make them 'inclusive' for all users and meet educators' objectives of achieving inclusion in *school settings* (see List of Definitions and Terminologies).

Chapter 10 discusses the implications of the findings for mainstream school designs. It identifies the challenges in designing 'inclusive' school spaces and the factors involved in addressing these challenges. It also questions current practices of school design and how school design is disconnected from primary users. The chapter concludes with suggestions of potential pathways for future research in creating 'inclusive' spatial design for children with LDs. It also highlights how the findings of this study are significant in the larger context of spatial design for children with LDs.

1.9 Limitations

This study is conducted in the Australian context; however, the global relevance of designing supportive learning environments for children with LDs using an innovative approach from a spatial design perspective could be explored further. Further, the study of learning problems including LDs is a vast and evolving area of research. Many theories are still developing, and data are still being tested for validity against emerging empirical evidence. In the absence of concrete data where it is stated that such children need specially designed schools, most Australian schools practice an 'inclusive' approach and integrate children with LDs into a conventional class. Therefore, it is difficult to obtain a large sample size of students with LDs within the same school classroom or campus.

During the theoretical research, it was found that LDs cover a vast spectrum of learning impediments, and each one has a subsequent spectrum of limitations. Upon investigating the possibility of designing buildings to support learning processes, this thesis finds that attention issues occur from factors other than ADD or ADHD, such as distractions posed by task-irrelevant noise (Gumenyuk et al. 2001). This is acute for the LD group, but also occurs in lower cases with no LDs. An understanding of the problems of the LD group will also be helpful for the broader group. It must be understood that this is an issue for all students, as most have attention issues in varying degrees across time. It would be helpful to focus on a group with an intense

case of LDs to realise the effects on a broader audience. This study is one link in a chain of research that aims to develop knowledge of school design rooted in environmental psychology and special needs education.

1.10 Summary

Chapter 1 provided a brief overview of the contextual underpinnings of this thesis and discussed the role of the physical environment in influencing children's behaviour, perception and performance. In doing so, it set the foundation to examine how school environments can be purposefully designed to support the needs of those with LDs in mainstream schools. Further, the chapter stated the research aims and the significance of examining the effects of the school environment on children with LDs, with the objective of identifying how school design solutions can be aligned with the concept of 'inclusion' in education. This chapter also briefly outlined the theories used to explore how school environments affect learning processes among typical children and those with LDs, as well as the role of spatial design in enabling children to maximise their learning processes. These theories are presented in Chapter 2, which discusses the methodological framework and methods used to explore the key questions of this thesis.

Chapter 2: Methodological Framework and Methods

2.1 Introduction

This exploratory[5] study employs a theoretical enquiry approach to explore the links between mainstream school environments and students with LDs coinciding with issues of inattention, hyperactivity, impulsivity and disorders of sensory processes (e.g., visual, perceptual, motor skills deficits). The main aim of this thesis is to explore whether mainstream school design can enable children with LDs in mainstream schools to maximise their learning potential. The theoretical component examines theoretical, documentary and empirical literature from the disciplines of architecture, education, environment–behavioural sciences and environmental psychology to develop a framework to better understand the phenomenon of the space–behaviour nexus and its relevance to developing strategies for the design of 'inclusive'[6] schools.

To understand the complexities of the relationship between space and behaviour in the context of learning processes, a mixed-method approach is used. This approach enables bridging interdisciplinary knowledge in the context of children's perceptions and behaviour and how these aspects define their spatial needs in the context of learning and learning spaces.

It is also necessary to use a mixed-method approach to limit drawbacks and avoid biases of using a single method while studying a young group of participants (Clark and Moss 2011; Creswell 2003; Morrow 1998, 2001). The theoretical enquiry was supplemented by case studies to gain a deeper understanding of children's perspectives of their school environments. The case studies in three primary schools

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[5] As defined by Singh (2007, 64), exploratory research will 'allow researchers to explore issues in detail in order to familiarize themselves with the problem or concept to be studied…enabling researchers in formulating research hypotheses'. In the context of this study, the exploration aims to gain a deeper understanding of the space–behaviour nexus and its potential to enable better learning for children with LDs in mainstream schools, as well as the key issues that need to be addressed in mainstream school designs to enable them to be inclusive of children with LDs.

[6] As defined in List of Definitions and Terminologies, inclusive educational practice is typical of mainstream schooling, where children of diverse abilities are welcomed to study in traditional and alternative pedagogical school models. The current study's focus of exploration is the potential of spatial design to respond to this diversity via design for mainstream schools based on the belief in the transformative qualities of physical environments on human behaviour.

in Perth aim to rationalise the significance of child-centred holistic approaches to school design as a response to current educational policies for mainstream schools to be inclusive environments for children with LDs. They are based on the theoretical framework defined by the literature on human–environment transactions with the objective of examining transactions between learners and their school environments as part of their learning processes. A mix of qualitative and quantitative methodologies are used for case studies, with the quantitative element aiming to contribute to gaining deeper meaning to data from qualitative research process. A qualitative approach is adopted, as the data sought for research questions can only be obtained by studying children's behaviour in real-world school settings and gaining their perspectives towards their environments (Burns 2000; Lincoln and Guba 1985). The case studies will be valuable in providing insights into students' interactions with space and will therefore contribute to the central thesis questions regarding ways in which spatial design can be inclusive for children with LDs in mainstream settings.

The data for the case studies are collected from primary school children in the 6–8-year age group from three mainstream[7] schools in Perth (one traditional and two alternative pedagogical school models) by triangulating open-ended questionnaires, surveys and visual methods supported by field observations. Traditional and alternative models differ in their educational approaches. The first follows a direct instructional approach, where student learning is directed and monitored by the teacher for a group of students. The alternative model follows an indirect student-centred model of exploration and self-guided learning. Implementation differences can occur based on the use and interpretation of behaviourist learning principles of maintaining student interest and offering corrective feedback in both models (Magliaro, Lockee and Burton 2005; Lillard 2012). As a result, educators' expectations of and needs from school environments differ in relation to their educational approach. As mainstream schools include children with a range of LDs, the focus is to develop an understanding of how design responses in mainstream schools affect children with and without LDs.

[7] In this thesis, mainstream schools form the sample setting for the case studies, providing data on how the environmental needs of children with and without LDs were met in their learning environments.

Both physical and social dimensions of a school environment are construed to play a role in the experiences of an individual and the interpretation of its affordances (Clark and Uzzell 2006). As children without LDs form part of the socio-learning environment of children with LDs, the social learning processes[8] of both groups are interlinked. Therefore, including both groups in the study is an important part of determining whether a school's spatial design can be 'inclusive', as the two groups influence each other's social and environmental interactions. This contributes to informing ways of designing mainstream schools that respond to the spatial needs of both groups and are therefore 'inclusive and child-centred' in nature.

While this thesis acknowledges the arguments of Tufvesson and Tufvesson (2009), who suggest that relevant data towards inclusive school buildings cannot be obtained from children with LDs, it argues that without the child-centred perspective of this group, solutions towards positive behaviour and learning cannot be developed to benefit or assist them in their learning objectives. Consequently, the case study model has been designed to acknowledge that such children may have difficulties offering answers in specific form. To combat this, alternative non-verbal techniques of wish poems and art surveys are offered to ensure trustworthiness of data.

This chapter outlines the theoretical framework used to explore the key thesis questions. It describes the methodological approach with the rationale for methods and sample selection for the case studies.

2.2 Methodological Approach

The main considerations of this study on space and behaviour in the context of school spaces and children with LDs are explored via a theoretical enquiry process supplemented by case studies and an analysis of interdisciplinary literature from the perspectives of architecture, education, environmental psychology and environment–behaviour science. The objective is to identify gaps and intersections between the sphere of school design, mainstream education and LDs necessary for the exploration of the thesis question of spatial influence on behaviour in the context of children with

[8] As defined in List of Definitions and Terminologies, learning processes are the ways in which children gain new skills, knowledge, attitudes and values (Gredler 2001). These include social and environmental dimensions of the school environment.

LDs. The combination of data from the theoretical component and the case studies is analysed using constant comparative analysis (CCA; see Figure 3.1) to generate answers to the central question of the thesis.

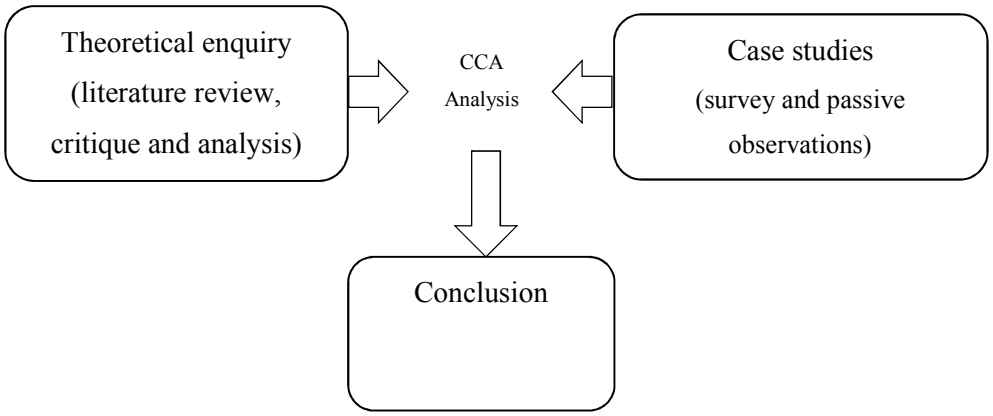

Figure 2.1: Research process diagram

This study uses a CCA process based on Charmaz's (2003) constructivist version[9] of grounded theory as an analytical approach and to guide the case study process. The methodology is not a constructivist grounded theory; rather, it applies CCA as an analytical approach to link the theoretical research with the case studies. The rationale is based on the objective of the exploratory thesis to explore the nature of key issues that can affect learning for LD groups from the spatial design perspective. This is a vital step in understanding the potential and extent to which design can respond to the spatial needs of children with LDs in the mainstream school setting. This is different from the inductive methods used in Charmaz's (2003) grounded theory, which combines an exploration of how, what and why questions (Charmaz 2008). This inductive method could act as a methodology in future research into questions raised by the current study.

This approach produces knowledge related to the thesis questions regarding space, behaviour and learning abilities by comparing the literature from the theoretical analysis and the case studies. It also supports the need for comparisons in the case studies between:

[9] As explained by Fram (2013), 'Charmaz's (2003) version of constructivist Grounded Theory (GT) distinguishes CCA process as a method which can be adapted and used with other methods (2)… and supported by naturalistic enquiry (3)'.

1. data collected using different tools of the case study to support triangulation (Burns 2000; Guba 1981) for greater trustworthiness of results
2. responses of participants with and without LDs to examine similarities and differences
3. data from the three mainstream schools to examine questions regarding articulation of space from the pedagogical perspective to understand associated spatial needs.

The constant comparison enables the refinement of evolving themes as the study progresses. For instance, comparisons within the literature on diverse learning abilities within mainstream classrooms streamline the focus onto children with LDs sharing common issues of inattention, impulsivity, anxiety and stress,[10] those with ASD and ADHD/ADD, and those with LDs co-occurring with these disorders. Thus, this study is limited to children with LDs and those with LDs co-occurring with spectrum and ADHD/ADD disorders, with a focus on examining the environmental factors that contribute to the common issues experienced by this group.

As discussed in Chapter 1, the following two theories based in environmental psychology are used as a lens for the theoretical enquiry and case studies and have the following objectives:

- Parsons' (1909) person–environment fit theory is used to understand what types of student–environment fit must occur for designs to be 'inclusive'.
- Gibson's (1986) theory of affordances is applied to understand what opportunities can be offered to children with LDs to make the student–environment fit occur.

These objectives provide a framework:

1. to define a frame of reference to guide the practical component of the case studies

[10] According to many researchers (Ahrentzen et al. 1982; Baum and Singer 1982; Evans 1982; Holahan 1982), environmental attributes can be a source of stress that has behavioural implications. In the context of education and LDs, studies show that environmental attributes can act as triggers to aggravate the symptoms of ASD (Shabha 2006) and ADHD (Farrell 2010), which can impede the learning processes at school.

2. to define and develop relationships between school design and the variables of the study, such as learning processes (e.g., behavioural, experiential, perceptual), performance, motivation, health and well-being.

These theories are discussed further below, highlighting the relevance of exploring key questions on child-centred perspectives and achieving inclusiveness in the design of school environments.

As the study progresses, the theoretical component indicates the need to further explore the following secondary questions:

- School design encompasses a broad range of elements (such as interiors with furniture and spatial design, light, colour and air conditioning, and exterior elements such as play areas, circulation paths and gardens) that are designed to match the project brief. How can these elements be examined within the framework of this study to determine the link between space and behaviour in the context of school environments and LDs?
- As the theoretical component of the study progresses, a need emerges for *child-centred design* (see List of Definitions and Terminologies) solutions that are designed to match children's perceptual and behavioural needs and provide opportunities to engage with their environment as part of the learning process. How can more be learned regarding children's perspectives, specifically those with LDs co-occurring with issues of inattention, impulsivity and sensory processes? This indicates the need to conduct observations of real-world school environments to understand how children with LDs, as defined in this study, experience, perceive and engage with their school environment.
- How can we identify whether there are any discernible differences between children with and without LDs in their preferences for and interpretations of their school environment? How will these understandings translate to school design?
- How can we obtain reliable data from a group that may have difficulties responding to conventional research tools such as open-ended questionnaires?

Such an approach requires the researcher to compare the literature (what is known) with observations of real-world settings (what exists in reality) to understand whether the link between space and behaviour can be explored further via a study of school spaces and a variety of student responses. A comparison is also required between 'what is known' from the literature on school design and 'what exists' in school environments to develop an understanding of the differences in how children with diverse learning abilities engage with, and what they prefer in, their school environment.

The best approach to understand human behaviour in the context of their settings requires a qualitative research process. As defined by Burns (2000, 388), qualitative research 'is a way of understanding people and their behavior and focusing on the truth as perceived by the individual'. This matches this study's objectives of understanding children and their interactions with their school environment. A qualitative approach is the most relevant because the exploration focuses on the experiences, interactions and perceptions of a specific group of individuals with specific needs (i.e., children with LDs in a mainstream school environment). A smaller section of this thesis also required a quantitative approach as discussed below.

Aliaga and Gunderson (2006) have defined quantitative research as a type of research which 'explains phenomena by collecting numerical data that are analysed using mathematically based methods (in particular statistics).' It is better suited to examining cause and effect relationships and limits the number of variables that can be examined in a study (Singh 2007). However, 'it fails to take account of people's unique ability to interpret their experiences, construct their own meanings and act on these' (Cohen, Manion and Morrison 2013, 15). As the focus of the current study is to gain deeper insights into the engagement and relationship between spatial design and its users, the key thesis questions are explored via qualitative research process and are supported by quantitative component from case studies. The emphasis is to explore a particularly complex issue of examining environmental influences on learning potential of those with LDs in the presence of multiple variables. For example: built and natural school environments, learning environments, LDs and learning processes. The study thus uses a quantitative approach to gain numerical

data from questionnaires and surveys (for example, image survey and wish poems) with the objective of developing a visual representation of the complex qualitative data collected. For example, graphs from image surveys depicts trends in preferences for various elements of school environment offering support and better interpretation of verbal responses from image survey. Similarly generation of word maps (Figure 2.6) from wish poems enabled a better understanding of the qualitative responses from wish poems on children's insights into preferred school environments.

The key aims from the quantitative approach are to examine:

- Trends in image preferences from interior, exterior and natural aspects of school environment.
- Trends in preferences for built versus natural aspects of school environment
- Trends in above preferences between those with and without LDs

No statistical methods are used for analysis of the quantitative data as the objective of using this approach is to gain an in depth understanding of the qualitative data from case studies and interpreted using the theoretical component of the study. The quantitative data was analysed as part of CCA method. The sample size of students as explained further is also not relevant for statistical purposes but appropriate to answering the current study's questions as outlined above.

A modified version of the post-occupancy evaluation (POE) technique (Maclennan 1991; Zimring 2003; Zimring and Reizeinstein 1980) is used to create tools for data collection (e.g., open-ended questionnaires) for the case studies. This is combined with visual surveys and passive observations to collect data from three of Perth's mainstream primary schools. As outlined above, the case study drives the naturalistic enquiry process, but it is interpreted in relation to the theoretical component using CCA. It is conducted with a focus on understanding the relationship between space and behaviour using the above theories of affordances and person–environment matches. This framework is applied to contextualise the case studies and understand how the three mainstream schools' designs are perceived by children of both groups. The aim is to learn more about the similarities and differences in perceptions to

provide an understanding of how these perceptual diversities can inform strategies for developing an inclusive solution to mainstream school designs.

2.2.1 Theoretical research

This study is based on a hypothesis grounded in environment–behaviour studies that support the notion that the environment can influence human behaviour (Broadbent 1980; Canter 1974, 1975; Moore 1979; Moore and Zube 1989; Rapoport 1990). The emerging hypothesis in this study is that child-centred designs (i.e., designs that are created to match perceptual needs and sensibilities) will elicit positive behaviour, resulting in better learning potential among children.

Taking into consideration the aims and objectives stated in Chapter 1, the theoretical component of this research investigates the following:

- It explores interdisciplinary literature to understand how school architecture has evolved to the current prototypes of school design, as well as the role of pedagogy in this evolution.
- It examines theories of spatial design and education related to environmental psychology and human behaviour in the context of children with LDs and their interactions with their physical environments to understand the common interdisciplinary overlaps and the relevance of these interactions to children's ability to learn.
- It explores the perceptual and behavioural needs of school children with LDs to understand how they perceive, experience and engage with their learning environments.
- It explores what it means for children with LDs to pursue learning in spaces designed for mainstream schooling to understand the specific spatial needs and preferences of this group in mainstream schools.
- It examines current architectural approaches to mainstream school designs to identify what can be done better to respond to the pedagogical needs of inclusion in schools. The aim is to understand the gaps and issues in mainstream school design approaches that might have resulted in spaces that are incongruent with the needs of children with LDs.

Literary data sources: Literature from books, published papers, journals articles, policy documents, reports and standards (building and construction) that relate to school design practices and education in the context of children with LDs are explored from various databases, including JSTOR, ProQuest, Science Direct, ERIC (Proquest), Springer Link, Wiley Online Library, Standards Online (Sai Global), ABS, Australian Education Research Database online and Australian Architecture Database (ARCH) Informit. These texts are coded into themes from architecture and education that coincide with the space–behaviour nexus and its transformative effects on psychological and physiological processes relevant to learning. As a result of this examination, the two theories of affordances and person–environment fit emerged as a lens that provides a methodological and analytical framework to examine the interdisciplinary overlaps between architecture and education from the perspective of environmental psychology and environment–behaviour in the context of children with LDs.

Methodological path of enquiry

Using the above two theories of affordances and person–environment fit as a lens, the theoretical enquiry is conducted as follows:

1. An examination of literature and theories on education, built environments and behavioural sciences focuses on understanding:

    - themes of environment and behaviour and their role in influencing the physiological and psychological state of users
    - themes of special needs education to understand learning processes for the LD group in mainstream schools.

    An exploration of architecture literature in the context of education is conducted in relation to historical precedents in school architecture to understand the effects of educational reforms and pedagogies on shifts in school design approaches.

2. Literature on specific environmental attributes and their influence on users examines the relevance of these links for LD groups studying in mainstream schools. The aim is to gain insights from existing architectural approaches on

ways to respond to the spatial needs of LD groups studying in mainstream schools.

3. An examination of theories and literature in the architectural context on what exists and what is lacking in current school design approaches is conducted to understand the issues and gaps in current practices that need to be bridged to respond to current educational practices of inclusion in mainstream schools.
4. The above literary data are examined to understand how these varying factors intersect to contribute to knowledge that will enable schools to be designed that respond to mainstream schools' policies of inclusion.

To develop a context for identifying links between architecture, education and behaviour, literature from environment–behaviour sciences is examined with a focus on individuals' experiences of and perceptions towards their environments. As the study progresses, the literature indicates that environmental influences extend to the natural aspects of school environments and play a key role in influencing students' interactions and experiences related to their learning processes (e.g., Ogden et al. 2010; Tanner 2000; Wood, Christian and Martin 2011). The enquiry evolves to include an exploration of both built and natural aspects of a school environment aligned with the focus of this thesis on developing inclusive design strategies congruent with children of diverse abilities.

Environmental psychology is a discipline that studies the interrelationships between the environment (built and natural) and humans, including the effects of environment–human interrelationships on behaviour and cognition (Bechtel and Churchman 2002; Gifford 2007; Stokols and Altman 2003). Its theories can be used as a lens to understand phenomena in humanistic disciplines such as social science and education. Consequently, the transformative influence of physical environments on behaviour is explored by studying previous research on the application of environmental psychology theory in the context of architecture and education. As the focus of this study is human–environment interactions in school environments, it is important to analyse literature and theories from this field to understand the role of these interactions in the context of children with LDs and the applicability of the overlapping themes in school designs.

The broad term that examines the applicability of environmental psychology is environment–behaviour studies (Moore 1979), which, in the context of architecture, include 'systematic evaluation of relationships between environment and human behaviour and their application in the design process' (Moore 1979, 46). But the applicability of this area of study is multidisciplinary (Moore 1984), and for this study it includes education where it has been applied to the evaluation of relationships between school environments and teaching practices (Martin 2004), and students' performance (Martin 2006) and behaviour (Guardino and Fullerton 2010). Such studies are examined for relationships between physical environments and behaviour by comparing common themes between school architecture and education. These studies are further explored from the theoretical perspectives of environmental psychology and special needs literature to identify how these themes relate to children and their learning abilities. Thus, examining literature from environment–behaviour studies bridges the gap between the architecture and education disciplines.

Theoretical frameworks

The central premise of the person–environment fit theory in the context of this research is that an incongruence between individuals' abilities and the environment leads to stress (Caplan and Van Harrison 1993; Vischer 2007). A congruence of environmental opportunities with users' needs (e.g., perceptual, psychological, physical) will elicit positive behavioural outcomes (e.g., well-being and work productivity). As outlined in Chapter 1, the theory of environmental affordances (Gibson 1986) suggests that users' perceptions of and responses towards their environment are linked to the opportunities provided to use their abilities. When the environment fails to coherently convey what opportunities are available to match individuals' needs with their abilities, they elicit negative responses from users. For instance, in the context of this study, the 'physical attributes of a space such as furniture and materiality provide information about the spaces potential function influencing student's impressions and elicits an associated response' (Graetz and Goliber 2002, 15). An absence of clear environmental cues for available spatial affordances to match users' needs could elicit a negative response from users. This implies that the environmental attributes of a school environment are vital to informing students' perceptions. The study examines the literature using the above

theories to identify how such environmental attributes in school environments are linked to learning processes among the LD group. The aim is to explore the potential of aligning the spatial needs of the LD group with a relevant design response.

The above theories are also used to understand existing education practices of creating *physical settings* (see List of Definitions and Terminologies) for learning to take place. It is important to examine these settings from the perspective of educators to understand the affordances or opportunities being sought to fulfil pedagogical objectives. From an architectural perspective, using theories from environmental psychology as a lens helps to identify the overlaps between the notions of physical settings and physical environments, which can then be used to develop designs with environmental affordances to facilitate learning.

In the educational context, constructivist-based theories are analysed to understand how children learn and engage with their physical environment in the context of school spaces. The constructivist school of thought considers learning a process in which knowledge is generated from experiences and interactions between students and their environment (Glasersfeld 1996, 2005). It also takes into consideration the responses elicited as a result of interactions between students and their environment (Fosnot 1996). Therefore, environmental experiences and responses are important areas taken into consideration for this study.

Constructivism-based theories of child development and education (e.g., Dewey 1916; Kolb 2014; Montessori 1912, 1964; Piaget 1970) have not only addressed the significance of environments on learners' mental, social and physical growth, but also set precedents for twenty-first-century learning (Lippman 2010a). However, the constructivist notion places greater value 'on learner's constructed understandings from social and physical experiences than the affordances and constraints of the physical environment which is viewed as a passive backdrop' (Lippman 2010a, 133). Examining these theories from the constructivist perspective is critical to understand how designers can respond by creating physical environments that mediate learning for a group with diverse learning abilities.

In the context of special needs education, literature on support strategies from spatial, environmental and pedagogical perspectives for children with special needs,

including those with LDs, ASD, ADD and ADHD, is explored to draw out concepts that can inform inclusive design strategies. The literature indicates other key theories and support strategies applied in the educational context for both mainstream and special needs categories. These are applications from occupational therapist Dr Jane Ayres' (1972, 1989) sensory integration theory, the environmental stress model, information overload theory (Gaines and Curry 2011) and arousal theory (Bell, Fisher and Loomis 1978). These three theories inform questions on environmental attributes that can act as catalysts, impediments or positive influences, depending on how they are articulated in school spaces, relating to the learning processes of children of both groups, and specifically those with special needs.

Research on challenges experienced by the LD group is examined to isolate those challenges experienced due to schools' physical and social environmental aspects. For students with LDs, learning in mainstream schools without specific affordances to respond to their needs can pose challenges to their sense of well-being and ability to learn, which subsequently influences their academic performance. A review of the literature on users' (children and teachers) challenges in mainstream schools finds two issues. First, teachers at mainstream schools experience significant stress and difficulties while trying to integrate the needs of the LD group with those without special needs (Engelbrecht et al. 2003; Forlin 2001; Vaughn 1996). Second, students with special needs, including those with LDs as defined in this study, experience challenges from both social (at risk for bullying by peers without special needs [Norwich and Kelly 2004; Whitney, Nabuzoka and Smith 1992], exclusion or difficulties integrating with peers [Nowicki 2003]) and physical environment (distractions posed by noise for ADD or ADHD students, sensory triggers for ASD students [Shabha 2006]) aspects at school. The impediments and positive affordances of environmental attributes in mainstream schools are further analysed to determine which of these environmental accommodations in terms of spatial accommodations created by educators can become part of an integrated and holistic approach to mainstream school design and contribute to a greater ability to learn by enabling a better focus and sense of well-being. These efforts might then contribute to better learning outcomes. Consequently, it is necessary to study education and special needs literature to understand how the needs of this group are being accommodated in spatial terms by educators, and to determine whether school design can support

educators' strategies by enabling a closer congruency between the school environment and children with LDs when studying in mainstream schools.

The critical analysis of literature on built environments and children in the context of learning highlights the need for a more holistic and integrated approach to achieve inclusive and child-centred school environments. It raises questions regarding designers' recognition of the pedagogical need for flexible and adaptable spaces to meet the diversity of students in mainstream schools. As seen in studies on learning spaces (Lippman 2010a; Rivlin and Wolfe 1985; Weinstein 1979), incongruence between users' needs and space results in spaces being re-organised to align with pedagogical needs. While these observations may be viewed as the success of a flexible spatial design, where users can find affordances to meet changing needs, it raises questions regarding how designers should interpret 'flexibility' to avoid crossing boundaries where flexible spaces lose focus on the pedagogical and functional needs of users (Krovetz 1977).

Further, theories in environmental and development psychology suggest that children's perceptual sensibilities towards their physical environment differ from those of adults (Evans 1980; Piaget and Inhelder 1963), and these differences need to be considered while creating learning environments. Design strategies that consider perceptual sensibilities and environmental attributes relevant to meeting the spatial needs of both groups of children require a deeper understanding of their perceptions in real-life settings. This indicates the need for an additional examination of space–behaviour relationships in a real-life school setting, which introduces the case study (practical) component of the study.

2.2.2 Case studies

The case studies address specific questions of space, perception and behaviour via a mix of qualitative and quantitative approaches applied to studying mainstream schools in session. It focuses on a sample group of primary school students in the age group of 6–8 years and includes both children with and without LDs. The setting is three primary school environments that were built according to conventional school building codes, but that differ in their pedagogical models. The case studies aim to understand the unique aspects of children's spatial perceptions and preferences when

approached from the above theoretical perspectives, rather than attempting to verify the theories using standardised quantitative methods (Charmaz 2003). The case study component:

1. focuses on individuals' experiences and perspectives in the naturalistic setting of a school environment to study the link between environmental attributes and learning potential (using POE tools adapted from previous studies on built environments)
2. compares these observations with the theoretical component to analyse the observations and address the research questions regarding children's environmental preferences and behavioural inclinations in school spaces.

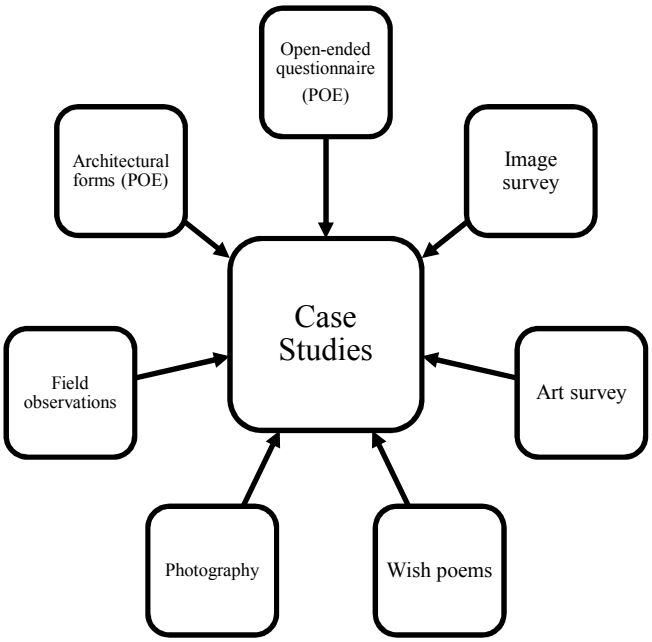

Figure 2.2: Mixed methods contributing to questions explored in the case studies

The case studies form a smaller section of the research methodology and use naturalistic enquiry as a technique to observe and gain insights into students' interactions with space. Questions about children's understanding and expectations of school spaces are explored via open-ended questionnaires, surveys and passive observations (see Figure 2.2) to provide an understanding of how design can play a role in enabling better learning. It also examines similarities and differences in the nature of spatial engagement and the needs of the two groups of children in the context of designs for mainstream schools.

The literature shows that it is important to involve children in the design process to obtain valuable data to inform and enable the development of child-centred inclusive design strategies (Bland and Sharma-Brymer 2012; Şahin and Türkün 2012). Thus, this thesis seeks data from children with issues resulting from LDs to inform strategies for child-centred inclusive spaces. Viable data can be difficult to obtain from young children for design research purposes (Şahin and Türkün 2012); therefore, mixed methods with triangulation is used to ensure the trustworthiness of the data.

An important aspect of the theoretical enquiry is that when alternative education models such as Montessori and Steiner are compared with traditional models of learning, the pedagogical differences often lead to corresponding differences in spatial expectations and the way learning spaces are articulated for respective pedagogical objectives (see Section 3.3.2). The case studies compare data from alternative and traditional models in mainstream schools to understand how they respond to inclusion pedagogically and architecturally. The aim is to identify which of these spatial responses work according to users.

The case studies explore occupied learning spaces and occupants' views of their physical environment to obtain insights into how theoretical assumptions of school design and student behaviour align with first-hand experience of the school building. Further, to meet the objective of designing architecturally inclusive school buildings, more knowledge is required regarding the uniqueness of occupants' perceptions of their physical environment—specifically, in the context of this thesis, identifying differences and similarities in preferences and engagement among children with and without LDs. Thus, Bernard's (1988) model is used to study occupants' perceptions of the physical factors of their classrooms. These methods seek to answer the following questions:

- How do children from the LD group engage, perceive and experience their learning environment?
- What are their spatial preferences within their occupied school? What does this imply for school designers in terms of their spatial needs from school spaces?

The above questions evolve as the literature is critically analysed, leading the exploration from focusing solely on interior environmental attributes to focusing on an integrated approach to include exterior school spaces, such as natural elements of a school project. The literature indicates that children often mention playgrounds and green areas over built areas as preferred places (Lucas and Dyment 2010; Sargisson and McLean 2012), as the former fulfil their inclinations to play and explore (Titman 1994). Thus, the case study component evolves to include the component of green elements in school environments such as outdoor play areas and gardens. This aligns with the overarching methodological approach of constant comparison for the development of theory while allowing the researcher to play a naturalistic role in the process of enquiry by being a passive observer of participants engaging with exterior school spaces.

Identifying place preferences to gain 'child-centred' perspectives for inclusive spaces

Studies on children's environmental use suggest that environments have a strong influence on children's emotional states, with findings highlighting the importance of accessible 'hiding places' to match children's needs to be alone and escape social pressures (Hart 1979; Moore 1990; Mostafa 2008). These needs may be more pronounced in cases where LDs are intensified due to a co-occurrence with ADHD, ADD and ASD disorders presenting symptoms of emotional and behavioural issues such as anxiety, aggression and depression. Students with LDs co-occurring with ASD may need a space to withdraw and yet remain within the social fabric of the classroom (Greville 2009; Scott 2009). These students in mainstream schools may seek out places that provide opportunities to restore their emotional state, withdraw and cope with their symptoms. The case studies examine the places and environmental attributes sought by participants with and without LDs, as well as the emotional states associated with these choices. Further, they determine whether these attributes have any spatial implications for mainstream school design in terms of understanding factors that need to be addressed to ensure a seamless design to accommodate the needs of both groups.

Studies of children's place preferences[11] are rooted in environmental psychology perspectives and aim to understand the underlying psychological dynamics that are influential in their choice of place in their environment (Korpela, Kytta and Hartig 2002; Lieberg 1997; Wohlwill and Heft 1987). A review of empirical studies of children's place preferences shows that children 'seek out' or prefer places they 'like', and these 'preferential relationships are influential on their psychological well-being and health' (Korpela 2002, 371). The hypothesis on which these studies are based is that children prefer using environments that they relate to positive emotional and behavioural states, and they reject those that fail to meet their expectations of function, use or coherency. When viewed from the theoretical framework of affordances, it means that if environments afford the needs or opportunities that are relevant to the needs of the LD group, then these spaces will elicit positive responses. Thus, knowing which attributes in their school environment are 'liked' or 'preferred' is essential in identifying specific attributes that can become part of inclusive design strategies for accommodating the needs of the LD group.

The case studies used a combination of questionnaires and other open-ended surveys (mixed method with triangulation approach) to determine specific place preferences in schools and associated emotional states. As Burns (2000, 419) explained, in the triangulation approach, a combination of 'two or more methods of data collection is applied to a study involving some aspect of human behaviour'. He also stated that this methodology helps to limit, if not eliminate, any 'biases' on the researcher's view of the specific subject's 'share of authenticity' being investigated. The data are then assessed regarding architectural qualities such as quality of facilities, spatial size and arrangements and outdoor facilities. The nature of physical environments has been linked with occupants' performance levels and physical and mental well-being, including learning spaces (Shabha 2006; Spencer and Blades 2009; Tanner 2000; Weinstein 1979). Thus, the better the perceived quality of the physical environment, the better the performance. Therefore, specific environmental qualities that define participants' preferences are explored to provide an understanding of the attributes

[11] Place preferences differ among user groups based on variables such as prior experiences, upbringing, cultural conditioning and peer preferences (Malinowski and Thurber 1996; O'Brien et al. 2000). While these variables are outside the scope of this study, it is necessary to explore them to gain a deeper understanding of the preferred 'spatial attributes' that will elicit a positive response.

that are influential in eliciting positive responses and thereby enable better performance in learning activities.

Additionally, the literature highlights that being in one's favourite place brings about feelings of restoration (see Hart 1979; Korpela 2002; Moore 1990), and the physical environment may act as a mediator of this process. Related studies suggest that natural settings have a positive and restorative effect (Kaplan 1995) on children's attentional behaviour (Taylor et al. 1998) and improve functioning and symptoms among 7–12-year-olds with ADD or ADHD (Johnson 2007; Kuo and Faber Taylor 2004; Taylor, Kuo and Sullivan 2001). This link between environmental preferences and their transformative effect on learning processes is an important aspect for exploration in the case studies, as it could result in design strategies that help to reduce stress and improve well-being and attention among children with and without LDs. Based on these considerations, the case studies explore both built and natural spaces in school environments to understand the environmental preferences of the participant groups. This approach was also used because the literature shows that no one space in a school can meet the diversity of abilities among students in a mainstream school, and design strategies must be both integrated and holistic in their approach.

Lastly, research shows that, to obtain meaningful interpretations of what defines 'special' places for children, it is important to investigate what they dislike in places such as playgrounds and other outdoor settings that form a realistic part of their school environment or imaginative fantasies (Van Andel 1990). It is not sufficient to explore their place preferences within a school environment to determine the best possible physical learning environment, as their preferences are linked to their perceptions of environmental affordances. Thus, a combination of surveys and passive observations will provide insights into children's likes and dislikes in the environmental context and ensure that the data collected using the mixed-method approach are trustworthy.

2.3 Sampling: Subjects and Settings

In this qualitative study, the non-probability sampling[12] technique of purposive sampling[13] was used to examine:

1. specific types of individuals (defined by age and learning abilities)
2. specific type of schools (defined by pedagogies and mainstreaming practice)
3. 'how' (rather than 'how many') in order to understand a complex phenomenon in a specific naturalistic setting.

The suitability of non-probability sampling for this thesis is outlined below:

- It addresses the issue of difficulty obtaining a random sample population of children with LDs.
- It is suitable for budget allowed for the project because it is more economical than the probability sampling technique.
- Subset of this method—purposive sampling enables multiple perspectives to be identified in the case studies (Lincoln and Guba 1985, 40)—for example, those from the pedagogical perspective of spatial needs for supplementary spaces to offer support to the LD group and learners' perspectives of spatial needs for engagement and experience as part of their learning processes.

This resonates with the case studies' aims of gaining a deeper understanding of children's perspectives—specifically those with LDs—of their school environment. The weakness of non-probability sampling is that it is not truly representative of the larger population (Gravetter and Forzano 2006). However, the trustworthiness of the results is increased by eliminating as many sources of bias as possible using the triangulation technique (Burns 2000; Guba 1981; Lincoln and Guba 1985) and mixed methods (Creswell 2003).

The respondents of this thesis were selected based on criterion purposive sampling (Palys 2008) and the settings or schools were selected beginning with purposive

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[12] Goodrich (Lang, Burnette and Moleski 1974, 234) defined sampling a 'representative fraction or subgroup of larger respondent class possessing some features as the larger group'. This sampling discussion refers to participants of the case studies as defined by selected sampling techniques.

[13] Purposive sampling is a technique that is 'based on a specific purpose rather than randomly' (Tashakkori and Teddlie 2003, 713).

random[14] sampling (Patton 2014; Teddlie and Yu 2007) of schools, as detailed below.

Subjects

Criterion purposive sampling focuses on specific attributes of a population of interest (Palys 2008). In this thesis, the population comprises children of both genders in the 6–8-year age group with and without LDs. These parameters of age and learning abilities are relevant in determining how the subjects of both groups engage and perceive their school environment, and whether there are discernible differences in their responses. The benefit of this type of sampling is that it allows the researcher to study the type of interactions occurring within a sample, and to detect the relationships between children's learning processes and their school spaces. A limitation of purposive sampling is that it does not guarantee a proportionate mix of children with and without LDs, thereby affecting the generalisability of the sample. However, the focus is not on proportionality, but on gaining a broader perspective of the challenges experienced in mainstream school environments among children with a diverse range of LDs. To avoid researcher bias, the selection criterion is grounded in developmental perspectives from education, as discussed below.

The age group of 6–8-year-old children in the case study phase were determined based on developmental perspectives. Early childhood (infancy up to age eight) provides a 'crucial window of opportunity for parents and societies to ensure that children are afforded resources and protections to gain skills they will need to meet and adapt with challenges of the future' (Masten, Gewirtz and Sapienza 2013, 4). Educational practices also aim for the early identification of LDs to ensure there is additional support and relevant interventions for students in preschool and primary school (Gersten, Jordan and Flojo 2005). Early identification reduces 'the likelihood of students slipping through the system with significant undetected learning problems' (Vaughn and Fuchs 2003, 140). Some authors also consider that early measures (identification and intervention) in preschool and primary school children with LDs—such as reading/learning disability (Jenkins and O'Connor 2002) and

[14] Purposive random sampling is a mixed-method sampling technique that combines quantitative and qualitative sampling techniques to generate answers to research questions (Teddlie and Yu 2007). In this thesis, the sampling involves a random process of selection from a list of mainstream schools and two sub-lists of alternative and traditional schools.

mathematics difficulties (Gersten, Jordan and Flojo 2005), and not limited to externalisation behaviours such as inattention and impulsivity (Hinshaw 1992)—may be a vital first step in enabling better learning outcomes, or in some cases reducing the severity of the LD in later years. In response to data highlighting the importance of academic interventions in primary school students, the researcher selected the primary school setting and participants as the focus of this study.

The overlaps of common age group denominators from alternative and traditional pedagogies are studied to find an age group common to both alternative and traditional schools. Alternative models such as Piaget and Montessori hypothesised that classrooms should be grouped according to developmental theories on children's age-based abilities. Montessori's developmental theory considered that by ages 6–12, children display reasoning, social and problem-solving skills (Lippman 2010a). Similarly, Piaget posited that children begin to display 'an understanding of logic around complex operations, objects and events and relations around the age of 6–7 years' (quoted in Collins 1984, 74) and logical reasoning skills at 7–11-years (Huitt and Hummel 2003; Ultanir 2012), as supported by earlier studies (Renner et al. 1976). The Montessori philosophy posits placing 6–9 age groups in lower primary classrooms spanning three years of age (see Edwards 2002; Lippman 2010a), while traditional schools in Western Australia group students aged 7–8 years in lower primary classrooms (Department of Education and Training [DET], Western Australia 2016). Lower primary classrooms, as classified by alternative and traditional pedagogical school models, were thus selected for the study.

Sample setting

As per the mixed-method sampling technique (Patton 2014; Teddlie and Yu 2007), 12 schools were randomly selected from a list of schools accredited by the DET, Western Australia. They were situated within the geographical proximity of Perth and excluded special needs schools. The list included alternative (i.e., Waldorf and Montessori models) and traditional school models in Perth to ensure the sample would present both groups of students required for the study. Alternative school models are based on notions of child-centredness. They emphasise the needs of the child and encourage environmental interaction as part of learning. Literature suggests that pedagogical differences manifest as different spatial interpretations. For

example, direct teaching models use row seating, whereas indirect models use open-plan classroom seating (Carbone 2001). Similarly, progressive educators in alternative school models use interior elements (kitchen counters, bookshelves, storage for study materials) that are scaled down to age-based anthropomorphic sizes to encourage independence and learning via engagement with learning environments (Lopata, Wallace and Finn 2005; Pound 2012; Walden 2009). Thus, it is important to compare alternative models with traditional models to determine how different models use physical environments to facilitate learning.

Another objective is to examine differences in models based on education concepts such as 'level of arousal' (Bell, Fisher and Loomis 1978) and information overload (Gaines and Curry 2011) with reference to spatial design (e.g., presence or absence of visual clutter and response from the LD group). These comparisons will provide insights into students' preferences (specifically those of the LD group) for traditional versus alternative spatial design in cases where spatial attributes are not aligned with these education concepts. The comparisons will also determine which environmental factors influence their choices, and the implications of those choices for the creation of inclusive school designs.

Accordingly, letters of invitation to participate in this study were sent to local school principals, which resulted in three schools volunteering for the study—two alternative and one traditional. However, of the two types of alternative schools (Waldorf and Montessori) that were invited to participate, approval was only obtained from Montessori schools. The process of conducting the case studies is detailed in the data analysis section 2.5.

The participating schools followed inclusive schooling policies, and each had one class of 6–8-year-old students, including those with recognised LDs, available for the study. Research was conducted over several school terms in accordance with the DET's (Western Australia) schedule. As the surveys were conducted in normal school timeframes, they had to be distributed across each school term to minimise disruptions and ensure that respondents were not adversely affected. The assistance

of teachers[15] was sought for the questionnaires and surveys to minimise disruptions and limit direct engagement with participants as part of maintaining the credibility of the data. Table 2.1 summarises the selection criteria of the subjects and settings.

Table 2.1: Sample type, size and setting

Sample type	**Primary school students of both genders aged 6–8 years**				
Sample size		School 1 (Montessori)	School 2 (Montessori)	School 3 (traditional)	Total
	Non-LD	12	3	6	21
	LD	2	3	1	6
	Total	14	6	7	27

2.4 Emphasis on Qualitative Research for Case Studies

The qualitative approach was emphasised for the case studies to obtain an in-depth understanding of the spatial needs of children with LDs in mainstream school environments. In the context of research conducted in a school setting where classes are in progress, qualitative[16] research provides flexibility and enables the research questions to evolve and adapt to changes in the situation on site (i.e., the classroom), and to stay focused on the uniqueness of the setting and events (Savenye and Robinson 1996). Anticipating the unpredictability of multiple factors involved in a classroom setting in progress, such as student attendance, weather conditions and the presence or absence of assistance of teachers in conducting the survey, a mix of qualitative methods enable optimum and trustworthy data to be obtained. Jacob (1987) explained that an advantage of qualitative research is that the initially selected methods based on the research questions can evolve to adapt with changes in the research question, issues and perception of the researcher when newer understanding and data come to light. During the case studies, such problems were faced with respect to participants being unable to complete part of the survey or surveys; in

[15] Gaining teachers' assistance is in accordance with the ethical guidelines of engagement with a young group of participants, and it is a necessary part of the naturalistic enquiry process in which the focus is on no to minimal interaction with participants under passive observation, except where teachers require clarification on survey forms.

[16] Savenye and Robinson (1996) defined qualitative research as 'research focused on gaining an in-depth understanding of human systems' at the micro level (within a classroom) or the macro level (such as a cultural system).

these cases, the researcher included non-verbal alternatives to obtain the missing data. Similarly, each school was studied across a number of weeks within a school term, and the pace of obtaining the data was altered as necessary to cope with changes in school schedules, breaks, curricula and availability to enable the study to continue.

The case studies examined a small sample of 27 students, including six with LDs. To maintain the quality of the data, including abstract concepts (such as that from an art survey), data triangulation was applied. It was anticipated that the small sample size and the young age group might present hurdles such as absenteeism of respondents and inability to express verbal or written responses for the selected type of questionnaire technique. Accordingly, it was deemed essential to use mixed methods, including open-ended surveys, observations and field notes, to support the data from the questionnaires. This enabled the evaluation and verification of data collected using these methods. For instance, using verbal and non-verbal surveys for children of both groups as well as visual methods (such as photography and sketching site details as part of field observations) allowed cross-verification of the data by triangulation. Thus, answers to the questionnaire regarding the most-liked place in the school could be verified using the wish poems and art survey.

Additionally, the study aimed to gain cognitive and perceptual insights into students' physical environments at school, where such insights can be better expressed visually than verbally (Zeisel 2006), specifically in the sample age group of 6–8 years, including students from the LD group (as detailed in the sampling section 2.3). Consequently, 'non-pre-coded' techniques such as drawings and image ratings were used to determine their perceptions and emotions regarding their school and occupied classroom. The responses were then analysed by coding them into conceptual groups of built and natural environments, interiors and exteriors, emotional associations, and activity–space interpretations, and then assessed with data from the questionnaires.

An aim of the case studies was to determine how children rate their existing school buildings. Thus, forms from previous POE studies were adapted to create tools of the survey for this study, as discussed in Section 2.4.1. POE tools were the most relevant from an architectural context to gain insights into perceptions of the occupied

school's built environments, and the questionnaires were adapted accordingly. Table 2.2 illustrates the tools used in the case studies.

Table 2.2 Case studies

Case studies	Questionnaires and surveys	Student insights questionnaire
		Image survey
		Wish poem and art survey
	Passive observations	Architecture research forms
		Field observations
		Behavioural observations
		Photography

2.4.1 Tools of enquiry from post-occupancy evaluations forms

As POEs[17] are conducted to obtain feedback from occupants regarding their existing designed environments, the tools used in POE are valuable for this study in obtaining data on environmental affordances and limitations from participants' perspectives, as well as identifying the types of responses these variations in environmental attributes elicit from children. In this study, POE forms used in previous studies (Cohen, Moore and McGinty 1978; Sanoff 2001b) were used as tools for case studies from a naturalistic approach and combined passive observations and surveys to maintain trustworthiness of the data. Based on the objectives of the case studies discussed in Section 2.2.2, the case study tools focused on obtaining the following qualitative data.

[17] Zimring and Reizenstein (1980) defined POE as an 'examination of the effectiveness for human users of occupied, designed environments'. It must be noted that in architectural practice, POE is conducted to gain insights into the failures and successes of a specific design after occupancy with prior knowledge of the design brief applied to the building (Zeisel 2006).

Questionnaire and surveys

Information on the LD group (e.g., type of disability and spatial affordances available to students to receive academic support or help their learning processes) were collected from the teachers who supervised and were in contact with large groups of children. Each classroom had one teacher and a teaching assistant. In every school, one out of the two volunteered to participate and assist in running the case study, while the other managed the class in session. Teachers' insights provided data on facilities and their use—for example, how the school environment had been organised by the educators to accommodate the needs of both groups of children. In the context of this thesis, it is important to understand the relevance of physical settings from an educational perspective, as they form part of spatial strategies to support the needs of the LD group and develop inclusive design strategies in mainstream schools.

The questionnaire and surveys aimed to obtain insights from participants regarding:

1. their views on the currently occupied classroom and school
2. which built and natural environmental aspects of the school elicited an emotional response (e.g., green spaces or a particular space within it, and the corresponding emotional association as indicated by the participant)
3. factors that governed their perception of the school's built environments, such as what was considered an attractive building and why.

Passive observations

> Observing behaviour in physical settings generates data about people's activities and the relationships needed to sustain them; about regularities of behaviour; about the expected uses, new uses, and misuses of a place; and about behavioural opportunities and constraints that the environments provide. (Zeisel 2006, 191)

Passive observations of spatial engagement and use formed the core of the case studies and provided data for comparative analysis and co-relating data obtained from questionnaires, including recording field notes, photographing sites and sketching. This was conducted with a focus on an architectural assessment of spatial

qualities of colour, function, furniture and movement, and attention was also paid to studying patterns of spatial use by children with and without LDs.

The behaviour of the participants was also observed in other informal learning spaces (arts and music room) to compare behavioural changes in engaging with the informal and formal classroom spaces. The aim was to observe whether the variations between the environmental affordances of the formal and informal learning spaces influenced behaviour and spatial engagement among users.

2.5 Data collection and analysis techniques for case studies

The list of methods used in the case studies comprised:

1. Passive observations:

a. architecture research forms (part 1/2)
b. field observations
c. behavioural observations
d. photography.

2. Questionnaire and surveys:

a. teachers' and students' insights questionnaire (part 2/2)
b. image survey
c. wish poem and art survey.

Table 2.3 illustrates how the surveys, questionnaires and passive observations ran parallel to each other throughout the case studies. This sequence enabled data to emerge regarding children's interactions with and perceptions of their school environment by comparing data from the case studies with data from the theoretical component of the study using the CCA approach.

Table 2.3: Case studies data collection sequence table

Sequence of surveys and questionnaires	Running parallel to sequence of surveys and questionnaires
Data collection tool 1: Part 2 built environment forms (insights questionnaires)	Part 1 built environment forms Field notes
Data collection tool 2: Image survey	Sketches
Data collection tool 3: Art survey +	Behavioural observations
Data collection tool 4: Wish poems	Photography

This sequence was designed to prevent respondents' answers from being prejudiced by the interviewer's presence and by being an outsider to the respondents (Burns 2000; Gravetter and Forzano 2006; Zeisel 2006). For example, an essential first step prior to data collection was to familiarise the interviewer with the 'locals' (Burns 2000, 402) or students in the entry stage of the field observations. Thus, for the first few days of the school visit, students were not asked questions, and the researcher's presence in the classroom was limited to introductions between the researcher and respondents and answering their queries and concerns regarding the research. Simultaneously, field observations and visual recordings were made by the researcher over a period of one to two weeks to enable the students to become further accustomed to the researcher's presence.

The surveys and questionnaires were gradually introduced within routine class schedules with the help of the teachers and their assistants to minimise alterations to participants' behaviour.[18] The teachers handed out invitations to the entire class, and participants were volunteers. Passive observations continued when students were busy or unable to participate, with the aim of pacing the data collection tools to be unobtrusive and less stressful to the participants with co-occurring issues with LDs.

Additionally, school terms and specific periods were negotiated so that 'first-day shock' or 'end-of-term tiredness' would not influence children's perceptions and answers (Burns 2000, 403). This sequence, along with adhering to school schedules

[18] Gravetter and Forzano (2006, 329) explained that the researcher conducting observations 'can inadvertently alter participants' behaviour by directly engaging with them and identifying closely with the individual's in the study thereby also losing objectivity' (as seen in a participant observation technique). In line with this study's naturalistic enquiry approach, the researcher engaged the teachers and/or their assistants in the data collection to minimise direct interaction with the participants.

and having a prolonged period of engagement with the participants, was essential to the quality and credibility of the data.

The rich and meaningful data gathered from the case studies were analysed using non-coding techniques of grouping information into concepts based on the theoretical framework described above. Each study was conducted over an extended period, varying from three to four weeks, distributed over a school term, as per the qualitative research approach (Burns 2000; Savenye and Robinson 1996; Zeisel 2006). An extended period ensured that the researcher was not obtrusive and became a trusted part of the participants' environment (Burns 2000). This was also vital for putting the participants at ease, thereby minimising the researcher's influence on their behaviour at the entry stage of the observations (Bogdan and Biklen 2011; Burns 2000). Consequently, the data gathered provided an assortment of insights into children's perceptions of their school environment, including their imaginative ideas for their learning environment. The data were verified against each other by applying a triangulation technique to combine the visual, observational and questionnaires methods, thereby limiting issues of authenticity and reliability (Burns 2000).

2.5.1 Passive observations

The passive observations combined the use of architectural research forms to support field observations on spatial qualities. These observations were then interpreted based on the literary data in the context of school design and children with LDs regarding questions such as: What exists in the real-world settings of the participants and their perceptions towards these spaces? What do children with and without LDs see as strengths and weaknesses of these learning spaces? The aim of these observations was to gain insights from the open-ended questionnaires into children's notions about their school environments, which may have been designed from an adult perspective.

Further, patterns of spatial use by children with and without LDs were noted on the drawings created as part of the observations of the school site, including its interiors, exteriors and landscape features. The aim was to use real-life examples to understand how an academic intervention initiative by educators in the context of space was

being interpreted and engaged with by children with LDs. The passive observations ran parallel to the surveys, as outlined in Table 2.3.

Rationale for parallel observations

The parallel observations allowed the verification of qualitative data from the open-ended questionnaires and filled in gaps where information was unclear or incomplete when students were unable to express their responses. The observations played a role in maintaining the trustworthiness of the data by triangulating the data sources from the passive observations, questionnaires and surveys.

Further, they contributed to the development of knowledge on the perspectives of children with diverse learning abilities regarding spaces that were designed according to standardised models of school design by applying a CCA process:

- Data from POEs (architecture research forms) on 'what exists' in the child's school environment from the designer's perspective (researcher's professional background in architectural design) were compared with data from questionnaires and surveys on children's perspectives on 'what exists' in their school environment.
- Data were compared to identify whether and how the group with LDs differed from those without LDs in terms of their responses and perceptions of their school environment.

The four components of the parallel observations and the data being sought are outlined below.

Part 1/2: architecture research forms

The architectural research forms were adapted from built environment–behaviour research (EBR) questionnaires created by Cohen, Moore and McGinty (1978) as part of a POE of a US military residential school. The forms were originally used in an evaluation of school facilities involving school children; thus, they are similar to the context and focus group of participants of this research. The forms are relevant and appropriate for this study because they are based on an architectural framework

focused on gaining users' input into how they perceive and experience their existing school environment.

The forms included a questionnaire section for gathering data on occupants' feedback on their existing school facilities, which was modified for use as an open-ended questionnaire for the case studies, to focus on gaining insights into children's and teachers' views of their existing school facilities, including classrooms and play areas. Additionally, as the survey also aimed to observe the physical aspects of the school's design, the modified forms included a section (Part 1, see Appendix A) for recording observation on the built environment (discussed in the next section).

Part 1 mainly notes 'existing' environmental features such as lights, wall colours, flooring material and play areas. These were used as part of the analysis to understand how users rated the existing qualities and their preferences within the existing facilities, which may have been designed according to standardised school design models.

Field observations

As part of the passive observations, field notes and sketches recorded children's postures and behaviour, with a focus on their engagement with their learning environment—both built and natural. Additional sketches of spatial use patterns and circulation were noted in floor plans and schematic diagrams to compare whether differences in pedagogies (between traditional and alternative models) influenced their behaviour and use of their learning space. Recording these patterns of use onto floor plans and sketches was particularly appropriate to observe all respondents at the same time and place, and thereby provide a better understanding of how the learning environment was being used during similar activities of studying, playing and reading.

The students were observed in their classrooms during class in session, at play, at lunch and during extracurricular activities such as rehearsals for assembly and art. All survey sets (three sets for three schools) and observations were conducted within 'routine' school sessions assisted by the class teacher and the teacher's assistant. Additionally, as stated by Gutman and Westergaard in Lang, Burnette and Moleski (1974, 320):

> If evaluation studies are to be worthwhile, they must produce information that architects can use to improve their work. To do so, evaluations must specify the user's characteristics in greater detail and must take into consideration what the users think about the environment. Since management and maintenance systems of the building contribute significantly to user satisfaction, they must be included in any evaluation study.

Accordingly, a significant number of illustrations, diagrams and sketches were made of respondents during observations—for example, of the class in session and at play (outdoors). In keeping with ethics protocols, it was not possible to photograph the respondents, so the visual documentation enabled the researcher to record how participants were engaging with their school environment. Part 1 of the built environment forms (see Appendix A) were used to note visible physical conditions of the school and evaluate these with answers from art and wish poem surveys and with data from Part 2 of the questionnaires to establish connections and maintain credibility of data.

Thus, Part B of the field notes involved sketching architectural diagrams reflecting spatial use and circulation plans to identify the most and least used spaces. These data were then matched with what participants with and without LDs reported in the questionnaires. The data were added to the analytical tables alongside the responses from the questionnaires to interpret and tally the answers from the questionnaires and surveys (art survey, wish poem and image survey) to understand what spatial attributes were considered congruent for children with and without LDs using a positive emotional association indicated from the questionnaires and surveys.

Behavioural observations on spatial use

The technique of recording data via visuals also aimed to explore the behavioural inclinations of this particular age group of children in the context of school spaces to determine age-based characteristics of spatial engagement. As Zeisel (2006, 191) explained, 'observing behaviour of participants in their physical settings generates data on behavioral opportunities and constraints that the environments provide'.

Prior to behavioural observations, the questions asked were:

1. What are the typical postures (natural tendency) of children in the learning environment at work? How far are these postures influenced by affordances of the classroom space (furniture, illumination, colour palette etc.)? Are these influences positive or supportive of their typical postures (sitting on floor, standing, lying on floor etc.)?
2. Which activity is most preferred during a school day, and which spaces correspond to these activities? The natural behavioural tendencies to explore and move are an important aspect of children's interactions with their physical environment (Cosco 2007; Day and Midbjer 2007). It was intended to explore how and if the existing physical environment was inhibiting or supporting their inclinations at school (i.e., to move, to work in groups, to work alone) deduced from the above observations, and to compare these observations with the survey and questionnaire responses.

Thus, Part C noted how children behaved in both indoor and outdoor spaces in the context of spatial use and their postures. It specifically examined how they interpreted the environmental affordances in these two spaces—one built and one natural in its attributes. The aim was to understand which attributes of the school environment from the choice of spaces available were perceived as most favourable as part of the learning processes, specifically for children with LDs. The data were also assessed for similarities and differences between the responses of the two groups of participants. The data collected were interpreted using the theoretical framework discussed above to ensure that the researcher did not lose objectivity due to empathy with the participants or the condition of their settings (Zeisel 2006).

Collecting the data was relevant to the study's objective of identifying strengths and weaknesses within existing school environments that respond to the needs of inclusive practices in mainstream schools.

Photography

Part D of the parallel observations included photographing site conditions,19 ranging from interior spaces to outdoor spaces. Photographs served the following purposes for this study.

First, they provided an understanding of what the designers had offered in terms of opportunities through the environment, and how these opportunities were aligned or incongruent with the needs of the participants. Second, due to their illustrative quality, photographs were used to better interpret the data collected from the questionnaires and surveys. For instance, one student reported that a preferred spot for quiet time was a 'secret garden', which turned out to be a patch in the school playground almost insignificant and unnoticeable to the adult eye. Upon closer observation, it was seen to be 'hidden' behind circular pipes and was big enough to offer a place to hide to peers in the same group, and possibly even adults. Thus, photographing the aspects stated in the questionnaires and surveys ensured that the data were interpreted in consideration of participants' perceptions of their environmental attributes, thereby ensuring data quality.

2.5.2 Questionnaire and surveys

> Questionnaires provide useful quantitative data when investigators begin with a very well defined problem, knowing what major concepts and dimensions they want to deal with. (Zeisel 2006, 257)

However, as this study is exploratory in nature, it focuses on qualitative data and hence uses open-ended tools. The quantitative data as stated previously supports and validates the open-ended qualitative data. To reiterate, the overall objective of the questionnaires and surveys (wish poem and art survey) was to obtain insights regarding:

1. children's views regarding the currently occupied classroom and school

[19] As Zeisel (2006) explained, photographs are useful to record physical traces of use, such as a path of trampled grass across a lawn where people may have used the environment in a new way, and leftovers of activities that help locate spaces that accommodate or partly accommodate planned activities, or that were used in unanticipated ways. They also provide missing traces where spaces designed for specific use have not been used for the purpose, leading to fruitful insights into why an available space or facility is not congruent with users' needs.

2. teachers' feedback regarding spatial affordances that are present or lacking for the LD group
3. the built environment aspects of a school that influence their sense of well-being, such as green spaces or a particular space within them
4. factors that govern their perception of school built environments, such as what is considered an attractive building and why
5. testing the space–behaviour hypothesis on indoor versus outdoor spatial preferences among children—specifically those with LDs.

These questionnaires (see Appendix A) were designed to elicit open-ended responses regarding children's preferences and dislikes of their existing learning environment. While standardised questionnaires focus on obtaining quantifiable data via coding, these questionnaires, although open-ended, were analysed by recording exact answers and subsequently grouping them into similar concepts of place preference and building ratings. Next, the responses were compared within each group to obtain data on attitudes towards the schools' built environments. The aim was to learn which emotional responses the schools' environments were eliciting in children—specifically those in the LD group. This understanding was vital to considerations of this study on design strategies that support the relevant behavioural needs of the LD group.

The questionnaires also included a visual component of students' 'cognitive maps' of their preferred place in the school or classroom. A cognitive map is an important tool in obtaining information in behavioural research contexts and is defined as a mental image of the individual's surroundings used to structure the way the environs are seen and responded to, evoking specific spatial behaviour (Downs 2005). The option between a classroom and school was given to the students to ensure that the questionnaire allowed for those whose preferred place in school was mostly outside of the classroom and, as such, their perception of the 'learning environment' might have been the school environment in totality. The aim was to learn how children in this age group perceive their school's environment, with a focus on understanding their interpretation of the 'school environment', and which of these elicited positive and negative behavioural responses by using the cognitive maps against their responses in the questionnaires and surveys.

Part 2/2: 'insights' open-ended questionnaires

Information on children's' behaviour and cognitive abilities were collected from the teachers who supervised and were in contact with the children. Additionally, the questionnaires obtained information from the teachers' perspective on school pedagogies and school facilities. This information was relevant for the following reasons:

- The information was compared with the researcher's observations of the facilities to gain a better understanding of the strengths and weaknesses of the school environment that could affect how space was articulated and experienced by the participants of the study.
- The information provided an understanding of how the teachers (as per their model of pedagogical constructs) had defined the learning settings, and the corresponding response in participants to these variations in spatial settings. Literature (e.g., Lillard 2012; Lippman 2010a; Pound 2012) indicates that Montessori and traditional pedagogies differ in the desired type of physical settings. The case studies compared how these varied interpretations of space were perceived by the children in the two groups within the same school and between the three schools—specifically, in terms of how the teachers had responded to mainstream policies of inclusion for those with LDs. This was further analysed in comparison with the literary data from special needs education to better understand the selected academic interventions in terms of space[20] in the classrooms that the teachers had created for children with LDs.

Analysis of Tool 1: Part 2 Insights Questionnaires

This questionnaire aims to gain insights into students' perceptions of their occupied learning spaces—mainly the features of their current school that they liked and disliked. Based on theories that children seek out and prefer environments that offer

[20] Academic interventions and support in the context of space for children with LDs refers to creating designated spatial zones or physical settings within mainstream classrooms to respond to the needs of these students, such as creating a dedicated study nook for those with inattention issues (e.g., Carbone 2001; Mostafa 2008). These form part of the strategies that educators incorporate to support the learning processes of children with LDs.

feelings of restoration (Hart 1979; Korpela 2002; Moore 1990), the second part of the questionnaire focuses on understanding the links between behavioural needs, emotional states and the spaces in school that students consider suitable in fulfilling these needs. These needs include seeking spaces depending on their suitability for socialising with peers, playing and quiet time. The aim is to identify links between school spaces, behavioural needs and emotional states of children with LDs, with the objective of furthering an understanding of their spatial needs.

Questions were asked regarding which spaces they would use when feeling the need to, for example, be by themselves, be with friends and have quiet time. The open-ended answers from the questionnaires were noted as direct quotes and then coded into user-satisfaction groups from indoor and outdoor school settings. Table 2.4 presents examples of how the responses on behavioural and emotional aspects (e.g., quiet time, feeling happy and feeling active) and associated spaces (e.g., part of a play area or study nook) were grouped into indoor and outdoor environments for each participant. They were then grouped into responses from LD and non-LD groups, to identify variations and commonalities in responses from both groups in relation to behavioural associations in their school environments.

Figure 2.3: Questionnaire's visual component for verifying responses

Table 2.4: Inference table for behavioural associations for indoor and outdoor areas in school settings

Behaviour/emotions (e.g., feeling the need for…/feeling…)	Indoor environment (e.g., classroom, library, art room, music room)	Outdoor settings (e.g., formal play areas, informal play areas, lawn, ovals, veggie patches, patios for meals)
Quiet time		
Active		
Happy		
Sad		
Be by self		
Be with friends		

The questionnaires also included a cognitive-mapping-based (Downs 2005; Zeisel 2006) 'drawing component of preferred place in school or classroom', which aimed to verify and enhance verbal responses from the questionnaire. The students were asked to draw a picture depicting their favourite spot in the school or classroom. These drawings were then analysed by classifying them into sets depicting built versus outdoor spaces and noting other data such as labels, annotations and verbal quotes that respondents offered with the drawings. These notes accompanying the visual content supported 'what was depicted with what was reported' within the questionnaire and improved data reliability.

Image survey

This second type of visual research method, adapted from an image rating survey of a school building and site planning (Sanoff 2001b), originally focused on obtaining parents' and teachers' insights regarding solutions to perceived issues in occupied school buildings to help them understand the sensitive role of an architect in a project (Sanoff cited in Walden 2009). In the context of this research, this adaptation of the image survey aimed to interpret students' aesthetic preferences related to the school environments (built and natural) in terms of scale, materiality, aesthetics and appearance, and to determine the factors that influenced these choices. In the context

of school and learning for the selected age group of students, the image survey determined:

- specific responses to 'perceived excesses' in the physical aspects of built environments
- participants' perceptions of and preferential factors relating to these school environments
- boundaries where the preconceived ideas of comfort and security of the familiar school settings were abandoned in favour of unfamiliar built environments.

This survey was crucial to gain a broader understanding of participants' perspectives on school environments in terms of materiality, scale, excesses and deviations in environmental features (e.g., colours, materiality) to cover environmental attributes that were absent from their current context.

Figure 2.4: Sample of images from image survey is unable to be reproduced here due to copyright restrictions. Figure 2.4 can be accessed via URLs found in Appendix B.

Figure 2.4: Sample of images from image survey (see Appendix B for all images)

The selection of images of school buildings (Appendix B) was mainly based on buildings that deviated from the 'norm' in terms of conventional school building and excesses in terms of appearance, cultural notions, affordances and aesthetics. The

idea was to determine 'how and why' children rated school buildings that appeared different and similar to those occupied by the respondents:

- To gain comparative insights into how they perceived their current school spaces against spaces that appeared similar but were not experienced.
- To understand the specific aspects of their familiar spaces that were important and influenced their sense of well-being or determined their preferences regarding learning spaces when the similarities ended.

To summarise, the factors that defined the image selection were:

- similarities (familiarity) in terms of appearance (built form, size, scale, aesthetics, materiality, colour, texture)
- environmental excesses in terms of materiality, colour and texture
- deviation from norm and familiarity (differences from Australian 'standard' form of school architecture and cultural notions of school architectural attributes, e.g., rural or urban architectural style, facilities and aesthetics).

The participants were shown 11 images (see Figure 2.4 and Appendix B).based on the above criteria and grouped into the following categories

- buildings (see Appendix B Images B1– B4)
- classrooms (see Appendix B Images C1–C3)
- miscellaneous school spaces within schools (see Appendix B Images M1, M2, M3.1 and M3.2).

The images contained human figures or students offering cues on how these spaces were being used. The participants were asked to rate these using smiley-face stickers, with each smiley face corresponding to how they rated the image (ranging from extreme dislike to extreme like; see Figure 2.5). This method was used due to its accessibility to children in this age group (see Appendix A).

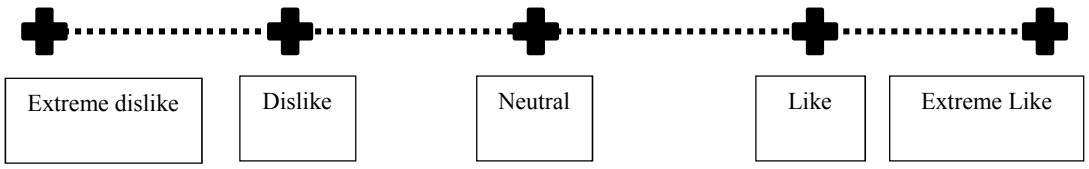

Figure 2.5: Image survey rating scale

Analysis of Tool 2: Image Survey

To minimise disruptions to class schedules, this survey was conducted in a group by the teachers or in coordination with teachers where a one-on-one survey (Gravetter and Forzano 2006) was the only option.

The responses were evaluated based on the attributes of the physical environment that influenced participants' ratings of the images and then the selection criteria from the perspective of the built environment. The data were then assessed against the responses from the questionnaires and passive observations to deduce which concepts elicited positive and negative responses from children of both groups. The aim was to obtain data that would help interpret what these choices implied for designing inclusive schools.

Table 2.5 shows how the responses were grouped according to learning abilities, comments on built environmental features of images shown in the survey and inferences drawn from these comments.

Table 2.5: Inference table for simulation and preferences—examples

Students' comments	LD/non-LD	Observers' comments
Like the windows, like the bricks—like the way it looks	Non-LD	Current school has a mix of hard and soft surfaces outdoors. But lawn areas are comparatively smaller than paved areas. LD student rates this building positively due to its size, which is bigger compared to the existing school. Two more students out of the remaining three quoted the same reason for liking it and noted other aspects they liked, such as the type of windows, brick style, colour palette and two-storey height. This is a possible indicator of students requiring a larger space than what is currently occupied.
It's OK—Too much grass	Non-LD	
OK.	Non-LD	
Like—Big building.	Non-LD	
Like it because it's big.	LD	
Like it because it has two floors. [I] like colours.	Non-LD	

Wish poems—'I wish…' open-ended qualitative data

The wish poem survey was adapted from a visual research method created by Henry Sanoff (2001b), wherein participants were asked to complete the phrase, 'I wish I had…in my centre' to gain insights into their aspirations for the centre. This visual research method not only supplemented the questionnaire surveys, but also provided an alternative for respondents who were unable to answer verbally or express their ideas and views in drawings. The data from the wish poems helped to reinstate and verify the responses from the other surveys, thereby ensuring quality and trustworthiness of the overall results. The participants were given a form with a wish poem (see Appendix A) and asked to filled in the blank spaces with their aspirations for their 'dream school'.

Figure 2.6: Word cloud from wish poem analysis

Analysis of wish poems

'Word cloud' tagging online software was used to calculate the words with maximum frequency from the collection of wish poems obtained from each school (Figure 2.6). The poems were then classified into concepts from architecture, education and environment–behaviour studies and tallied with the answers from the open-ended questionnaires. An objective was to examine spatial engagement predispositions in this study's sample group, as indicated in the questionnaires and field observations of behaviour.

The wish poem survey provided rich data on aspirations for learning environments that might not have been obtained from a standard questionnaire aimed at obtaining specific insights. While some of the whimsical wishes, such as a 'flying classroom' or a 'roller-coaster in the classroom', seemed untranslatable to a built space, it pointed to strong natural tendencies to be mobile and active at all times. Thus, they point to design strategies in spaces that support natural inclinations of being able to engage with the learning space in an uninhibited manner. Additionally, the wish poems were tallied against the open-ended art survey on the students' dream school to verify their preference for green settings in a school, as suggested in the literature reviews.

Art survey: open-ended art activity

The art survey[21] sought to gain additional insights into participants' expectations of the school facility as a learning environment, while also providing an alternative medium of expression for those who found it difficult to express their views verbally or in written form.

The survey was conducted in groups with the support of the teachers and the teachers' assistants. Care was taken to distribute the survey gradually to prevent respondents from being influenced by each other's ideas, thereby affecting the trustworthiness of the responses (Burns 2000; Gravetter and Forzano 2006; Zeisel 2006). Students were given A4 art paper and asked to draw a picture of their 'dream school' that depicted their aspirations for a better learning environment. They were told that the picture should depict elements that they wanted to have, or that were lacking, in their school. When submitting the drawings, the students either labelled

[21] Many studies have used children's drawings to evaluate their environmental perceptions (Barraza 1999) of aspects such as the schoolyard environment (Tamoutseli and Polyzou 2010), mainly because they provide a non-verbal approach for students with varied abilities. Literature reviews of children's drawings note three models of research into children's drawings from an emotional–expressionistic perspective: the first model explores personality traits; the second model focuses on classifying emotional indicators; and the third model examines the ways in which children depict personal or emotionally significant topics (Barraza 1999). The third model is relevant for this study to explore children's strongest desires in the context of a potential school, as these models suggest that in the age group of five and above, intellectual and visual realism development influences children's drawings.

the drawings with annotations or offered information verbally when they were unable to spell. These were all noted down onto the relevant drawings.

Analysis of art surveys

Given that art assessment is a subjective process, the art surveys were assessed alongside data from the wish poems (i.e., word frequency map and open-ended questionnaires), while using this study's theoretical framework as a criterion for assessing the responses.

Thus, data from the 'dream school' art survey were grouped into two themes. The first theme was drawings that depicted the built environment, and the second group comprised drawings that illustrated natural settings. Specific aspects of these natural and built environments were identified for redundancies to tease out data that were more viable and relevant to the research questions of place preferences and behavioural inclinations.

Analysis via the coding of concepts from the art survey and word-mapping from the wish poems was conducted to:

- explore whether the children represented mostly built environmental elements or natural elements in their drawings
- determine which place was most commonly represented as a potential part of the dream school.

The data that were obtained by applying the above considerations contributed to a better understanding of the factors that need to be acknowledged when designing solutions for child-centred and inclusive school environments.

2.6 Delimitations

As stated previously, the study is limited to children with LDs co-occurring with other disorders in mainstream schools. This was a result of the CCA process, which indicated that children with LDs share common issues of inattention, impulsivity, anxiety and stress in children with ASD and ADHD/ADD and among children with these disorders co-occurring with LDs. As indicated by the literature, teachers in mainstream schools face significant challenges in meshing the needs of those with

and without LDs in the same settings (Engelbrecht et al. 2003). Thus, there is a need for spaces that support children's spatial needs to provide better support to the LD group. Consequently, the researcher limited the current study to mainstream schools and included both traditional and alternative mainstream schools, as both models aim to offer academic support to those with LDs. This thesis does not cover special needs schools because spatial design strategies are being applied in practice for special needs schools, including for those with LDs.

2.7 Ethical Considerations

The case studies were conducted with strict adherence to ethics policies and approvals from Curtin University's Human Research Ethics Committee (HREC) and the DET, and the researcher obtained a Working with Children Check clearance. The case studies were conducted in accordance with guidelines and procedures provided by the university's HREC and the National Statement on Ethical Conduct in Research Involving Humans.

The research raised some ethical concerns because it focuses on children who represent a particularly vulnerable group; therefore, the rights of the participants were protected at all times in terms of identity and confidentiality. No names of participants—schools, teachers, parents and children—were recorded or used in the research. Instead, aliases or numeric codes were assigned to respondents and processed in line with coding systems of analysis.

The schools selected for this study were contacted after obtaining the above approvals, clearances and permission. Written approvals were only sought from parents (on behalf of respondents) and teachers after obtaining consent from the school principals. After signing the consent form, the primary participants (i.e., the students and their class teacher) were informed both verbally and in writing that they could withdraw from the study at any point. The principals, parents and teachers were each given a summary copy of the research topic with the researcher's contact details so participants could clarify any doubts or concerns. Where a meeting was requested, time was spent explaining the research and clarifying queries regarding the manner of conducting the case studies.

The researcher initially decided to avoid having direct contact with the students to avoid influencing their responses, and to limit the researcher's presence in the school to the observation of patterns of spatial use and children's attitudes towards their environment. For the questionnaires and surveys, the researcher planned to request assistance from the teachers or their teaching assistants to interview the students at their convenience, and the researcher would then collect the filled-in answer sheets from the teachers. However, in some cases, to avoid interruption to routine tasks and schedules, the surveys were conducted on the same premises in the presence of the teacher to ensure completion in line with the allotted time schedules.

An information sheet outlining the participants' rights, confidentiality and protection of identity was given to participants (see Appendix A for selected examples).

No photographs were taken of school spaces while occupied by students. For the analysis of the elements of the built and natural environments, sketches were made and photographs were taken of both the interior and exterior school areas selected for the study after obtaining permission from the respective schools. These activities were expressly undertaken when these spaces were not in use by students. Additionally, to ensure that the respondents' rights were respected, if a participant wanted to opt out of a survey or interview at any point, their wish was respected and their participation was cancelled from the data collection records.

2.8 Summary

This chapter described the research design process, the methodological framework applied to it, methods of enquiry and the rationale for using a combination of methods and qualitative approaches to conduct this exploratory study. It outlined the links between the theoretical framework and the supplementary case studies in terms of how the key theories of environmental affordances (Gibson 1986) and person–environment theory (Parsons 1909) were used as a lens to view the data obtained from the case studies. This chapter also described the non-probability sampling approach and the rationale for using this sampling method and CCA, which was used to link the data from the case studies with the data analysed from the theoretical enquiry.

Chapter 3 examines interdisciplinary literature on the environment and its relationships with various dimensions of learning from environmental psychology and neuroscience perspectives to further an understanding on how the disciplines of school design and education can be bridged to develop inclusive school design strategies.

Chapter 3: Environment–behaviour Nexus in Schools: Insights from Environmental Psychology and Neuroscience

3.1 Introduction

Many theories have been proposed in the context of environmental attributes and human behaviour. While the literature is extensive on these theories, this chapter examines interdisciplinary literature from architecture, school design and education, with a focus on:

- themes of environment and behaviour relationships and their influences on learning processes (behavioural, sensorial, perceptual and experiential)
- themes of special needs education, with a focus on the relationship between the environment and the learning processes of those with LDs.

The aim is to illustrate how this understanding can bridge the disparate areas of school space design and education. The review subsequently examines perception and the value of understanding this phenomenon to link the literature on school settings and learning. It discusses environmental psychology and neuroscience theories that are relevant to furthering an understanding of how schools' environmental attributes can affect various learning processes.

Environmental psychology[22] as a discipline was initially an extension of psychological studies into physical settings of behaviour (Gifford 2014). It emerged 'in the latter half of the 1960s as a problem-focused discipline which expanded to respond to practical questions posed by architects and planners about real-world design decisions' (Holahan 1986, 381). This thesis is grounded in key theories and concepts from this discipline, with a focus on Gibson's (1986) theory of environmental affordances and Parsons' (1909) person–environment fit theory. These two theories are used as a lens to understand the space–behaviour nexus in the

[22] The roots of environmental psychology can be traced back Hellpach writings of 1911, who was first to use the term in the early twentieth century (Pol 2006). Although branching into architecture and planning occurred in the 1960s, the review considers these theories and concepts relevant to furthering an understanding of environments and behaviour in the context of school design, education and children with LDs.

context of the school environment and its influence on the learning processes of children with LDs. Other theories explored in this chapter are environmental stress (Altman 1975; Stokols 1985), sensory overload (Evans 1984), restoration theory (Kaplan 1995) and level of arousal (Bell, Fisher and Loomis 1978), with the aim of analysing how environmental attributes can support or impede learning processes. Examining these theories on environmental factors and their influence on human behaviour lays the foundation to understanding what needs to be done differently in mainstream school designs so children with diverse spatial and learning needs can study in the same environment.

Lastly, this chapter discusses the links between environmental attributes with learning processes and learning abilities from the education perspective, as well as the implication for school designers and why this knowledge is important in developing child-centred and inclusive design strategies. Figure 3.1 illustrates the key relationships examined and the themes that emerge from them.

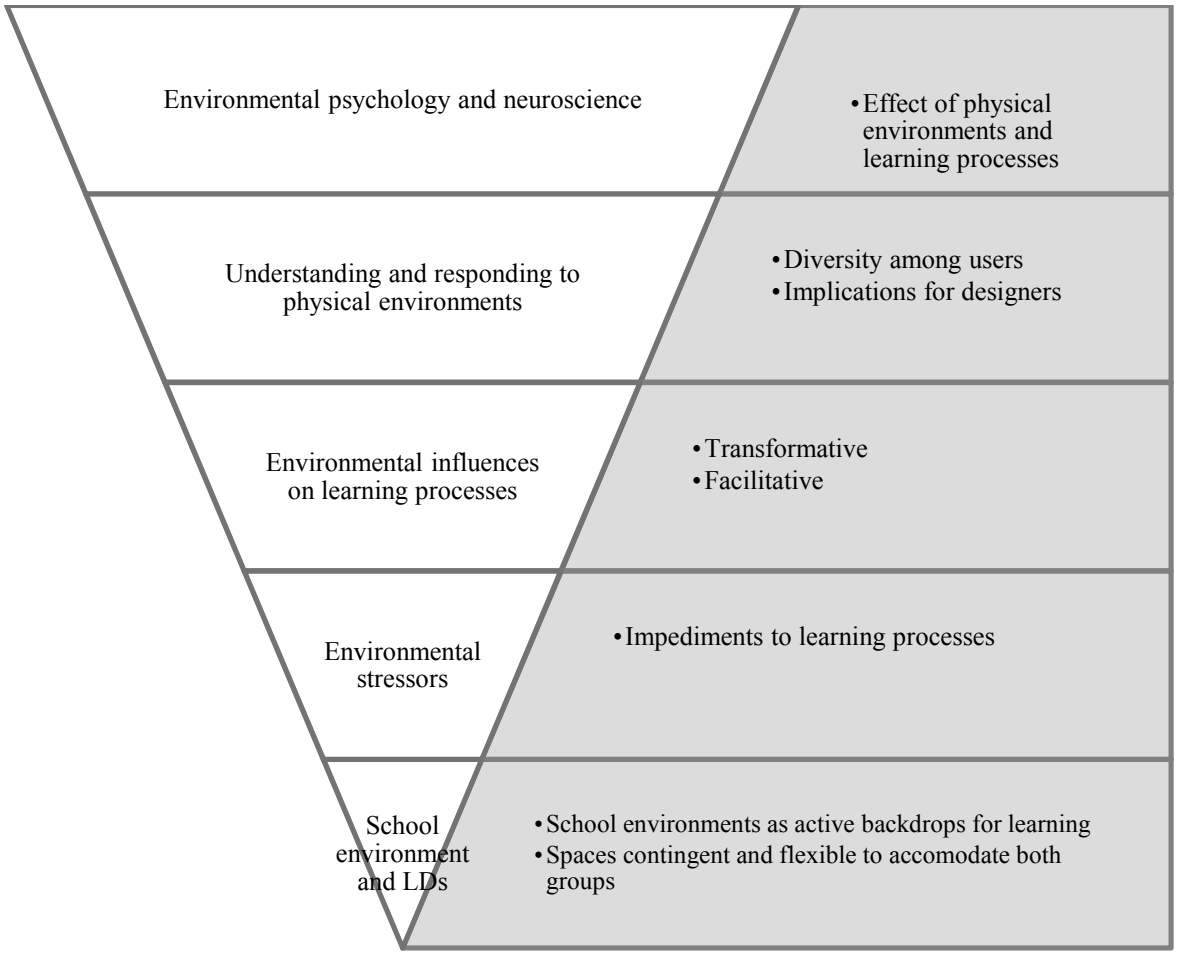

Figure 3.1: Hierarchy of relationships explored and emerging themes

3.2 Neuroscience: Concepts That Bridge Architecture and Education

As defined by Goswami (2004a, 175), neuroscience is the science of unravelling the mysteries of the brain while encompassing the disciplines of neurology, psychology and biology. Studies from the neuroscience and EBR disciplines provide empirical evidence to suggest that physical environments influence the brain, which is the seat of thinking, reasoning and behaviour (Eberhard 2007; Zeisel 2006). It should be possible to influence behaviour architecturally (Gage 2003 quoted in Eberhard 2007). As explained by Brody and Mills (1997) and Baum (1985), neuroscience also includes empirical research on LDs, ADHD and ASD, seeking to understand why some individuals have LDs arising from neurological disorders, when they may otherwise be intellectually similar to typical children, or even gifted. Neuroscience can provide ways to optimise learning (Goswami 2004a) and help to 'understand the relationships between human sense experiences and their influences on human functioning' (Barrett and Barrett 2010, 222). Neuroscience thus has significant potential to bridge the gap not only between architecture and human behaviour, but also, with relevance to the aims of this study, between the school environment and LDs.

One common overlap in the literature between neuroscience and architecture can be found in the phenomenon of perception. Perception in neuroscience refers to the recognition of an object or experience through a process initiated by one or more of our senses (Eberhard 2007). However, in architecture, perception relates to our responses to our surroundings or physical environments. In both disciplines, the act of perceiving involves our senses—the seat of which is the human brain (Eberhard 2007; Zeisel 2006). An understanding of the role of perception in experiencing architecture is relevant to finding intersects between architecture and education for the considerations of the study, as perception also forms part of the learning processes. his chapter examines literature that highlights intersections between the phenomenon of perception and architecture, education and environmental psychology perspectives. The aim is to examine the value of recognising users' perceptual understandings and their subtleties towards their school environments to develop strategies that can support learning abilities.

3.2.1 Role of environmental perception and experiences in creating engaging school environments

This section focuses on examining the interplay of perceptual factors involved in experiencing and responding to space. Understanding these factors is relevant to creating experientially balanced and engaging school environments. Perception of environments begins with first experiencing them using a combination of sensorial processes. As Rittlemeyer (1994, 16, cited in Walden 2009) explained:

> We all see spatial forms and colours… hear the sound of spaces, sense warmth or coolness… (use) sense of equilibrium… movement… somato-visceral senses… all of which are significantly involved in perception of architecture…. Entering the new gymnasium for the first time, visiting the assembly hall in an ancient castle, or the barn of a farm, students receive impressions of architectural and spatial constellations that influence their reactions. Clearly, 'seeing' a building or a room is not just a matter for the eyes but a combination of—at least—the visual, equilibrium, and kinaesthetic senses.

Additionally, proprioceptive (position and movement) and vestibular senses (gravity, head movement and balance) enable individuals to understand their body's position in space and negotiate its movement within it (Ayres, Robbins and McAtee 2005). Experiencing architecture is therefore a combination of physiological and psychological processes that begins as a biological sequence of the processes of the brain and influencing our perceptions of how we feel and respond to our built and natural environments. Our sensory experiences influence our behaviour in these spaces.

Based on brain research evidence, Walden (2009, 77) argued that when qualities of being dynamic, interesting or pleasant are attributed by learners to the architecture of a school, they are a result of sensory stimulation of respective senses such as sight, sound, movement and touch. He further stated that 'The decisive factor in this is active engagement with the environment, and this in turn depends on how interesting, pleasant and meaningful that environment is perceived to be'. Further, from an educational perspective, learners draw positive or negative impressions of their social and physical learning environments based on their perceptions of these environment (Graetz and Goliber 2002; Kaplan and Kaplan 1982). Environmental

attributes in terms of their qualities, affordances and cues thus enable perceivers or students to form these impressions and influence their attitudes and motivation to use the learning space (Weinstein 1992). To facilitate learning, the design of school environments should address what primary users of school spaces perceive as meaningful spaces for learning, and the characteristics of spaces that generate interest and/or motivation to encourage engagement in learning.

3.3 Theories from Environmental Psychology

Environmental psychology and its practitioners (environment–behaviour studies) provide a foundation to link person–environment transactions by 'investigating fundamental psychological processes such as environmental perception, spatial cognition, social space, human development, and personality as they filter and structure interactions with the environment' (Gifford 2014, 543). Building on data from environmental psychology and neuroscience may be the key to bridging the diverse disciplines of architecture and human behaviour. A deeper understanding of this knowledge could be used to communicate with educators (i.e., perspectives of educational psychology and what they need from school environments) and interpret children's needs (perceptual, psychological, neurological, cognitive and behavioural) as part of inclusive and child-centred design philosophies for mainstream schools.

3.3.1 Sensory overload theory

The notion of sensory overload is based on models of environmental stress that consider 'that excess of information causes stress by taxing the limited information processing system of an organism' (Evans 1984, 9). System models of environmental stressors (Altman 1975; Stokols 1985) also theorise that congruence between individual needs and environmental affordances need to occur to prevent stress. Environmental stressors are considered by theorists to influence cognitive and attentional capacities and diminish performance levels. Sources of environmental stressors include background noise, which can adversely affect attentional capacity, and insensitivity to auditory cues after prolonged exposure (Cohen et al. 2013). This theory is an important consideration for this study's aim of understanding the type of environmental congruencies that need to occur between those with LDs and their

school environments so that the effects of environmental stressors may be minimised or eliminated by design.

3.3.2 Level of arousal

Level of arousal refers to physiological and behavioural responses to environmental variables linked to performance and behaviour in humans (Bell, Fisher and Loomis 1978). As arousal theory considers the overall motivation of an individual to engage in particular tasks, it is also linked to motivation to learn in education (Weiner 1990). Sustained arousal is also an aspect of maintaining perceptual interest in architecture, which may explain 'why certain patterns, such as building facades with low absolute complexity, easily create boredom' (Weber 1995, 128). This theory examines the intersects between school design and special needs learning literature and provides an understanding of how environmental attributes can generate and maintain interest in occupying and experiencing designed school spaces.

3.3.3 Attention restoration theory

The notion of restorative environments is based on Kaplan's (1995) attentional restoration theory (ART), which considers that spending time in natural environments enables individuals to recover from mental fatigue and restore their attentional capacities (Berto 2005). It further considers that attention can be restored by diverting to a task that uses a different part of the brain (Kaplan 1995). Environmental stimuli that are considered to impede performance can cause stress (Ahrentzen et al. 1982; Baum and Singer 1982; Evans 1982; Holahan 1982), as discussed in the stress models below. In such situations, providing restorative environments in the form of green elements in school environments can act as a contingency to recover from negative environmental stimuli. For instance, both built and natural aspects of the school environment can include spaces with green elements that offer children an opportunity to recover from psychological and cognitive fatigue that may arise as part of the learning processes (Hartig 2004; Kaplan and Kaplan 1989; Trancik and Evans 1995). This notion of providing restorative spaces in school environments may assist learning abilities for both groups, but more specifically for those with LDs co-occurring with issues of inattention.

3.4 Understanding and Responding to Physical Environments: Do Environmental Responses Differ for Children with Learning Disabilities?

Our responses to our environment are based on what we see, how we interpret what we see and how we respond to what we see. They are also governed by variables such as our attitudes, social or cultural background and environmental cues (such as materials, furniture settings and quality of furniture settings and lighting [Rapoport 1994]), which provide immediate information about the function of the settings (Graetz and Goliber 2002; Moore 1986; Weinstein 1979, 1992). Perceptions of and responses to environmental attributes among children with LDs may differ from those of children without LDs, which may influence their interpretations of environmental cues and meanings. This diversity has been observed among special needs groups of children, such as those with low achievement levels, as a manifestation of sensory dysfunction in ADHD (Deacon, Woodhouse and Watts 2005) and impaired social, communication and behavioural skills in children with ASD (Rinehart et al. 2006; Singhania 2005). Zentall (2005) explained that these differences are due to 'biogenetic, over or under sensitivity to the stimulation available from their tasks and environment'. This is illustrated by the attention of ASD children being directed at familiar stimuli and low-intensity objects, whereas children with ADHD have inattention issues linked to a change or novelty of objects, task or environment (Zentall and Zentall 1983). These differences in perceptions of and responses to certain environmental attributes could increase the complexity of designing a school environment that seeks to mesh the needs of both groups of children in mainstream settings. However, identifying how to accommodate diversities such as perceptual and behavioural aspects from spatial contexts is vital to designing inclusive spaces in mainstream school environments.

Based on ecological perspectives of environment–behaviour transactions, Moore (1986) found evidence that well-defined school spaces that clearly convey cues for potential functions through physical elements (such as different floor materials to suggest activities, zones for reading using shelving as partitions and illumination to define spaces) have been shown to encourage more exploratory behaviour, social interactions and collaboration than in moderately or poorly defined settings. The

preference for a specific setting appears to depend heavily on users' cognitive impressions (Graetz and Goliber 2002). Kaplan and Kaplan (1982) stated that these are further determined by four cognitive factors:

- coherence[23] in understanding the settings
- complexity or perceived impression of setting to occupy interest
- perceived ease of use
- perceived expectation of successful learning in the setting.

The above determinants of environmental qualities overlap with the theory of environmental affordances. Gibson (1986) suggested that the materiality of objects in the physical environment, as well as the total physical environment, such as glass, wood etc., convey direct information regarding the most likely function of the environment. Environmental attributes of learning spaces (e.g., spatial arrangement of chairs and desks, ambience and colour palette) influence attitudes and preferences among classroom users. Graetz and Goliber (2002) explained that students try to make sense of settings and respond to them based on the type of environmental cues provided. If the settings fail to provide coherent communication regarding the opportunities they offer, a negative response is elicited from students in the form of low motivation to use the space. The design of school spaces should aim to articulate the opportunities that are available in terms of how the space can efficiently fulfil its functions as an inclusive and child-centred learning environment to facilitate learner–environment transactions.

The four cognitive impressions are especially important in influencing preferential relationships between children with LDs and learning environments. Children with LDs that are intensified due to spectrum disorders and sensory deficits perceive and interpret their physical environments differently than those without these conditions. Studies suggest that children's perceptions of spaces—specifically for those with LDs—could be different because they differ from typical children in varying degrees due to certain deficits such as sensory processing skills, gross motor skills and perception (Deacon, Woodhouse and Watts 2005; Farrell 2010). Similarly, children with LDs caused by neurological disorders differ in how they respond to and

[23] Coherency of space mainly refers to the anticipated spatial use aligning with what the space 'appears' to offer and is defined by factors such as ambience, furniture settings and quality of settings.

negotiate with school spaces. For instance, a student with ASD with a deficit of motor skills would find it difficult to access classrooms via staircases and respond with an intense dislike of being at school (Betts, Betts and Gerberd-Eckhard 2007, 27). When such studies are interpreted using the person–environment fit theory, it suggests that when students with LDs are not presented with coherent environmental cues on the spatial affordances that match their abilities to use school spaces; it influences their motivation to learn.

3.5 Environmental Influence on Learning Processes

> '… studying in a comfortable environment enhances not only well-being, but also satisfaction and therefore productivity and learning'. (De Giuli, Da Pos and De Carli 2012, 335)

Many learning theories (e.g., behaviourism, cognitivism, constructivism) offer distinct perspectives of learning processes, each associated with distinct teaching and learning approaches. However, this section focuses on literature that examines and provides a deeper understanding of the role of learners' physical environments, which education theorists believe are linked with learning processes.

The above theories from an environmental psychology perspective are applied to explore the relationships between physical environments and learning processes. The aim is to examine the validity of incorporating environmental considerations in school design to develop child-centred design strategies.

3.5.1 Link between environments and cognitive processes

Neisser (2014) explained that cognition refers to all aspects of thinking in terms of how we gain, store and process knowledge. Cognitive processes refer to a combination of mental processes such as perception, memory, attention, conceptualising and symbolic (Pick 2003). Different learning theories (e.g., behaviourism, cognitivism, constructivism) have their own perspective on how learning occurs and the role of cognitive processes as part of gaining knowledge. Ertmer and Newby (2013, 48) explained that the behaviourist approach considers the 'learner as being reactive to their environment as opposed to participating actively in exploring their environment'. Lippman (2010a) stated that this approach accepts the

notion that the learner is passive and the environment is active, and it overlooks learner–environment transactions and the potential of learners to affect the spaces they occupy. Cognitivism also emphasises the role of environments in learning, but it focuses on how the mind acquires knowledge, processes the information and stores and retrieves it (Ertmer and Newby 2013; Snelbecker 1989). As discussed in Chapter 2, constructivism emphasises learner–environment transactions. It also considers that learning occurs when learners engage with their environments and use mental processes for interpretation, reflection and abstraction to construct and create knowledge (Glasersfeld 1996, 2005). The physical environment is therefore a vital part of the cognition process through which learners construct new meanings and knowledge.

3.5.2 Environmental influence on sensorial processes

Sensorial processes refer to the way in which our nervous system receives, processes and understands sensory input to formulate and express a response (Dunn 2001). The process involves touch, hearing, movement, balance, sight, taste and smell. The notion of the environment positively influencing behaviour by encouraging environmental interactions through sensorial stimuli aligns with a theory applied in special needs education practices. The sensory integration theory (SIT) was proposed by Dr Ayres (1920–1988), an occupational therapist and educational psychologist who was recognised for her work on encouraging brain function to help children with LDs (Miller and Kinnealey 1993). The SIT theory is at the forefront of studies in education and practice for children with special needs and LDs (Thompson 2011, 202):

> Sensory integration theory posits that sensory integration is a neurobiological process that organizes sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment. Sensory integration is information processing. (Ayres 1989, 11)

Figure 3.2 shows the five key components of the SIT model.

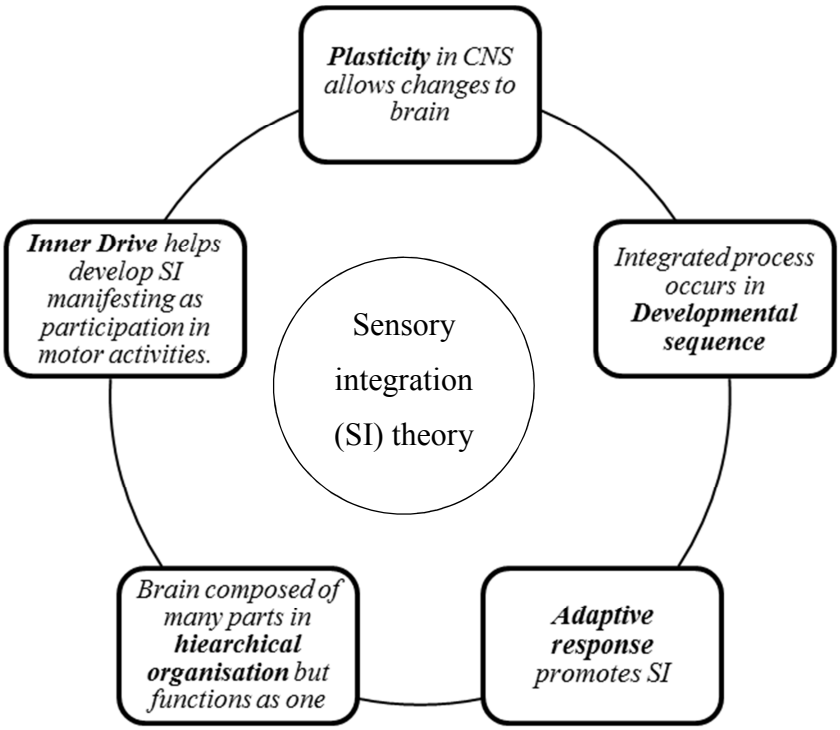

Figure 3.2: Schematic SIT model based on Ayres' theory

The theory first assumes that plasticity that is present in the central nervous system of the human body will allow changes to the human brain by using SIT intervention techniques. Second, the sensory integration process occurs in a developmental sequence. Third, the multiple regions of brain function are considered to work as an integrated whole, but in a hierarchical system of organisation. Fourth, establishing an adaptive response among users promotes sensory integration, where the ability to produce an adaptive response is based on sensory integration. The last assumption is that individuals possess an inner drive to develop sensory integration, which acts as a causal factor in encouraging participation in sensorimotor activities.

Based on these assumptions, the theory proposes four groups of sensory-integrated equipment in school spaces (Table 3a). The SIT model seeks to create experiences that elicit sensory responses to trigger weak or absent sensory processes. As this theory was developed as a model to enhance learning for children with LDs (Ayres, Robbins and McAtee 2005; Bundy et al. 2002), it forms the crux of much education research and practice involving all groups of special needs children, including those with different spectra of LDs (Miller and Kinnealey 1993), ASD (Pfeiffer et al. 2008) and behavioural disorders (Devlin et al. 2011). Based on the SIT model, Miller and

Kinnealey (1993, 484) explained how it translates to learning settings using SIT equipment.

Table 3a: Role of Ayres' SIT theory-based equipment in adding learning skills for children with learning disabilities

Type	Equipment	Aimed at
Tactile equipment	Textured mats, vibrators, pillows etc.	Eliciting touch, engagement, sensory processes
Non-suspended mobile equipment	Balls, rolls, barrels, tilt boards, ramps, scooter boards, trampolines, jumping boards, sit-n-spins	Motor skills, mobility, balance
Hanging equipment	Hammocks, bars, gliders, inner tubes, bolsters	Motor coordination, focus, balance
Motor planning equipment	Obstacles, jungle gyms	Developing judgement of motor processes and new challenges

Source: Miller and Kinnealey (1993)

A permutation and combination of the above equipment is expected to enable the development of neurobiological processes where deficits are observed among children with developmental disorders. However, studies show benefits in other aspects of the learning process, such as attention and behaviour. For instance, in a study conducted on students with severe developmental disabilities, the findings supported Ayres' theory that employing multi-sensory experiences such as those in the classroom space, play equipment and other environmental variables helps raise levels of continued attention among students with severe issues integrating sensory information from their environment (Thompson 2011, 202). Further, children with ASD or other sensory deficits respond differently to sensory stimuli than typical children (Baranek 1998; Dunn 2001; Watling, Deitz and White 2001). As explained by Hahn (2012, 23), 'individuals with autism spectrum disorders can be sensitive to colour, brightness, size, reflection and patterns and may report pain when in contact with the visual stimulus that affects them'. They may engage in inappropriate repetitive behaviours to regulate their sensory systems (Quill 2000). Consequently, children with ASD and sensory deficits need opportunities to self-modulate sensory output (Schilling and Schwartz 2004). Such environmental affordances from the

design perspective have been explored in special needs schools (see Table 3b), but they are yet to be explored extensively in terms of meshing the spatial needs of children with sensory deficits or disorders when studying in mainstream school environments.

Table 3b: Examples of special needs schools with design features to support learners' needs

School/location	Type of design features	Purpose of affordance/feature
Horsham Special Development School, Sensory Garden, Victoria, Australia	Variety of material palettes and colours, smells and sounds. Natural daylighting in interiors. Respite areas.	Afford sensorial experiences to stimulate and evoke senses. Minimise use of artificial lighting and associated issues (e.g., flicker, glare causing distractibility).
Leongatha Specialist School, Leongatha, Victoria, Australia	Kitchen garden.	Mesh the inside with the outside of the school environment to match pedagogy and provide opportunities for enriched experiences with natural spaces.
Hartvigsen K–12[24] School, Utah, US	Patterns on the floor. Window sills placed higher than seated eye level. Classrooms treated with acoustic panels. Appropriate storage.	Enable learners to organise themselves and wayfinding. Reduce distractions. Prevent distractions by sensory overstimulation. Enable students to stay organised and prevent stress due to clutter.

Sources: Council of Educational Facility Planners International (CEFPI)[25] 2013, 2015; Association for Learning Environments (A4LE) 2010, 2012, 2013, 2014.

It is essential for school designers to understand how the SIT theory can be applied in the design of mainstream school spaces where educators may apply Ayres' SIT theory from the design perspective to mesh the needs of those with and without LDs. The following questions need to be explored so design solutions can respond to educators' objectives of a positive multi-sensory experience for children with LDs:

[24] Only selected features have been listed here as examples. A complete list of features can be found at http://media.a4le.org/southwest/utah/Hartvigsen.pdf.

[25] The CEFPI is currently known as Association for Learning Environments (A4LE) and has charters present globally. It is a professional organisation focused on improving learning environments for children (A4LE 2016).

1. How can the design of schools (architecture, interiors and site) respond to requirements that invite touch, pose appropriate sensory challenges and trigger sensorial responses from users?
2. How can the relevant combination of built environmental features be deduced?

Table 3b shows that design solutions need to consider how to incorporate SIT-based elements so they would extend to both the natural and built aspects of children's learning environments. The architectural design process consequently needs to design the building from the inside to the outside—that is, from classrooms to play and landscaped areas.

The above literary data on SIT equipment with support from a neurological perspective provides an overlap between school design and education—specifically for those with special needs. These commonalities can then form a framework to begin addressing challenges in meshing the spatial needs of children with and without LDs in the design of mainstream school environments.

3.5.3 Environmental influence on experience: value of designing 'experientially' rich learning spaces

Children interpret their environments using sensorial processes that involve experiencing the environment. O'Neill (2001, 4) considered that the way we perceive the three dimensions of our spatial environments goes beyond the visual spatial system and involves a haptic system 'which involves the integration of many systems, such as touch, positional awareness, balance, sound, movement, and the memory of previous experiences'. Experiencing the environment therefore involves all sensorial processes. Most educational theorists consider that learning involves exploration and engaging with the environment (Ertmer and Newby 2013). Experientially rich environments that invite touch and respond to the perceptual, behavioural, cognitive and sensorial needs of children can contribute to better behavioural and learning outcomes.

Kessler (2011) argued that built environments are not merely 'shelters' for users; rather, they convey meanings, elicit emotions and provoke thoughts among users, thereby creating specific types of experiences within these environments. As

discussed previously, these experiences are governed by how a built space is perceived by users in terms of its affordances such as opportunities for engagement, aesthetics, comfort and level of arousal. Environmental affordances therefore play a vital role in influencing users' experiential views of spaces. Further, these experiences can influence sense of well-being and behaviour. One study found a correlation between 'ugliness' of settings and feelings of fatigue, discontent and dissatisfaction in classrooms (Mintz 1956), whereas another found that negative aspects of classroom settings influence students' task persistence (Santrock 1976 quoted in Ahrentzen et al. 1982, 228). Environmental experiences form a vital part of various contemporary pedagogical models (e.g., Montessori 1912, 1964; Steiner's Waldorf model [Oberski 2006; Ogletree, 1998]) and learning theories such as behaviourism, cognitivism and constructivism. School designers must acknowledge that every environmental attribute can play a role in creating positive and negative environmental experiences, which can accumulate to enhance or impede learning for children.

In relation to experiences relating to sensory stimuli in the environment, Adams (1991, 19) stated that:

> The built-environment is infinitely varied in opportunities for aesthetic experience. It is a rich and easily accessible source of reference and a valuable resource for learning and teaching. It can provide a focus, a setting, and a subject for study.

As the various learning theories[26] (e.g., Piaget and Vygotsky) suggest, children form their own experiences at play and out of their inherent quality to explore and investigate their learning environments. It may be seen that children learn from both the built and natural environments, taking the process out of the school building itself to play areas and other accessible areas on the school site (Titman 1994). Environments that encourage children to interact effectively with their surroundings translate to opportunities for children to learn at their own physical and developmental levels (Trancik and Evans 1995), thereby acting as a 'third teacher' in addition to their teachers and parents (Gandini 1998).

[26] Learning theories that emphasise the role of the environment in learning are discussed in Chapter 4

Further, experiential learning considers that children's experiences act as the primary source of material, and they learn from their tangible experiences with people and objects at school (Adams 1991). This is elaborated from the educational perspective, as shown in Figure 3.3

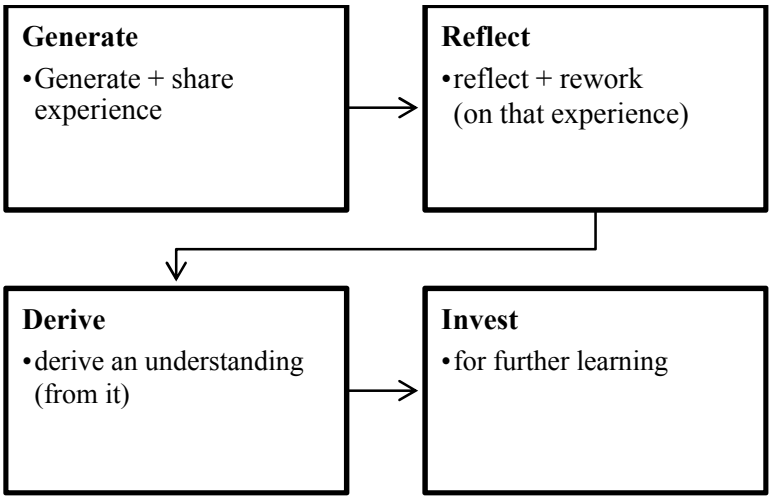

Figure 3.3: Learning process based on sensory experiences (adapted from Adams 1991)

However, in the case of children with LDs such as ADD or ADHD, where staying focused or engaging with peers poses challenges, educational models including holistic ones such as the experiential learning model may present a situation with students failing to perform and being embarrassed (Klein 2009, 17). Contradictorily, in alternative models such as Montessori, a similar approach encourages both groups of children to learn, with teachers as facilitators to ensure these issues are addressed. While pedagogical interventions can ensure that children with LDs are supported in all pedagogical models in accordance with current inclusion policies, designers must consider how to best respond to individual pedagogical requirements of space and inclusion policies. Consequently, this thesis proposes exploring the literature on alternative school models with a view to understanding how the pedagogical definitions of space enable children with LDs to be inclusive with those without LDs in mainstream settings.

Other authors have also highlighted the importance of the experiential value of environments from an educational perspective, arguing that environments are a rich source of information for learning and have an emotional influence on users' sense of place, and therefore should be aesthetically positive (Adams 1991; Day 2007) and

experientially engaging (Barrett and Barrett 2010). This suggests that the greater the perceived experiential value[27] of school environments, the better the motivation to learn. The motivation[28] to use a space also depends on whether it provides the relevant setting and opportunities for person–environment interactions to occur in that space. For instance, the school architecture forms the framework within which teaching and learning take place; its success depends on whether the space supports the teaching and learning objectives—for example, by enabling the teacher to arrange the space to match their understanding of learning settings and student behaviour (Martin 2006). Further, as Cornell (2002, 41) explained, 'The environment should be a place where people want to be, not a place they have to be. They should be motivated by fun and enjoyment as much as by a desire to learn'. A school's environmental attributes, ranging from its architecture to its landscape setting, provides cues relating to what the space provides in terms of opportunities to learn and engage with the environment as part of students' learning processes. Purposefully designed environmental affordances that offer positive experiences can be valuable in positively influencing children's experiential views of their learning environments, thus influencing their motivation to learn in spaces designed with these considerations.

The value of person–environment transactions and the resultant experiences as part of learning are also highlighted in Kolb's (2014) experiential learning theory,[29] which considers that learning occurs through formal and informal experiences (Itin 1999). Experiences can be both social and physical in the context of education, and the design of school spaces therefore plays a role in offering relevant experiences that facilitate learning through the social and physical dimensions of the

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[27] The notion of experiential value in the context of environmental psychology refers to how we positively or negatively interpret our quality of experience in space, derived from our perceptions and responses to our environment (Mehrabian and Russell 1974). It is subjective in nature depending on the user's background and context (Lorentzen et al. 2015).

[28] Children's motivation to be at school depends on socio-environmental factors such as their liking of teachers and their relationship with peers and their school environment (Ladd and Coleman 1997; Ladd, Kochenderfer and Coleman 1997). While the first two are outside the scope of this study, physical environmental factors (built and natural) form the focus of this study's exploration.

[29] Kolb's (2014) experiential learning theory posits that learning is continuous and occurs via a combination of perceptual, cognitive and behavioural processes and is conceptualised in terms of processes rather than outcomes. It is an important part of exploring learner–environment relationships for the current study, as it sets the foundation for contemporary educational practices such as outdoor and fieldwork (Burroughs 2015), and it is similar to other learning theories that emphasise the role of the environment and experiences in facilitating learning.

environment. The design of school spaces—whether built or natural—can play a vital role in how and what children learn through formal and informal experiences. Additionally, such designs can help teachers to facilitate learning by using the physical environment to create settings for formal and informal experiences.

3.5.4 School environments and behaviour

Weber (1995, 2) stated that the effect of architecture is unavoidable because most human activities occur within the context of buildings and cities that create both physical and psychological environments. He explained that the form of buildings and their aesthetics and appearances elicit a corresponding response in humans in perceptual and cognitive terms. In addition to functional aspects of learning spaces, the design should ideally incorporate primary users' natural behavioural tendencies, such as that of exploration and engagement with physical environments. As Dudek (2000, 10) argued that:

> the notion of designing a children's environment, such as a school, which does not facilitate a degree of imaginative interpretation, or one which does not allow children to develop their own spontaneity, chance meetings and interactions with their peers, may fail to engender interest in education amongst the pupil body.

As most children spend a significant amount of their developmental years in schools, their psychological and behavioural dispositions in using and understanding space should be one of the first considerations in guiding the design process of a school building. In explaining the nexus between spatial conditions and learning performance, Walden (2009, 78) stated:

> that there is more to a space than just the four walls, floor and ceiling; a space has to be enhanced by adding aspects such as colour, light, thermal comfort and so on, combining to significantly influence the sense of well-being and readiness to learn, thereby also the learning performance.

Thus, when the school environment works to promote a sense of well-being among users, it may assist in improving learning abilities by influencing the behaviour of both teachers and students.

Clark and Uzzell (2006) argued that social aspects of the school environment are as influential on children's behaviour and sense of well-being as physical environments, and that individuals perceive their environment holistically and do not perceive the social and physical dimensions separately. These social aspects are metamorphic and include facilitation by teachers who create settings for formal and informal experiences for learning to occur. For instance, while physical space (e.g., a secluded study nook) may be provided, the teacher (social attribute) governs its effective use (Ahrentzen et al. 1982). Extensive studies on children's development further indicate that both social and physical environmental affordances positively influence the brain by increasing learners' intellectual capacity (Ramey and Campbell 1991; Ramey and Ramey 2004). This thesis acknowledges that both dimensions are vital to positive learning experiences and enhancing learning abilities. While the social aspects are outside the designer's control, this thesis supports Clark and Uzzell's (2006) argument that designed environments can bring about a fusion of physical and social affordances of the environment by acknowledging the interplay between the two aspects. Further, as Moore (1986, 205) explained, 'the effects of physical environmental variables can only be understood when studied in interaction with social environmental variables'. Thus, to design school spaces with meaningful and engaging affordances for children, designers must also consider social environmental aspects to create learning spaces that support the social dimensions of learning.

Other studies with a focus on students with LDs with co-occurrence of other disorders (e.g., ADHD and ASD) also indicate that environmental accommodations in the form of spatial opportunities to self-regulate, withdraw, work independently, socialise and restore can positively influence emotional states and behaviour (Clark and Uzzell 2006; Hartig 2004; Kaplan and Kaplan 1989; Trancik and Evans 1995; Walden 2009). Authors also suggest that green elements of school design can facilitate the social aspects of learning processes and encourage interactions and play that are vital for the development of both the mind and body (Conners 1983; Fjørtoft and Sageie 2000; Hendricks 2011); thus, affordances to facilitate the social aspects of learning are not limited to built environments. A holistic understanding of the limiting or enhancing effects of schools' environments on students' sense of well-being and learning processes could be a vital part of approaches to inclusive designs for children from both groups in mainstream school settings.

3.6 Environmental Stressors: Inhibitors to Successful Learning

There have been significant discussions by researchers and authors from varied disciplines on the importance of the number of hours that children spend in school environments in their developmental years, and on the value of physical environments in influencing learning processes and outcomes (Ahrentzen et al. 1982; Dillon 1976; Linton et al. 1994; Savanur, Altekar and De 2007; Wingrat and Exner 2005). Studies from the developmental perspective also show that interventions from the physical (built and natural) and social (peer relationships, socioeconomic backgrounds) dimensions of the school environment in infancy and early childhood have lasting effects until adulthood (Campbell et al. 2001). Conners (1983, 15) argued that a growing number of studies indicate that the design of environments can cause stress for users directly or indirectly; consequently, designers must abandon assumptions 'that as long as certain minimum standards for size, acoustics, lighting, and heating were met, productive environs existed and the teaching and learning process would proceed normally'. This section explores the literature on how the design of school spaces can stress learners, with the aim of understanding how designers can avoid designing negative spaces that impede learning abilities.

In accordance with environmental stress models, Bell, Fisher and Loomis (1978) explained that stimuli in the physical environment (e.g., background noise, inadequate illumination, thermal discomfort) act as sources of environmental stressors and impede performance. From a neuroscience perspective, Goswami (2004a, 10) explained that 'the limbic system of brain (seat of emotions) is connected to frontal cortex (seat of reasoning and problem solving); when students experience stress, these connections break impeding learning'. Further, a mismatch between students and their environment in terms of their behavioural and emotional needs could mean that they expend energy trying to cope with the situation rather than resolving on a difficult task (Ahrentzen et al. 1982, 248). School environments that impede learning processes consequently influence children's ability to learn.

Authors of environmental psychology literature (Ahrentzen et al. 1982; Baum and Singer 1982; Evans 1982; Holahan 1982) also consider that environmental attributes influence feelings of stress, which may have behavioural implications. Built environments have also been construed as a source of psychological stress in

instances where users' goals, such as socialisation, restoration from stress and private interactions, are thwarted, and no provision is made to act as an efficient coping mechanism (Evans 2003; Zimring 1982). Studies have subsequently explored the varied environmental sources of stress, such as overcrowding (Brown, Ralph and Brember 2002; Crawford and Sean 1996) and noise levels (Cohen et al. 2013; Evans et al. 1991), which adversely affect users' performance and mental and physical health, and they have explored how these can be avoided. Nonetheless, the cumulative effects of environmental stressors on children with LDs is still emerging, and the current study seeks to contribute knowledge in this area.

As Graetz and Goliber (2002) explained, thwarting may occur due to discrepancies between the environment and users' needs, such as between spatial size (physical aspect) and density of users (social aspect). Glass and Smith's (1979) meta-analytical study on overcrowding and density, which was conducted in the context of learning spaces, indicated that higher social density is linked with lower student achievement, and the effects are also governed by educational activities occurring in the space. A low student–space ratio has been found to be better developmentally, whereas higher classroom density has been linked to aggression and destructive behaviour (Weinstein 1979). Evans et al. (1998) found that the effects of residential crowding extend to performance at school, with difficulties indicated in behavioural adjustments and lower academic achievement compared to students from low-density households. Thus, disproportionate and undefined spaces impede learning by adversely affecting behaviour, achievement levels and sense of well-being. Designers must therefore question recommended spatial sizes when conceptualising school designs based on pedagogies, learning styles, user groups and potential activities to ensure the best potential match for learning to occur.

A significant amount of literature exists on schools' physical environments and their influence on children's behaviour and development, with links found between environmental attributes such as spatial size, quality of openness, provision or lack of windows and corresponding issues of overcrowding, noise distraction and thermal discomfort (Ahrentzen et al. 1982; Evans 2006; Weinstein 1977, 1979). Studies have also highlighted how inadequacies or the poor quality of environmental attributes impede learning abilities. For instance, Essa et al. (1990) found that a poorly

illuminated classroom causes discomfort and difficulties for students in meeting learning objectives. Another study demonstrated that background noise negatively affects students' achievement levels and influences sentence perception levels in children with LDs (Bradlow, Kraus and Hayes 2003). These environmental sources of impediments to task completion could prove even more challenging for students with LDs and further impede their learning processes (Haines et al. 2003), as well as aggravate the symptoms of their disabilities (Forns et al. 2015; Zentall and Shaw 1980). It is therefore crucial that schools be designed acknowledging that their environmental attributes could support or impede learning processes depending on whether users' spatial needs have been considered as part of the design strategies. The design response should include contingency spaces as coping mechanisms when person–environment mismatches occur due to diversity among learners, resulting in stress.

Based on the constructs of the person–environment fit theory, an alignment of environmental affordances with children's needs from an environmental perspective could lead to better productivity and lower stress. Further, environments are construed to influence positive feelings when they fulfil children's psychological needs of privacy, control and security (Hart 1979; Moore 1990). Thus, an alignment of environmental attributes with children's psychological needs may elicit positive feelings. A significant amount of literature indicates that the nature of physical environments is linked with users' performance levels and physical and mental well-being, including learning spaces (Shabha 2006; Spencer and Blades 2009; Tanner 2000; Weinstein 1979). Other studies have found links between the quality of school environments and students' achievement scores (Uline and Tschannen-Moran 2008) and measures of competency—specifically self-perception (Hughes 2005; Maxwell 2007). These studies demonstrate that the better the quality of physical environments (in terms of their condition and affordances), the better their performance.

Lastly, when both children with and without LDs are affected due to negative stimuli from the environment, it could cause associated classroom management[30] issues and prevent teachers from efficiently meeting the teaching and learning objectives of the

[30] Classroom management refers to 'actions taken by the teacher to establish order, engage students, or elicit their cooperation' (Emmer and Stough 2001, 103).

curriculum (Dunn et al. 1985). Learning spaces can therefore provide opportunities that consequently act as contingency spaces for such behavioural needs and issues as they arise. For example, Weinstein (1977) examined the effects of minor changes to physical attributes in an open-plan classroom on students' behaviour. Design changes such as providing easily accessible study carrels limit frequent disruptions, where students had previously reached out for study materials. The results are statistically significant and support the hypothesis that even minor changes to physical attributes can result in positive behavioural outcomes. Classroom management issues for teachers can be reduced by making simple design changes in furniture arrangement—for example, sociofugal seating to limit communication and social activities (Lippman 2010a; Osmond 1966; Wolfgang 1996) or flooring materials such as carpets to limit distractions caused by off-task behaviour or children with ADHD (Carbone 2001). Spaces that provide flexibility for teachers to adapt settings to their needs would enable the needs of the two groups studying in the same space to be meshed.

3.7 Environmental Influence on Learning Disabilities: Education Perspectives

Many studies on various elements of built environments have sought to explain the effects of environmental attributes on children's behaviour and sense of well-being. These studies on specific school environmental aspects are the focus of the review in Chapter 5 in the context of children with LDs—specifically those where the LD is intensified due to a co-occurrence with other disorders of inattention, impulsivity and hyperactivity. This section focuses on education literature, which illustrates via various studies on the transformative influence of schools' physical environments on the behaviour of children with LDs, specifically when co-occurring with issues of inattention, impulsivity, hyperactivity and sensorial processing disorders (symptomatic for some students with ADHD and ASD). These environmental influences on behaviour may act as inhibitors or supporters of learning processes for children of both groups, but more so for those with LDs. The focus is on understanding environmental influences that the educational perspective considers affordances or constraints of learners' environment, with the aim of developing knowledge of how these environmental attributes can become part of inclusive

design strategies to support children with LDs, while also taking a child-centred approach to mesh the needs of the two groups.

In the context of students with ADHD, including inattention, impulsivity and hyperactivity, it is speculated that incompatibility with the environment (physical, social), combined with the issue of deficits in perception and gross motor skills, prevents learning processes and associated activities from occurring successfully, and where physical learning resources are unhelpful in the broad spectrum of disorders associated with ADHD, except for certain learning tools (Farrell 2010). However, the spatial layout within a school or classroom can positively assist ADHD students. Carbone (2001) explained that direct learning pedagogical models use strategies such as traditional seating patterns in rows (to limit distractions due to adjacent peers), whereas open-plan models (indirect student-centred models) may require seclusion areas or study nooks with partitions (using bookshelves and storage) to offer an easy transition between varied instructional paradigms when inattention and distractibility pose challenges to learning. A classroom designed with the provision of space (in terms of spatial profile and area) to create seclusion zones or pedagogically relevant seating layouts encourage the possibility of relevant pedagogical interventions or innovations (Moore and Lackney 1994). Children with ASD in an inclusive classroom may have symptoms of deficits in gross and fine motor skills and muscle tone and, more importantly, they may lack the physiological ability to adapt to environmental factors such as temperature and skin sensitivity (Betts, Betts and Gerberd-Eckhard 2007). Such deficits in motor skills and perceptual differences can manifest as limitations in negotiating school structures such as 'wayfinding'[31] from one school building to another (Baumers and Heylighen 2010). Poor wayfinding can lead to disorientation and cause anxiety (Conners 1983). As we use our sensory abilities to experience our physical environments, it is also possible that built environmental features of school buildings influence the behaviour and symptoms of children with LDs by acting as sensory triggers.

[31] As described by Conners (1983, 17), wayfinding is 'actual behaviours people employ while trying to find their way in the environment'. It involves interactions of attributes of the user and the environment (Allen 1999); thus, it depends on individuals' spatial cognitive abilities and responses to environmental affordances when trying to purposefully find their way to a specific destination.

The above aspects reiterate the need for school design professionals to make well-informed design choices so that undesirable ambient environmental conditions may be reduced or eliminated via design. This first implies that built environmental factors can influence the way children with learning problems negotiate and feel about school spaces, subsequently influencing their desire to learn at school. Second, these implications should be used to identify specific environmental factors in school design that can make school buildings more accessible and coherent to students with limitations of sensory and cognitive processes. It is crucial for design professionals to understand that inclusive learning spaces need to be not only a pedagogical concern for educators, but also a critical aspect incorporated by architects and designers in the design of school spaces.

There can be additional risks to academic performance for those with LDs from social and non-physical aspects of school environments. Some of the common issues known to affect children with learning problems at school are anxiety and stress caused by negative feelings such as low self-esteem and frustration (Mercer and Pullen 2005), regardless of the root cause of LDs. Children with LDs also struggle to cope with the social challenges of studying in mainstream schools, such as bullying and performing academically to keep up with their peers (Norwich and Narcie 2004; Nowicki 2003; Whitney, Nabuzoka and Smith 1992). Again, stress can impede learning for children in general; however, the effects may be more severe for those with LDs co-occurring with other disorders such as ADHD (Farrell 2010) and ASD (Shabha 2006). While both social and physical dimensions are important when creating inclusive learning environments, this study focuses on furthering the knowledge from the perspective of schools' physical environments regarding how transformative influences of the environment include negative effects on learners of both groups. Strategies to limit these effects are vital to provide better learning abilities for students with LDs studying in mainstream schools.

3.8 Discussion and Conclusion

The outcome of the review of relationships between environments and behaviour revealed that there are overlaps between the disciplines of design and education; first, as indicated from the theoretical perspective of environmental psychology; and second, from the evidentiary perspective of neuroscience. These overlaps from the

interdisciplinary literature demonstrate that the effects of the school environment on learning processes and sense of well-being will subsequently enable both groups of children to maximise their learning potential. The understanding of transformative environmental influences on the users of space is common to disciplines of school space design and education. These overlaps are further explored through theories from environmental psychology to understand the implications of these intersects for inclusive and child-centred design solutions. The review thus illustrated how these overlaps bridge the disciplines of school design and education.

Neuroscience provides empirical evidence to ground previously proposed hypotheses and theories from varied disciplines, including environment–behaviour studies (with relevance to the current study), that environment and behaviour are interlinked, and it is possible to influence human behaviour via school environments (including architectural, landscape, built and natural environments). It may now be easier to push the boundaries to try to find potential design alternatives for learning spaces that will enable children with LDs to maximise their learning potential when studying in a mainstream classroom. According to Eberhard (2007), empirical evidence from neuroscience suggests that buildings are important in influencing our minds. Thus, in line with the findings of the review, the collective elements of the physical environment play an important role in allowing students to maximise their learning potential.

The review also demonstrated how evidentiary data from neuroscience supports environmental psychology theories, suggesting that environmental influences can impede or enhance learners, especially those with special needs or LDs. Based on these theoretical and empirical perspectives of environmental psychology and neuroscience, the review addressed how schools' environmental attributes can be perceived negatively, thus causing stress and impeding performance, psychological health and attentional capacities among learners. Conversely, environmental attributes can positively affect learning processes, subsequently aiding learning abilities for children with LDs and improving attentional capacities and sense of well-being for those without LDs. The review demonstrated that for designers to create spaces that elicit positive responses, they must investigate what children construe as negative aspects of their school. By highlighting the interdisciplinary

intersects, the review established that not only does knowledge exist on merging the disciplines of school design and education, but that the application of this knowledge will enable designers to create inclusive and balanced school designs that also act as active backdrops for learning.

Neuroscience is not a new discipline; it has been evolving at an incredible rate, as seen from nineteenth-century texts on the origins of neuroscience (Finger 2001). However, data from this field that will directly inform design disciplines are still evolving. Further, the cause of LDs is a developing field, with studies finding various causes of LDs in children, such as neurological anomalies (Farmer and Klein 1995; Shaywitz et al. 2002). The issue of still-emerging knowledge in neuroscience for architecture and design use, as well as diversity in the causes of LDs, makes it an extremely complex task for school designers to isolate design strategies that will benefit all types of LDs. This complexity further increases when developing an inclusive design response in mainstream school environments as a result of debates on the definition of LDs and objective identification criteria in education (Büttner and Hasselhorn 2011; Lyon et al. 2001), as well as a corresponding response in terms of spatial affordances for children with disabilities. Consequently, an iterative approach in keeping with emerging knowledge on LDs is required to develop holistic design responses that are sensitive to children's spatial needs and their influence on learning processes in school environments.

Despite the issue of evolving data on LDs, existing data from interdisciplinary studies in architecture, education and neuroscience provide evidence to support the development of strategies for the design of learning spaces for those with LDs, caused in part or whole by neurological factors (Goswami 2004a) such as dyslexia (Vellutino et al. 2004). The review thus highlighted that evidence from neuroscience provides a better understanding of environmental psychology theories on the nexus between physical environments and human behaviour in the context of education and special needs students. Being connected to a scientific discipline (of biology), the evidence supporting the theoretical links between environments and learning processes will provide a foundation for further studies on potential design strategies that are supportive of the learning process for children with LDs studying in mainstream schools.

The analysis of the interdisciplinary literature indicates that environmental interactions and experiences form a crucial part of learning processes. Experiencing school environments involves a combination of physiological and psychological responses (Walden 2009). The various learning theories (for e.g., Piaget, Montessori, Steiner, Vygotsky) (Whitehouse 2009), including constructivist perspectives, theorise that perceptual, behavioural, cognitive, emotional and sensory processes play a role in experiencing school environments and learning and constructing new knowledge (Naylor and Keogh 1999; Ultanir 2012). Further, spaces are evaluated by users as positive and supportive when they clearly communicate available affordances and if these affordances are congruent and flexible for learning to occur. Therefore, it is essential that designers acknowledge that children learn by interacting with their physical environments, and there is significant value in designing spaces that give children opportunities to form positive experiences and motivate them to use learning spaces.

It is argued that experientially positive designs may influence children's sense of well-being and thereby their ability to learn. When factors such as children's perceptions and psyches are carefully considered when designing schools, children will have far better chances to learn than in schools that are not designed with these considerations. However, these considerations require an examination of the types of tendencies displayed by children in both groups in regards to perceiving and engaging with their school environments. Are these tendencies similar or different for those with and without LDs, and how can designers respond to potential diversity from the design perspective?

The transformative influences of the environment on users form the crux of educational theories such that they are valued as backdrops to facilitate better learning experiences, behaviour and abilities. However, the review indicated that built and natural school environments can play an active role in facilitating learning by creating opportunities that match children's perceptual, experiential, behavioural and cognitive sensibilities of space. These sensibilities are considered processes by which learning occurs, and responding to them via design will facilitate learning in school environments. Based on the theoretical underpinnings of affordances and person–environment fit, it is argued that establishing such a match subsequently

enhances motivation to learn, attentional capacities and sense of well-being among children, all of which enable them to maximise their learning potential.

The review demonstrated that it is crucial for designers to achieve a balance in terms of creating environmental affordances and matching them with learners' spatial needs. More importantly, to address the issue of potential unpredictable factors (such as socioeconomic background and health conditions) outside the scope of the design, contingency spatial strategies need to be explored to offer spatial support that is relevant for special needs groups, such as need for privacy, need to work independently or need to withdraw when person–environment matches are disturbed.

The review explored various theories of environmental stress (Altman 1975; Stokols 1985), sensory overload (Evans 1984), level of arousal and attention restoration (Bell, Fisher and Loomis 1978) to better understand (from theoretical perspectives) the relationship between school environments and learners' behaviour, performance and sense of well-being, and how these can combine to influence better learning processes and abilities in children with LDs. The review illustrated that when environmental influences are evaluated or perceived negatively by those from special needs groups, it can intensify their LDs. Although sufficient knowledge exists on the positive and negative influences of physical environments on users' physical and mental health (Brebner 1982; Canter 1974, 1975; Lehman 2011; Moore and Zube 1989; Walden 2009), the review distinguished specific aspects of learner–environment transactions that can be investigated further as part of inclusive and child-centred design strategies.

A further examination of the literature on eliciting positive responses to school environments from those with special needs, including children with LDs, indicated the potential of providing positive environmental stimuli (such as those suggested in Ayres' SIT theory). These sensory affordances can be articulated as spatial design strategies for those with LDs co-occurring with developmental and spectrum disorders, and studying in mainstream school settings, such as seen in examples of special needs schools in Table 4b. The review also demonstrated how environmental attributes can be construed as positive stimuli and affordances when they assist in maintaining a level of interest, offer enriching learning experiences, act as spaces for restoration and regain attentional capacities. Children with LDs may require these

additional environmental affordances that support their learning processes, and that also include them in mainstream education; it is argued that these strategies need to be more prominent in mainstream schools and not limited to special needs school designs. By applying these strategies, it may be possible to mesh the needs of children with and without LDs in mainstream school settings.

The review highlighted that the effects of school environments comprise interlinked influences of both physical and social elements. Educators emphasise using physical environments as passive backdrops (Lippman 2010a) to meet schools' basic functions and responsibility to offer education. However, as explained in Chapter 1, educators also seek spaces that respect children's developmental needs, create opportunities for growth, encourage socialisation as well as privacy, foster a sense of well-being and self-esteem, and promote a sense of security (Weinstein and David 1987). Fulfilling these educational needs requires that both the built and natural spaces of school environments provide relevant stimulation and opportunities to facilitate the above aspects (Clark and Uzzell 2006). Thus, designers need to recognise two aspects when designing inclusive and child-centred mainstream schools: first, understand what these socio-environmental aspects are to create environments that mediate the social dimensions of learners' environments; and second, examine whether the physical and social aspects of school environments differ between those with and without LDs. If there are differences, designers should evaluate how the design can respond to this diversity. Consequently, this review found that a holistic and integrated view is needed in conceptualising school environments that are responsive to both physical and social dimensions of learning, and that provide learners with environments that are rich in opportunities to experience, engage, restore and stay motivated to learn.

Learning is more effective when school environments support learning processes and respect the interplay of these processes between learners and the environment as part of constructing knowledge. Thus, designers should consider the consequences of design decisions, which can mediate or impede learning processes. As LDs are not a single disorder, but coexist with other disorders (Lyon et al. 2001), designers must also consider providing contingency spaces to respond to diversity within the special needs group, and for situations where the person–environment fit may be insufficient

for specific cases of LDs. Thus, this chapter raises two questions regarding design considerations for mainstream schools. First, how can a school's design provide flexible contingency spaces for children with LDs? Second, how can a school's design respond to diversity between, and mesh the needs of, both groups of students in mainstream schools?

Chapter 4 reviews the interdisciplinary literature from architecture and education regarding historical precedents in school architecture to better understand the interrelationship between educational reforms and pedagogies and the corresponding shifts that have influenced school design. It notes that educational reforms are linked to change in school designs and highlights the gaps in current design approaches that need to be filled so that school spaces respond to the needs of current educational practices of inclusion in mainstream schools.

Chapter 4: Establishing the Foundations for the Study of School Environments

4.1 Introduction

Chapter 4 establishes the theoretical underpinnings of this thesis by exploring the historical precedents and background of school building design, education and LDs. First it traces the path of evolution of school building design and associated educational reforms from pre-nineteenth-century notions of controlling behaviour (e.g., monitorial schools) and progressive notions encouraging environmental interaction (e.g., Montessori) to current notions of school design with an inclination towards budgets and standardisation of space.

Second it reviews the literature on how learning occurs and the background of LDs. In examining the various perspectives of learning, it highlights the literature from scientific and theoretical disciplines illustrating the consensus that learning occurs when newer experiences are generated through an interactive process with the environment (Glasersfeld 1996, 2005; Goldberg 2002; Hannaford 1995; Lippman 2010a; Naylor and Keogh 1999; Zull 2002). Purposefully designed school environments can therefore play a role in enabling learner–environment transactions to occur and for learning to take place. Further, it explores special needs literature on the nature of learning experiences for children with LDs who study in mainstream schools. This understanding will inform school designers on what spatial affordances are required to create inclusive school environments.

The overall aim of this chapter is to gain a deeper understanding of the interplay of factors between school environments, pedagogies and learning. This understanding will provide a foundation to explore how school design can enable better learning potential for children with LDs in mainstream schools.

4.2 Evolution of School Buildings

To understand the origins of education and school building design, one must consider periods prior to the nineteenth century, when the concept of education greatly varied from current ideas. Although some ancient civilisations had models for adult learning, it was not common to impart knowledge for intellectual nourishment specifically to young children. For example, the ancient civilisations of India had 'Ashram schools' or 'hermitage schools', which formed the pedagogical foundation of many modern alternative schools in India (Wijesinghe 1987). In some instances, a small number of children were provided with skills and knowledge based on their class, role in the society, gender or learning what was considered necessary to their future role in society.

Western models had similar concepts of teaching and learning in which children of the elite received private or public education in an apprenticeship (Tanner and Lackney 2005 cited in Baker 2012). In the agrarian period of 1600–1750, very few children were formally schooled in defined school environments, as the key objective of educating children in this period was to enable them to support their family (Lippman 2010a). Different models of teaching developed with diversified curricula within these socio-cultural systems based on prevalent socioeconomic class systems. The notion of education in the pre-nineteenth century differed considerably from the current approach to education. As a result, there was no development of specific physical environments for the education of children during this period.

It can be deduced from the constantly evolving styles and trends in design disciplines that architecture and building design have also been influenced and moulded by the ever-changing political, cultural and economic phases of society. In turn, these changes create a shift in social perceptions that further cause a metamorphosis of spaces into settings, resulting in particular spaces with clearly defined functions such as kitchen, toilets and classrooms (Dudek 2000). Nineteenth-century society saw a series of rapid global changes. Modern socio-cultural values influenced by industrialisation and urbanisation necessitated learning to become an essential part of life for urban populations, with curricula and style based on aspects such as socioeconomic status (Tanner and Lackney 2005 cited in Baker 2012) and religion or race (Rivlin and Wolfe 1985). Spaces typical to schooling began to evolve into more

defined settings, with rooms designed into areas for teaching and basic facilities. However, these spaces were not designed with an emphasis on the needs of children due to a lack of understanding of behaviour–environment relationships.

This period saw the evolution of the institutional workhouse school developed from the prison model, which also formed the early prototype for mass education (Dudek 2000). The foundations of mass-education systems lay in the Monitorial or Lancastrian model, which developed into the industrial workhouse model of school design. As conceptualised by Bell and Lancaster (Hager 1959; Miller 1973) in early-nineteenth-century Britain, the Lancastrian model promoted rote learning in sterile environments guided by older students who were allotted authority as monitors of younger students. As Hager (1959, 165) explained, 'monitorial instruction required little more than a bare room, since most of the pupils stood, grouped about "stations" along the schoolroom walls where they learned by rote the information their monitors had earlier received'. The design strategy applied here was based on Jeremy Bentham's panopticon principle, which promoted the concept of the 'power of the gaze'—a system where the classroom was conceptualised for construction in a manner that allowed the teacher to see every student at all times and in all places, regardless of their position in the class. As Taylor (1996, 6–7) explained, this was projected by placing the teacher's desk on an elevated 'dais' and using 'raked' flooring to give the teacher 'panoptic sight' across the classroom (1996, 6–7 quoted by Hassard and Rowlinson 2002, 11). The intent was to ensure discipline by creating the illusion of being watched at all times. Bentham (1787 cited in Miller 1973, 15) explained that the idea behind this system was to ensure that 'Morals reformed, health preserved, industry invigorated, instruction diffused, public burthens lightened… all by a simple idea in architecture'.

The parallels were that both schools and factories involved 'inmates', or a large group of individuals, who needed to be monitored and disciplined using minimum resources (Hassard and Rowlinson 2002). These large spaces functioned as learning spaces for 450–1,000 people (Spring 1972) and lacked any kind of spatial segregation based on age and learning abilities. The need to house a large number of

students and associated activities[32] necessitated such 'all-seeing and all-knowing' spaces. These spaces reflected an attitude of conformity and a 'one-size-fits-all' approach from an adult perspective and focused on standardising children's behaviour. There was no spatial provision for those with special needs such as LDs; those who fell behind or did not conform to this system were generally labelled deviants or abnormal (Rivlin and Wolfe 1985).

The industrial model was one of the most prominent architectural and educational models in the context of schools, and it was the first design prototype for facilitating mass education. Dudek (2000) noted that the imprint of these past systems can still be seen in the majority of schools in the United Kingdom and other Western countries. Around the world, colonisation transferred these models to locations such as India (Wijesinghe 1987), resulting in a decline in the traditional ways of teaching and learning, such as those that emphasised the natural elements of school environments. The new spatial settings defined by the philosophies of control and monitoring resulted in sterile and uninspiring built environments.

There were few changes in the early twentieth century. Schools were upgraded to accommodate changes in technology and social perception, but there was no consideration of the psychological aspect of spaces relating to children. Silberman (1970) suggested that it could be inferred that the understanding of a child's psyche was of little importance, and questions were not asked of these systems of education until the early to mid-twentieth century, when psychology and environmental psychology began to evolve as disciplinary areas of study and practice. These new disciplines urged practitioners to create physical environments that were 'humane' and sensitive to users instead of designing them solely to exert control or discipline. Dudek (2000, 11) highlighted the disciplinary gap influencing school architecture, stating that 'School systems in some shape or form had been developing throughout the world from the earliest part of enlightenment; there was no coherent idea as to the educational needs of teachers and the school environment'.

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[32] For instance, the industrial model also initiated a system of standardised tests to evaluate students' performance. The aim was to reassure parents that the financial investment in their children's education was well founded by showing children's progress at school via their standardised test scores (Miller 1973). School spaces were consequently designed to accommodate large numbers while enabling educators to monitor students under examination.

Social and religious reform, as well as industrialisation and urbanisation, resulted in global educational reforms around 1750–1870. In the US, common school reform occurred from 1830, when public schooling was introduced to respond to the country's socioeconomic development and individuals' potential (DeYoung 1989; Nasaw 1981; Rivlin and Wolfe 1985). Similarly, in the UK, reforms in school architecture were based on proposals such as those by Henry Kendall's Design for Schools and School Houses (1847) and Henry Barnard's School Architecture (1848) (Dudek 2000). These publications focused on architectural features of façade style, and the latter on practical aspects of health and safety. These reforms influenced the development of spaces as large spaces for a multitude of children controlled by the teacher with no significant deviation from the monitorial school model. The classroom interiors still had the element of control and supervision, with the key difference of generous spatial sizes, such as those seen in Whiteley Woods Open Air School (1911) (see Figure 4.1).

Figure 4.1: Structured setting, Whiteley Woods Open Air School (1911) is unable to be reproduced here due to copyright restrictions. Figure 4.1 can instead be accessed via (Dudek, Mark. 2000. Architecture of Schools: The New Learning Environments, page 8. Oxford: Architectural Press).

Figure 4.1: Structured setting, *Whiteley Woods Open Air School* (1911) (Dudek 2000)

The structured[33] classroom in the Whiteley Woods Open Air School was spacious, yet both space and pedagogy offered no provision for free engagement or exploration

[33] Structured environment refers to highly organised spatial seating prepared by educators such that all students face the teacher, who plays the role of the 'controller' (Dudek 2000). This is different from structured settings presented by progressive educators such as Montessori and Froebel, who encourage self-directed learning through exploration and play among children (Pound 2012).

outside guidelines set by educators. This new model was the first model of public schooling where the idea that 'children may enjoy schooling was an alien concept… and were expected to be docile, obedient and industrious failing which punishment was likely' (Dudek 2012, 51). Urban schools of this period developed into large spaces with bleak environments that were not conducive to the fertile imaginations and holistic development of young children. However, within these public education systems, an aesthetically developed, if not completely holistic, style of architecture evolved in Scotland, conceptualised by Architect Charles Rennie Mackintosh in 1902. This introduced the idea that school architecture can appear relatively refined with better planning, design, finishes and decorations, even if it is being designed for children (Dudek 2000). While this set a precedence by connecting educational pedagogies of the past to a new architectural typology of the urban school, the designs were yet to focus on children's learning and behavioural needs.

4.3 Progressive Educators and the Resultant Learning Environments

The late nineteenth and early twentieth centuries also saw the emergence of more 'humanistic' educational visionaries such as Tagore, Froebel, Dewey, Steiner and Montessori, who shaped progressive and new ideas into education (Nicholson 2005). Radical changes in the thinking of these educators brought about changes in the architecture of schools, with physical environments created to provide positive learning experiences, including the natural elements of the school's environment. Colonised countries such as India saw an alternative schooling model in '*Shantiniketan*', or abode of peace, as conceptualised by Tagore (1928). This philosophy favoured a spiritual, child-centred educational practice. Similar to the Western progressive models, this alternative model emphasised child-centredness and considered that learning occurs when there is a seamless meshing of the built and natural environments of a school. Upitis (2004) explained that schools designed by or based on the educational philosophies of Dewey, Froebel, Steiner and Reggio Emilia had physical spaces that aimed to shape and assist the teaching of the child. These models require a deeper exploration from design perspectives to identify how the physical aspect of the school's environment supports children's learning processes,

and if there are lessons here for designers who seek to create school environments to be inclusive for children with LDs.

These new humanistic notions based on child-centred education influenced 'architectural consciousness during the second half of the twentieth century' (Nicholson 2005, 49). Theorists such as Freobel and Dewey further defined the context in which the child is the centre (such as their activities and experiences) with a focus on moral, intellectual and mental development through education (Chung and Walsh 2000). School environments based on these models differed significantly by creating spaces that resonated with their respective pedagogies to facilitate learning. However, the spaces were deemed by educators to be passive backdrops rather than active tools to facilitate learning. This could potentially be a result of a lack of knowledge of the nexus between environment and behaviour, as child psychology and theories of environmental psychology were yet to gain recognition (Silberman 1970).

Table 4.1 illustrates the various pedagogies and their emphasis on children's development through engagement and exploration with the school environment. Whitehouse (2009) explained that these models influence school design from 'inside–out', where the needs of primary users are considered first (e.g., designing handles and furniture scaled to the size of children), before moving to the outside form of architecture and design. The school's design aims to provide opportunities to stimulate mental and intellectual growth via experimentation and engagement with physical and natural environments. Table 4.1 highlights this relationship between the various fundamentals of progressive educators and the learning environment by outlining the areas where they seek environmental affordances to meet their pedagogical objectives.

Table 4.1: Examples of models based on progressive notions of learning with an emphasis on environments as part of the learning process

Educationalist/ philosopher	Theory/fundamentals	Emphasis on environment as part of learning
Froebel	Froebel initiated the kindergarten movement and rejected the notion that children are blank slates (Sniegoski 1994). His child-	Emphasis on play and engagement with nature as part of learning. Teachers' key role is to organise the

Educationalist/ philosopher	Theory/fundamentals	Emphasis on environment as part of learning
	centred model considered that children learn best through free play and art-based activities using specific objects created to facilitate learning (Chung and Walsh 2000).	learning space to guide children's learning and prevent aspects that might impede their self-directed learning[34] processes (Sniegoski 1994; Pound 2012).
Steiner[35]	Steiner considered schools community and cultural centres (Oberski 2006; Walden 2009). Curriculum includes arts (painting and Eurhythmy, which is a dance form unique to Waldorf education) and mainstream subjects such as maths and science imparted via artistic means (Upitis 2004).	Emphasis on the role of the body and sensory system in acquiring knowledge from the physical environment. Colour, form and sense of movement in Waldorf school designs are considered significant in Waldorf education and space.
Montessori (1870–1952)	Supports the notion of decentring the teacher, which represents the sharing of power and responsibility of learning between teachers and children (Ultanir 2012).	Encourages student interactions with structured learning environments to facilitate self-directed learning via exploration and experience. Asserts that the physical environment must provide opportunities for self-directed individual learning and collaborative group learning.
Dewey (1859–1952)	Dewey's philosophies on experiential education[36] inspired philosophies for subsequent educational theorists and philosophers such as Piaget and Vygotsky (Ultanir 2012). Children learn through 'doing', and their education should be based on real-life situations	Emphasis on content of children's experiences (physical and social) as a vital part of gaining knowledge through self-directed activities (Ultanir 2012).

[34] Self-directed learning refers to the concept of learning where learners are encouraged to take charge of their learning by identifying what and how they want to learn and the resources required to meet learning objectives, and by selecting appropriate pathways to meet learning outcomes (Ultanir 2012).
[35] Schools based on Steiner's philosophies were named as Waldorf schools.
[36] Experiential education is different from experiential learning, a holistic model for adult learning proposed by Kolb (2014) '*which combined experience, perception, cognition and behaviour*' (24) to explain the learning process.

Educationalist/ philosopher	Theory/fundamentals	Emphasis on environment as part of learning
	(Pound 2012).	
Piaget (1896–1980)	Piaget's proposed cognitive schema theory rejected the notion that children's minds are blank slates, instead suggesting they can actively process new information presented to them. In line with this theory, four main periods of cognitive development exist during the evolution of a child's mind: sensorimotor stage (ages 0–2), pre-operational stage (ages 2–7), concrete operational stage (ages 7–11) and formal operational stage (11 years to adulthood).	Emphasis on learning through discovery and adaptation to new experiences while considering children's developmental and cognitive abilities (Pound 2012).
Vygotsky (1896–1934)	Built on the work of Piaget and proposed the notion of social constructivism, which posits that learning occurs as a combination of social and individual processes. Emphasises two aspects (Harland 2003; Thomas 1990; Wertsch and Sohmer 1995). Social learning environment (language and culture) is vital to cognitive development. Zone of proximal development refers to the difference between what a child can do or is unable to do without assistance.	Asserts the value of constant interactions between learners and their social environment to influence cognitive development for learning to occur.

Table 4.1 demonstrates how various pedagogical models incorporated schools' environmental aspects to facilitate learning. These alternative systems were beginning to question the one-size-fits-all principle of conformity, as reflected in the design of spaces on the basis that the principle of conformity lacked an understanding of children's needs and sensibilities relevant to learning. Alternative pedagogical models thus initiated a deviation from conventional school settings into

spatial approaches that attempted to 'watch over' and not 'control' students' learning.[37]

Further, Table 4.1 suggests that Waldorf and Montessori schools appear to place greater emphasis on utilising the physical environment to articulate their respective pedagogies. Given this integration of the physical environment with teaching pedagogy, these two models were further examined to try to understand the intersections present between school spaces and education.

4.3.1 Steiner's Waldorf schools

Figure 4.2: Second Goethaneum, Dornach, Switzerland (northwest view); Steiner's style of avoiding right angles in buildings in (Adams, David. 1992. 'Rudolf Steiner's First Goetheanum as an Illustration of Organic Functionalism'. *Journal of the Society of Architectural Historians* 51 (2): 182–204) is unable to be reproduced here due to copyright restrictions. Figure 4.2 can instead be accessed via (https://doi.org/10.2307/990714)

Figure 4.2: Second Goethaneum, Dornach, Switzerland (northwest view); Steiner's style of avoiding right angles in buildings (Adams 1992)

The Waldorf School was founded by Austrian scientist and philosopher Rudolf Steiner (1861–1925). The Waldorf model merged architecture and education based on a spiritual belief system[38] referred to as Anthroposophy (Lippman 2010a). Steiner viewed schools as community and cultural centres that offered essential knowledge

[37] It is interesting to note that Froebel and Steiner had an architectural background, which may have influenced their conception of school design and been reflected in the architecture of these schools being in-sync with their educational philosophies (Upitis 2004). This is not to say that educators must become designers to be able to design holistic learning environments, but to stress the importance of collaborative disciplinary efforts to achieve this end.

[38] Gray (2010, 44) explained that Steiner's spiritual beliefs—that, 'architecture's principal role was in achieving the Anthroposophical objectives of individuals attaining oneness with the universe'—raised questions regarding the validity of his expertise as an architect.

for healthy thinking as adults (Oberski 2006; Walden 2009). He recognised the importance of the sensory system and the role of the body in acquiring knowledge (Eisner 1996). Learning environments were detailed and included wall colours in pastel shades, wooden furniture, natural lighting concepts and naturalised objects inside and outside the classroom, which made them unique in curriculum and built environment compared to mainstream schools (Oberman 1997 cited in Upitis 2004).

Steiner's recognition of a relationship between space and human life was articulated via shape, dimension, form, ambience and colour in the built environment of Waldorf schools. A unique design feature of Waldorf school buildings is the elimination of right angles (Figure 4.2) (Dudek 2000), giving them a vault-like appearance suggestive of cathedral naves (Walden 2009). The underlying principle is that architectural designs should not only be grounded in structural functions, but also be organic living forms to communicate with the physical, emotional and spiritual states of occupants (Steiner 1999). The buildings were asymmetrical with specific interior colour palettes based on classroom organisation levels. Lower classes had warmer orange–red colours, higher classes had yellow and upper classes had blue–violet, with all of the colours in pastel shades akin to watercolour washes (Walden 2009). Steiner's theories for built space apportion colours with ethical and spiritual properties relevant to students' holistic developmental needs (Adams 2005; Walden 2009).

Figure 4.3a: Centralised form based on rose and stem schematic plan, Waldorf school, Germany is unable to be reproduced here due to copyright restrictions.. Figure 4.3a can instead be accessed via (Dudek, Mark. 2000. *Architecture of Schools: The New Learning Environments*, page 231. Oxford: Architectural Press).

Figure 4.3a: Centralised form based on rose and stem schematic plan, Waldorf school, Germany (Dudek 2000)

Figure 4.3b: Interior atrium, Waldorf school, Germany is unable to be reproduced here due to copyright restrictions. Figure 4.3b can instead be accessed via (Dudek, Mark. 2000. *Architecture of Schools: The New Learning Environments,* page 233. Oxford: Architectural Press).

Figure 4.3b: Interior atrium, Waldorf school, Germany (Dudek 2000)

Figure 4.3c: Ground-floor plan, Waldorf school, Germany is unable to be reproduced here due to copyright restrictions. Figure 4.3c can instead be accessed via (Dudek, Mark. 2000. *Architecture of Schools: The New Learning Environments,* page 228. Oxford: Architectural Press).

Figure 4.3c: Ground-floor plan, Waldorf school, Germany (Dudek 2000)

The juxtaposition between curriculum and the physical environment is evident in the way Steiner carefully conceptualised the teaching and learning processes using both natural and built forms of the environment. In a comparative study of school playgrounds in traditional and alternative models of schooling in Australia, Malone and Tranter (2003) observed that the potential of extending curricula outdoors is significantly enhanced in the Orana Waldorf School (Australia) by providing a seamless transition between indoor and outdoor spaces. They added that this continuity and connection via design and planning of school buildings and sites is

further reflected in children's responses on the school grounds as an extension of their learning. For instance, the children explored the neighbouring forests and then returned to continue work on an ongoing cubby house project and other school activities, with the teachers facilitating these activities as part of cognitive development processes. This example illustrates that the Waldorf philosophy-based design successfully incorporated both natural and built forms to concur with the learning experiences and objectives.

Another example reflecting continuity in spatial experiences derived from nature was outlined in Dudek's (2000) case study of a German Steiner school designed by architect Peter Hubner. Dudek(2000) observed that the school's centralised plan was conceptualised around the form of a rose with petals and a stem (see Figure 4.3a). Designs based on organic forms potentially influence the asymmetrical forms of the building and set a precedence for a new approach for school design, where the built form contrasted with conventional school design typologies of the period. As Gray (2010, 59) explained, Steiner's 'ideas remain powerfully present in the work of a number of architects for whom Anthroposophy presents a means to move beyond conventional ways of thinking about architecture'. There is limited literature in Steiner's educational philosophies on how school spaces will respond to diversity among learners' abilities, such as students with LDs. Nonetheless, Steiner's principles of design and experiential pedagogy are worthy of exploration, as they highlight that learning is not confined to classrooms from an educator's perspective. A corresponding design response is required to examine school design approaches holistically, placing equal emphasis on the various dimensions of the school environment (e.g., built and natural, interiors and exteriors) to create designs that allow pedagogies to be unobstructed by design.

4.3.2 Montessori pedagogy and learning environment

Maria Montessori (1870–1952) was the founder of the Montessori pedagogical approach[39] and developed one of the first innovative holistic models of teaching for children with intellectual disabilities (Edwards 2002). Lillard (2012, 380) explained

[39] This model of education evolved in the slums of Italy in 1900 following success in developing educational solutions for special needs children in an Italian Orthophrenic School (Chisnall 2011). Given its focus on special needs learners, it was necessary to examine it for spatial affordances that respond to the needs of children with LDs.

that ‘Montessori extended her knowledge of sensorimotor development from education of children with mental disabilities to typical children’, convinced that the same approach of focus on development and sensory integration for learning would work for both groups of children. In the context of this study, the Montessori model is important because of its principle of including children of diverse learning abilities in the same learning environment, which could further an understanding in this area.

Montessori’s child-centred approach is defined by a self-guided, exploratory style of learning. As a result, innovative learning materials and didactic concepts of using the physical environment (physical and built) for learning processes have been developed (Walden 2009). This model of education recognises the transactional nature of learning, where children are construed ‘to acquire knowledge through practical applications’ and engagement with their environments (physical, natural, social) (Lippman 2010a, 148). The idea is to respect children’s unique tendencies and different abilities, with children encouraged to learn at their own pace in a carefully designed environment with ‘manipulative learning materials’ (Lopata, Wallace and Finn 2005) to elicit specific sensorial responses and motivate self-guided learning (Lillard 2012). The relevance of this model in the context of this study is that a child-centred approach for education must be supported by child-centred design in school environments so the teaching and learning processes can occur concurrently.

Montessori learning setting and space

The Montessori classroom aims to be a highly organised space with a variety of seating arrangements, including both independent and group seating (Hojnoski et al. 2008). The classroom space is further zoned to suit curricular subjects (Lillard 2012; Montessori 1912, 1964). Zoning of spaces offers variety in learning opportunities to match the varied learning abilities of children in a particular class. The second key aspect to be noted here is the customisation of micro aspects of a learning space into child-sized elements, such as furnishings (chair, desks, shelves, kitchen cabinetry) and study materials (Pound 2012). The pedagogical intent is to give children opportunities to develop independence and movement by incorporating the physical elements of the learning environment into the educational pedagogy. These aspects also provide user diversity in a single classroom space, which is one of the key

challenges for designers in designing a space to meet the complex needs of its occupants.

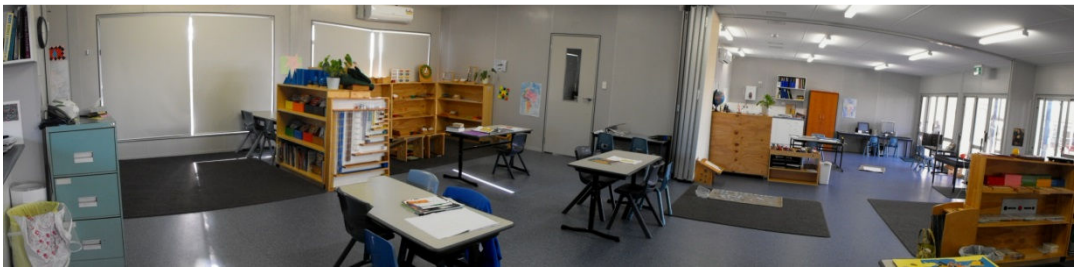

Figure 4.4: Montessori open-plan classroom reflecting zoning of a classroom space

The Montessori approach of integrating aspects of the physical environment with teaching and learning processes resonates with the person–environment fit[40] theory, which supports the need to harmonise the person with their environment to provide a better sense of well-being, productivity, health and behaviour. The main idea behind the person–environment fit theory is that when occupants are in environments that offer attainable tasks, engage their interests and allow them to express their interests freely, they are motivated to perform better (Holland 1997). Enabling such a match between individuals and their environments can have a positive effect on their behaviour (Altmaeir and Hansen 2011). This suggests that there is theoretical support for Montessori principles, where 'manipulating', learning materials, environment and curriculum are intended to create multiple opportunities for learner–environment congruencies so environments are adaptive, flexible and inclusive for students of varying learning abilities.

Empirical evidence of the influence of Montessori education on developmental abilities is limited (Walsh and Petty 2007) and divergent on its efficacy, even though it theoretically 'embodies many elements known to enhance learning and development' (Lillard 2012, 380). Some studies show relatively better outcomes than other models (Besançon and Lubart 2008; Dohrmann et al. 2007; Lillard and Else-Quest 2006), while others show no clear differences or poorer outcomes (Cox and Rowlands 2000; Krafft and Berk 1998; Lopata, Wallace and Finn 2005). Lillard

[40] As discussed in Chapters 1 and 2, the person–environment fit theory proposed by Parsons (1909) is grounded in environmental psychology and illustrates how person–environment congruencies are crucial for better performance, lower stress and achievement levels.

(2012) suggested that these divergences may occur due to varied interpretations of Montessori pedagogies influencing responses and outcomes, but the model is still associated with significant positive outcomes compared to other widely practiced models. Despite these divergences, the potential of drawing upon this child-centred school environment as part of creative inclusive spaces for those with LDs is ripe for further exploration.

Montessori pedagogy for children with learning disabilities

According to McKenzie and Zascavage (2012), Montessori classrooms are a model of inclusiveness in education because they embody the key attributes of valuing students via a highly individualised curriculum that is unpacked in a carefully organised space and responds to the diversity of students' developmental and learning needs. Mastropieri and Scruggs (2009) outlined four areas of focus in this model that are followed to maintain policies of inclusiveness. They are: scope and sequence (extent, depth and order of content), curriculum (learning materials/ equipment, curricular design and diversification of subjects individualised to each grade), pacing (setting speed of study based on inclination to learn) and types of learning (diverse styles/pathways for teaching based on individual learning abilities and developmental needs). These areas of focus act as cornerstones in a learning system that is flexible and adaptable to meet the needs of children with LDs arising from behavioural and sensory disorders. For instance, one of the curricular subjects includes 'sensorial activities' using specially designed learning equipment to elicit multi-sensory responses (acoustic, visual, tactile, gustatory, baric, chromatic and thermic) and refine them (Lillard 2011). Recent findings from an education study on special needs children from the higher end of the spectrum strongly advocated the benefits of implementing multi-sensory integration experiences into learning to enhance attention for special needs students with inattention issues (Thompson 2011).

The concept of zoning within classrooms and varied types of seating arrangements also offers students with and without LDs the alternative to choose a spot relevant to their learning needs to complete classroom tasks. The provision of such zones is important for those with issues of sustaining attention or who require a highly individualised and structured niche in the classroom (e.g., those with ADD/ADHD or

ASD). Similarly, the concept of pacing allows children to progress according to their capacity and willingness to learn. Thus, special spaces that are relevant to children's learning needs could be provided in the classroom to allow them to be included in mainstream schools. As this model relies on the physical environment as part of the pedagogy, it can bridge the areas of education and architecture and create inclusive spatial design strategies.

4.4 Twentieth-century School Buildings: Influence of Modernism and Concepts of Standardisation

Twentieth-century schools were a combination of designs; some were driven by progressive visions, while others continued to be designed on par with developments in construction technology[41] (Lippman 2010a). They were also grounded in philosophies of education (teacher-driven direct instruction [DI] models) and architecture (modernist ideas of form following function) of the period (Jilk 2012). The modernist architectural philosophy strictly followed educators' efficiency needs, ignoring 'non-functional factors of architect's aesthetics, the community's image and the client's politics' (Jilk 2012, 31). This approach was further influenced by World War II, when time and cost efficiency in facility planning processes were crucial in addition to functional efficiency (Jilk 2012; Walden 2009). This gave rise to 'standard prototypes' or the 'kit-of-parts' approach, where schools could be assembled in a time- and cost-efficient manner in response to site conditions (Knapp 2010). This prototype could be easily re-configured to respond to the site, including vertical and horizontal addition of parts to respond to growth (Rieselbach 1992; Rivlin and Wolfe 1985 cited in Lippman 2010a, 7). However, in terms of responding to child behavioural theories, these prototypes continued to focus on 'standardising behaviour' (Rivlin and Wolfe 1985). The spatial design approach, which focuses on function, time and cost efficiencies, gave rise to rigid and inflexible spaces (Jilk 2012). Consequently, there was a corresponding shift in school architecture with larger spaces in response to the issue of 'inflexibility' of modernist architecture and new developments in pedagogies.

In the post-war period, school environments were recommended to be designed as large spaces offering flexibility and the ability to be divided into smaller rooms for group discussions, as in US schools of the 1950s and 1960s (Lippman 2010a). These design approaches were used in schools practising both traditional (DI)[42] and

[41] Construction technology refers to the process and systems used in the construction of buildings and structures such as framing, electrical and mechanical systems.

[42] Educational approaches started diversifying into structured, direct learning, (where students were directed and monitored by the teacher with instructions disseminated to a group of students) and indirect student-centred models of exploration and self-guided learning, such as the Montessori model discussed above. The implementation could differ based on use and the interpretation of behaviourist

alternative (indirect instruction) pedagogies.[43] However, these new spatial design approaches did not focus on the end users, despite the alternative pedagogies being child-centred models. Similarly, Germany took a more holistic approach after the post-war period, and schools were pushed to be more student-centred positive spaces to contradict the harshness of the political ideologies of the Third Reich (Walden 2009). These models evolved into the concept of the 'open-plan classroom', but they were not universally accepted as models that emphasised child-centredness for school designs, as discussed below.

Open-plan classrooms

In the 1960s and 1970s there was a continuation of attempts to 'humanise' education and address issues of cost efficiency in school designs (Brubaker 1998; Flynn and Rapoport 1976; Rivlin and Wolfe 1985) using the concept of open-plan classrooms[44] (Figure 4.5). This resulted in the conception of open-plan designs characterised by movable partitions, storage units and no interior walls (Educational Facilities Laboratories 1960 cited in Rivlin and Wolfe 1985). Lippman (2010a) explained that the key design approach was to offer minimal constraints to learners and encourage engagement by providing diverse spaces for individual and group activities. It was considered that such designs were supportive of learning methods, and that they could be an effective alternative setting for children with emotional behavioural disorders[45] (Knoblock 1973).

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learning principles of maintaining students' interest and offering corrective feedback in both direct (Magliaro, Lockee and Burton 2005) and indirect models (Lillard 2012).

[43] Indirect instruction—see above.

[44] The discussion here refers to open-plan education (an architectural approach) and not open education (an educational approach).

[45] This thesis focuses only on those with LDs, but it includes a review of the literature on children with disorders that could coexist with LDs, and in some cases intensify it, as discussed in Chapter 1.

Figure 4.5: Open-plan classroom is unable to be reproduced here due to copyright restrictions. Figure 4.5 can instead be accessed via (Holahan, Charles J. 1982. *Environmental Psychology*, page 147. New York: Random House).

Figure 4.5: Open-plan classroom (Holahan 1982)

While this was again a radical concept of spaces for structured learning (settings in rows of seats) in typical schools, educators' views differed on its effectiveness in enhancing learning. As Rivlin and Wolfe (1985, 151) argued, 'open architectural style was not accompanied by a parallel change in the educational process'. For instance, educational research that approached open plans from an environmental psychology perspective found that reading and writing behaviours were less frequent, whereas behaviours of social activities, travel and housekeeping activities increased among students in open-plan learning spaces compared to traditional classrooms (Beeken and Janzen 1978). This raised questions regarding the suitability of open-plan schools for children who were prone to inattention and hyperactivity. Ahrentzen et al. (1982, 236) argued in support of the concept, stating that 'research on the relation between environment and behaviour should examine closely the notion of "fit" between users and their settings and between program and settings', and consequently help to encourage children to take charge of their own learning. These buildings failed to acknowledge the transactional nature of learning requiring interactions between learners' social and physical environments, even though they aimed to support learning via experience and discovery (Lippman 2010a, 26).

In the 1960s and 1970s, progress was made in understanding the subject of children with disabilities, behavioural problems and learning disorders, and there was a push to include these children in mainstream classrooms (Flynn and Rapoport 1976). Prior assumptions regarding limiting stimuli for children with 'hyperkinetic' or hyperactivity issues were abandoned in favour of less restrictive open-plan

classrooms. However, open-plan classroom designs failed to function effectively for children with and without LDs due to distractions caused by noise transference and surrounding areas affected by open-plan design (Shield, Greenland and Dockrell 2010). Other critics added that open-space schools failed to support 'private study' or learning activities that had to be completed individually (Arnold and Rand 1979; Propst 1972) due to the nature of the task or due to LDs (e.g., ASD). Evans (1980, 450) argued that this is not always the case, as teachers and students responded differently to distractions caused by noise in open-plan spaces.

Previous studies also presented conflicting data on the viability of open-plan designs. One researcher suggested that children with ADHD benefit from structured environments (Cruickshank 1967), while another concluded that open-plan designs could be beneficial (Wilson, Langevin and Stuckey 1972). Walberg and Thomas (1972) suggested that open-plan spaces should have a pedagogical structure with explicit guidelines (such as on mutual respect) to overcome issues for children with LDs. It was speculated that a clear and consistent structure would encourage positive behaviour among students with hyperactivity issues as part of their learning environment because they would have freedom to engage without the stigma of being noticeably different (Flynn and Rapoport 1976, 289). Since these studies, there has been scarce literature on other forms of LDs and physical environments in the education and architecture fields. There have been misperceptions of the concepts of 'open space' and 'open education', with the terms being used interchangeably, in terms of what was being measured in the context of open space and learning behaviour relationships (Ahrentzen et al. 1985). Consequently, spatial design interfered with teachers' objectives to facilitate learning (Proshansky and Wolfe 1974). Nonetheless, in alternative pedagogies, such as in Montessori and Steiner's Waldorf schools, teachers use open-space settings with respective pedagogies projected onto them, enabling learning by interaction and negotiation with their physical environments.

4.5 Twenty-first Century School Buildings: Emerging Challenges

In the post-modern period (1980–2000) there was a better understanding of how to match children's needs with the curricula, but few developments had occurred in designs; the setting still expected primary users (teachers, administrators and

students) to adapt to the design of the facilities (Lippman 2010a,b). Jilk (2012, 31) argued that to move away from the twentieth-century framework of 'maximising flexibility' at the cost of eliminating crucial aspects such as 'sense of place for the users', architects needed to ensure that 'school facilities respond to multiple effective strategies of teaching and learning'. Walden (2009, 75) argued that a 'wish list' or critical list of requirements for the schools of the future should 'contribute to a positive, educational quality of the learning environment', where children are encouraged to engage with the environment and explore through a design that provides such opportunities. This poses a challenge for designers of responding to the diversity of users and teaching strategies within a classroom.

A broader recognition of LDs and pedagogical developments in the twenty-first century meant that children with LDs were moved into mainstream schooling systems. While mainstream schools started being inclusive of children of both groups, this was not clearly reflected in school design, partly due to delays in the development of specific knowledge of LDs (Büttner and Hasselhorn 2011; Lyon et al. 2001), and partly due to a continued lack of understanding of the importance of school environments in children's learning processes.

New trends in student expectations, technology and concepts of learning add new dimensions to what designers need to incorporate in their approach to school design. Oblinger (2006, 1) identified the following dimensions of spatial design in current educational systems: 'learner expectations, the principles and activities that facilitate learning and the role of technology'. Further, there are three corresponding trends in 'this collection: changes in our students, information technology and our understanding of learning'. Walden (2009) added that 'schools in developed countries such as America may see dramatic and radical changes in school architecture with the advent of internet and wireless technology' (Walden 2009, 33). These changes may be seen globally, with a similar advent of information and wireless technology in other developed and developing parts of the world. However, it remains to be seen whether schools of the future will align with the inclusion policies of mainstream education for children with LDs and the emerging understanding of using ecological and environmental aspects as non-medication interventions to assist in learning abilities.

4.6 Discussion

The outcome of the discussion on the evolution of school design furthers an understanding of the limitations and successes of various systems of design from past to present school design approaches. It illustrates how school building designs and educational reforms have mirrored political, socio-cultural and economical states of society. However, as the various historical examples demonstrate, a corresponding shift in school design was not always evident in terms of responding to children's behavioural, perceptual and psychological sensibilities or the pedagogical needs of spatial settings to facilitate learning in accordance with respective learning theories. It may be argued that the current practice of inclusion in mainstream schools requires a corresponding shift in design approaches, where school environments seamlessly accommodate the needs of children with and without LDs. Further, the review of various pedagogical and design models suggests that there are intersections between design and education perspectives, as reflected through environmental considerations in the context of various pedagogical models (e.g., Montessori, Vygotsky). The review thus provides a foundation to further examine the notion of the person–environment fit in mainstream school environments by establishing congruencies between the needs of children with LDs and their school's physical environment.

The review of the evolution of school design suggests that previous systems of mass-education-based school architecture are still seen in current approaches to school design. This is evident in the emphasis of current design approaches on flexibility and cost effectiveness, leaving primary users (teachers and students) to adapt or reorganise space for learning to take place (Jilk 2012; Lippman 2010a,b; Walden 2009). Moreover, the concepts of standardisation of space, such as that seen in the kit-of-parts prototype (Knapp 2010) and behaviour (Rivlin and Wolfe 1985), have previously failed to respond to the pedagogical and developmental needs of children and to facilitate learner–environment transactions. Most public school designs have focused on standardisation aspects of school design as a testament to this approach, as general school design approaches are largely inclined towards facilities, procurements and budgets (Gallaher et al. 2004; Lackney 2015; Lippman 2010a; Walden 2009). This design approach, which is reminiscent of past systems of mass education, indicates gaps in understanding how mainstream school spaces can work

towards achieving better learning abilities for both groups of children. Further, the emerging nature of knowledge of LDs (Büttner and Hasselhorn. 2011; Lyon et al. 2001) poses many unknown factors for researchers and educators who are keen to develop strategies for children with LDs. The outcome of these gaps are generic school designs based on the 'one-size-fits-all' approach that are hardly responsive to users' diverse needs. However, there is a broader disciplinary consensus on the need to develop holistic design approaches to address the needs of these children.

The review outlined the various pedagogical models and learning theories (e.g., progressive, Monitorial, Montessori) while exploring how school systems evolved to the current settings for learning. It demonstrated that whether educational practice focused on self-directed learning, as in progressive models (through exploration with the environment), or on guided learning, as in traditional models (directing the learner through environmental settings), both schools of thought used the environments to articulate how and what was learned. These progressive models illustrated the various ways in which learner–environment transactions take place for learning to occur. For instance, Steiner's philosophy focused on the movement of the body in space and derived experiences as part of learning processes. Vygotsky's notion of social constructivism required the physical environment to provide opportunities to support learners' interactions with their social environment. Further, the review of these models underlined educators' requirements to create specific experiences (such as through discovery and adaptation, as per Piaget's philosophy) with the aim of achieving specific goals such as moral or physical development. Contrary to common perceptions among educators that schools' physical environments are passive backdrops to learning (Lippman 2010a), school environments play a valuable role in facilitating learner–environment transactions if the environments are designed with an understanding of the type of interactions, activities and experiences that educators seek for effective learning.

The review further examined the Waldorf and Montessori school models in depth, as there appeared to be significant reliance on the physical environment to articulate their respective child-centred educational philosophies. For example, Steiner's designs highlighted how pedagogies can be articulated through school design, merging built and natural spatial forms to offer enriched learning experiences.

Similarly, the Montessori space iterates the value of creating physical environments to match children's abilities (e.g., ergonomic and developmental) and enable learning via better engagement and experience with the physical environment. For example, space is zoned to allow learners to find a match with their own pace of learning, thus responding to learners' diverse needs. The notion of child-centredness resonates with the central theme of this thesis, which is to examine potential design solutions for mainstream schools that are user-centred or driven by the needs of primary school children, including those with LDs. Consequently, these two models explore the ways in which design and education can be brought together to facilitate learning for students with diverse learning abilities.

The review highlighted that the Montessori model creates affordances (through space and its organisation) to facilitate person–environment (learner–environment) congruencies. The Montessori model is thus worthy of further examination to understand how user diversity in terms of LDs and developmental needs can be addressed through architectural design, as in educational practice. Deviations may occur due to interpretational and implementation differences between educational systems (Lillard 2012), but the Montessori model can be explored in terms of students' perceptions of and interactions in an open-plan space, which the literature suggests would fail for children who require structured and organised settings.[46] Consequently, this study conducts case studies of traditional and alternative schools to obtain answers to the above questions of different spatial settings and students' attitudes towards them.

While the argument on the superiority of one form of education over another is outside the scope of this thesis, the main idea behind Waldorf and Montessori's education models is that spaces that are designed with consideration for how children learn and teachers teach would work better in terms of a better sense of well-being and behaviour, resulting in better teaching and learning outcomes. At their core,

[46] As discussed previously, in open-plan settings, arguments exist between authors regarding the suitability of children with LDs (e.g., attentional issues) studying in open-plan settings (Beeken and Janzen 1978; Carbone 2001; Cruickshank 1967; Knoblock 1973; Weinstein 1979; Wohlwill and Weisman 1981). This physical aspect needs to be examined in real-world settings to understand how such spaces are engaged with and perceived by students with and without LDs, as well as its implications from a design perspective.

design paradigms should include the needs of children (e.g., developmental, behavioural, perceptual and social) followed by the pedagogical needs of teachers.

The following considerations emerge for designers when conceptualising a design response that is inclusive and focuses on the needs of the children from both groups.

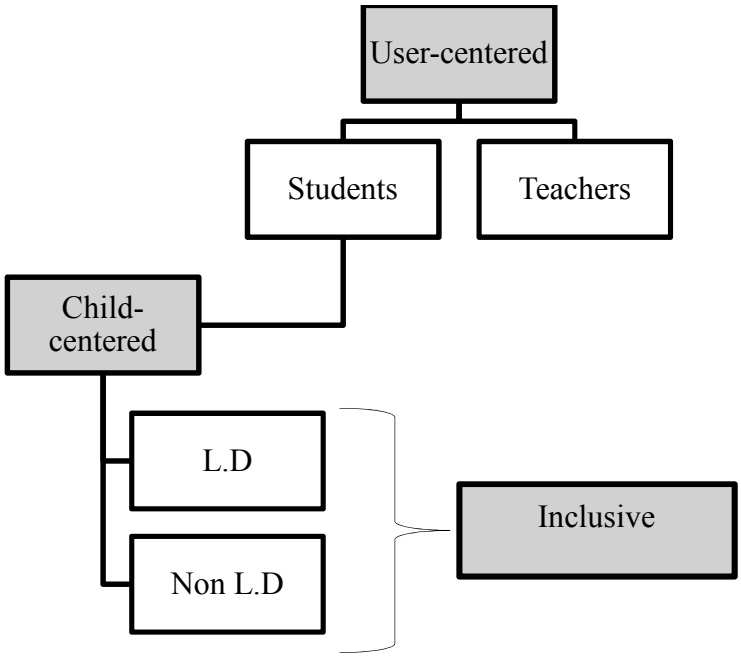

Figure 4.6: User-centred approach to create inclusive environments

Figure 4.6 shows that emphasising the needs of primary users—namely, students with and without LDs and teachers—will meet the objective of both child-centred and inclusive school designs, as discussed below.

Child-centred (focus on students' needs): The technological advancements of the present day require that school design be based on educators' efficiency needs to facilitate learning (Büttner and Hasselhorn 2011; Lyon et al. 2001). However, children's behavioural and developmental needs also require serious consideration, specifically for the LD group, where co-occurring disorders result in different needs. Emphasising students' needs requires design approaches that recognise the relationships between learners and school spaces. Recognising these relationships and diverse learning needs will enable designers to create inclusive spaces for children with LDs.

Teacher-centred (focus on understanding prerequisites of educators): As educators facilitate learning by organising the social and physical environments for

learners (Clark and Uzzell 2006; Lippman 2010a; Weinstein 1979; Weinstein and David 1987), it is important to understand what educators seek from school environments when designing efficient learning spaces (Butz, 2002). If spaces offer the relevant affordances for teachers to accommodate the needs of both groups, it could subsequently help teachers to maintain inclusive education practices.

4.7 Perspectives on Learning and the Nature of Learning Experiences for Children with Learning Disabilities in Mainstream Schools

Chapter 1 outlined how LDs are understood and how they define the focus of the current study. This section further examines how learning occurs from various disciplinary perspectives, with an emphasis on the role of school environments in facilitating learning. It also explores interdisciplinary literature on the experiences of learners with LDs while studying in mainstream schools. The aim of the review is to gain an understanding of the nature of the experiences of children with LDs in mainstream schools, which is necessary to build a foundation for developing child-centred, inclusive school designs.

4.7.1 How learning occurs: constructivist, developmental and neurological perspectives

Philosophers and education researchers have presented numerous theories on how learning occurs. These theoretical concepts have evolved over time, ranging from learners as passive receivers of wisdom and blank slates (Berryman 1991) to learners viewed as active constructers of knowledge as part of their learning processes (Glasersfeld 1996, 2005; Lippman 2010a). The following discussion highlights that it is essential to understand these perspectives of how learning occurs to design school environments that provide relevant experiences and opportunities to support learning processes.

Constructivist perspective on how learning occurs: Ultanir (2012, 195) defined constructivism as an epistemology that 'offers an explanation of the nature of knowledge and how learning occurs in individuals'. Naylor and Keogh (1999, 99) defined learning from the perspective of constructivists 'as an active process where

learning occurs when learners construct meaning by linking new ideas with their existing knowledge'. Constructivists agree that learning occurs when individuals construct new knowledge through engagement with their environments, including with their built and natural environments (Glasersfeld 1996, 2005; Lippman 2010a). From a constructivist perspective, learners are active participants in knowledge creation, and learning involves seeking meaning through processes of reflection and abstraction (Glasersfeld 1996). Learners are required to draw meaning from their perceptions and interpretations of their environments. School environments can thus provide the relevant affordances for the development of meaning by facilitating learner-focused transactions.

Developmental perspective on how learning occurs: Developmental perspectives consider that learning occurs when individuals are given opportunities that are relevant to their age and developmental stages (e.g., cognitive, physical, psychological). For instance, Piaget (1970) construed that learning requires discovery by action, and the learner's environment should provide opportunities that are aligned with their stages of cognitive development. These stages of development recognise that learning occurs differently based on children's age and 'with the children's ability to construct cognitively or individually their new knowledge within their stages and resolve conflicts' (Ultanir 2012, 203). Similarly, Montessori (1912) considered that a child's development occurs at an individual level, as well as in stages of six-year periods, each with specific sensitivities. This concept is reflected in the way children are grouped in multi-age classrooms spanning three years in Montessori schools (Edwards 2002; Lippman 2010a). These phases were attributed with the development of specific abilities considered to occur in four distinct levels spanning from birth to six years of age, 6–12, 12–18 and 18–24 (Grazzini 2004). Learning occurs when learners are given developmentally sensitive learning content and an environment that encourages self-directed learning (Ultanir 2012). Steiner's notion of child-developmental theory in the context of learning recognised three cycles of seven-year periods: infancy to seven years, 7–14 and 15–21, 'seen as an upward spiral of knowledge' (Lippman 2010a, 152). Again, Steiner considered that learning occurs when school environments are created to nurture and respond to learners' needs through experience and engagement with the environment. Learners'

environments are therefore considered an important factor because they provide developmentally appropriate activities and opportunities for learning to take place.

Scientific perspectives on how learning occurs: From the biological perspective of neuroscience, learning takes place when the brain undergoes change as a result of new information or experiences (Goldberg 2002; Hannaford 1995; Zull 2002). Bransford, Brown and Cocking (1999, 149) further added that, from 'a neuroscience perspective, instruction and learning are very important aspects of a child's brain development and psychological development processes. Brain development and psychological development involve continuous interactions between a child and the external environment'. This emphasis on interactions between children and their external environment as a crucial part of learning resonates with the theories put forward by developmental theorists (e.g., Piaget and Vygotsky), who considered that children learn 'by doing', which refers to learning via experiencing and interacting with children's social (relations and communications with teachers, peers and technologies) and physical (spaces, objects in space) environments (Whitehouse 2009). An understanding of the various types of interactions between children and their school environment is vital in developing design strategies that support children's learning and instruction needs within school spaces.

An extensive study of children aged six months to 12 years of age from high-risk, low-income family backgrounds indicated that a social and physical environment that is rich in opportunities to learn via play and socialisation with classmates and good nutrition positively influences the brain by raising the intellectual capacities of learners (Ramey and Campbell 1991; Ramey and Ramey 2004). The availability of enriching social and physical environmental opportunities is vital to give the brain new experiences for learning to occur. Consequently, school environments need to be designed purposefully to offer enriching opportunities for effective learning to take place.

4.7.2 Importance of physical conditions and settings for better learning

Literature reviews on the influence of school facilities and environmental quality on students' performance, achievement levels and sense of well-being (Lackney 1999; Schneider 2002; Woolner et al. 2007) have found that environmental factors can

significantly influence learning. Physical conditions (both built and those organised by educators) are important for learning processes because they influence children's ability to interact effectively with their surroundings (Maxwell 2007, 230). Therefore, designed physical environments can influence learning by 'providing a balance between individual capabilities and environmental challenge' (Trancik and Evans 1995, 311).

A US education study (Hughes 2005) in 5–10-year age group, which explored the relationship between students' achievement scores in specific subjects (reading, maths and science) and the school environment found that 'all building design variables had a statistically significant relationship with student achievement' (Hughes 2005, 2). The building variables that influenced scores were aspects of the school site, movement patterns, meeting spaces, natural lighting and the psychological effect of colour and design elements. In another US study from the environment–behaviour perspective on the role of physical environments (ranging from educational settings to built environmental factors) in learning among 3–4-year-olds, Maxwell (2007) found that there was a nexus between measures of competency—specifically, self-perception and quality of physical environments. Uline and Tschannen-Moran (2008) observed related results in schools in Virginia, US, finding a correlation between the qualities of school facilities and students' achievements in two test subjects (English and Mathematics). Evans and Maxwell (1997) confirmed that noise has a negative effect on children's ability to learn. Studies also suggest that noise affects language, communication and cognitive skills in children in general (Wachs 1982). These findings demonstrate that qualities of physical environments and settings can affect various dimensions of learning, ranging from students' achievement levels and general ability to learn to communication and cognitive abilities, implying that schools' environmental attributes play a crucial role in enabling children to maximise their learning potential.

4.7.3 Background of learning disabilities

Although the term LD was coined in 1962, the issue of learning impediments was identified as a problem between 1800 and the 1920s, when brain injuries and mental impairments were related to reading disorders (Swanson, Harris and Graham 2013). The evolution of the idea began with the initial classification of the disability of a

brain-injured child in the 1800s, and it continued until the 1960s, when the term was altered to minimal brain dysfunction (MBD) (Harwell and Jackson 2014). The span of more than 100 years in the understanding of learning problems indicates the complexity of the issue. As Lyon (1996, 57) explained, 'Overall, the field of learning disabilities emerged primarily from a social and educational need and currently remains a diagnostic practice that is more rooted in clinical practice, law, and policy than in science'.

In the 1970s there was broader recognition of LDs, and several debates developed with regard to the causes, symptoms, therapies and diagnosis of LDs (Lyon et al. 2001). Current statistics on children with learning impediments due to neurological disorders such as ADHD, ADD and ASD show a significant rise, partly because of an increase in the ability to diagnose, and partly due to recognition of these conditions (Lyon 1996). For instance, an Australian survey (Sawyer et al. 2000) found that 11% of children and adolescents have ADHD. Similarly, 8.4% (5.2 million) of children aged 3–17 years in the US have been diagnosed with ADHD (Bloom, Cohen and Freeman 2012), and approximately 19.0% (1.6 million) of students in England and Wales have been diagnosed with special needs requirements (Office for National Statistics, UK 2012). It is important to note that LDs are prevalent in most classrooms.

Trout et al. (2007) reviewed non-medication interventions aimed at improving academic outcomes for children and youth with ADHD and found that studies on non-medication interventions are limited due to issues such as methodological difficulties. They concluded that there was a paucity of research on non-medication interventions, and the limited literature requires further systematic analysis to determine which intervention method is the most significant for students with ADHD. In the case of ADHD, the most common treatment is stimulant medication (Barkley and Murphy 2006). Some authors have suggested that reviews of medication studies on the effect of achievement levels show that there is little evidence that the efficacy of such medication is directly related to academic achievement (Raggi and Chronis 2006; Schachar et al. 2002). Ongoing debates regarding the efficacy of one method against another (e.g., drugs versus behavioural intervention) have continued, implying that ADHD-, ADD- and ASD-related

conditions are complex. Nonetheless, the evidence from these studies could guide school designs that aim to contribute to a non-medication intervention process for students with LDs.

LDs could arise as a manifestation of difficulties posed by a vast spectrum of disorders (ADD, ADHD, ASD), each of which has a subsequent range of difficulties, such as sensory dysfunction (including visual and auditory) in children with ADHD (Deacon, Woodhouse and Watts 2005; Tufvesson 2007) and impairments in social interactions, communication and personal behaviour in children with ASD (Singhania 2005; Rinehart et al. 2006). These issues pose significant challenges for children in coping with peers and being motivated to learn. Moreover, inattention issues can occur due to variables such as teacher–student ratios (Kantrowitz and Evans 2004) and educational approaches (Strayhorn Jr. and Bickel 2002). Inattention and impulsivity is common in several LDs, such as when co-occurring with ADHD, ADD and ASD (Clibbens et al. 2002; Drechler et al. 2005; Singhania 2005). For instance, children with ADHD, ASD and ADD have difficulty concentrating on tasks when placed in an environment with diverse sensorial inputs, as they are sensitive to environmental stimuli (Reese et al. 2005; Zentall 2005). Difficulties due to sensitivity to environmental stimuli require a corresponding design response to enable these students to maximise their learning potential.

While debate and research on LDs continue today, the emerging idea and general agreement on the use of the environment as part of an intervention method to provide supportive surroundings for improved learning is paramount to this thesis. As Mercer and Pullen (2005, 539) explained, 'children with learning disabilities demonstrate significantly higher rates of social, emotional and behavioural problems than children without disabilities'. Other studies suggest that medication alone is insufficient for improving academic achievement in children with LDs such as ADHD (Raggi and Chronis 2006; Schachar et al. 2002), and improvements in attention due to medications do not directly influence academic achievement (Corkum, McGonnell and Schachar 2010, 12). These studies imply that if a school's spatial design responds to the specific needs of this group, it could support educators in facilitating non-medication support strategies for children with LDs in mainstream schools.

4.7.4 What it means for children with learning disabilities to study in mainstream schools

Prior to exploring questions on how the design of school environments can assist learning for those with LDs, it is important to examine questions around the nature of experiences for children with LDs who study in mainstream schools. The aim is to understand the nature of learner–environment experiences that need a response from design perspectives to facilitate learning for children with LDs. As discussed earlier, learning is linked with both social and physical dimensions of school environments. Consequently, both dimensions are explored to obtain an understanding of the nature of experiences for children with LDs in mainstream schools.

Nature of experiences in mainstream school design and children's spatial needs

The school environment is important in the life of young children because they spend a significant amount of time there, and the environmental experiences of childhood continue to be influential in one's adult life (Weinstein and David 1987). To understand and create nurturing and supportive learning spaces in mainstream schools that are responsive to the needs of children with LDs, it is necessary to understand the nature of their learning experiences and the associated spatial needs.

Children with LDs experience a range of challenges posed by their environments that affect their disorders and deficits. Some children with ADHD and ASD can be more sensitive to environmental stimuli due to heightened sensory awareness and visual processing abilities (Freed and Parsons 1997). In others, spatial perceptions can differ based on motor skills deficits (Baumers and Heylighen 2010), which influence how they negotiate space. The presence of disorders such as inattention, impulsivity and hyperactivity also necessitates the need for spaces to enable children to receive academic support or respite (Carbone 2001; Mostafa 2008), as discussed below.

Education researchers have established that of the limitations faced by children with LDs such as anxiety and stress (Mercer and Pullen 2005), distractions in the physical environment can greatly impede their learning. Studies on spatial arrangements (e.g., open-plan classrooms) suggest that internal planning and qualities of space tend to affect motor activities and generate stress among students (Smith and Connolly 1980), while unsuitable seating arrangements can result in children with ADHD

fiddling or rocking in their chair (Mitchell 2006). These results indicate that schools' environmental factors can adversely influence learning for children in general, but the effects may be worse for those with LDs. However, design responses can provide opportunities for this group to negotiate these challenges. For instance, children with LDs due to inattention issues could be given a study nook to either work independently or receive one-on-one academic support (Carbone 2001; Reiber and McLaughlin 2004; Strayhorn and Bickel 2002), thus allowing them to be part of mainstream classrooms.

In the context of students with ADHD co-occurring with LDs, it is speculated that incompatibility with the environment (physical, social) and the presence of other deficits such as perception and gross motor skills prohibits successful learning processes and associated activities (Farrell 2010). A study on built environmental factors and their influence on the behaviour of children with ASD (Shabha 2006) found several environmental aspects that act as 'sensory triggers' and adversely affect students with ASD, as outlined below.

The main triggers were visual ones of undefined spaces and illumination sources. A visual disorder in other school spaces, such as classrooms, playgrounds and the cafeteria, was also considered an adverse sensory trigger on the behaviour of ASD students. Other sensory triggers were auditory ones of 'unexpected noises' and sounds of a higher pitch. Another finding was considered a positive behavioural effect of using the sounds of nature and music.

Conversely, studies have shown the positive influence of schools' environmental attributes on learning abilities. In a recent study by Hastings and Wood (2000), schools in the UK implemented the results and found that the rearrangement of furniture in classrooms improved students' concentration. Another school successfully experimented with methods of spatial rearrangement and planning to match with the study task, achieving favourable results. The 'Brindishe Community School' in Lee, South East London, has an open-plan design based on evidence from neuroscience and psychology, and yet noise is not an issue (Taylor 2000). The school amalgamates pedagogical changes based on brain research and uses interconnected spaces and facilities to engage children's perceptual senses. However, these studies were an exploration of conditions for children in general; they did not focus on

children with LDs. Other researchers from environment–behaviour perspectives have stressed the importance of designing engaging and enriched outdoor environments in school spaces that appeal to the emotional and psychological disposition of children and subsequently promote positive behaviour, such as socialisation with peers (Simkins and Thwaites 2004).

These studies reiterate the links between school environments and children's learning processes (e.g., behavioural, sensorial, perceptual, psychological), which have transformative influences on learning for those with LDs. The mismatch between the needs of children with LDs and spatial affordances may affect their overall motivation and ability to learn. Spatial provisions (e.g., study niches) for teachers would enable them to offer relevant academic support to children with LDs while continuing routine teaching activities. This implies that learning could be challenging for those with LDs in a standard mainstream school space if spatial affordances to match their special needs are absent. Further, where spatial provisions are not responsive for teachers to facilitate academic support for learners with LDs, it could subsequently disrupt the teaching and learning processes for both groups of children in the same environment. That is, if school spaces are designed to support these students, these design considerations would also benefit other children in the same learning environments by enabling both teachers and students to meeting their teaching and learning objectives.

Nature of experiences related to the social environment in mainstream school design

The social dimensions of school environments (such as socialisation with peers and play) are vital in forming positive learning experiences that contribute to better abilities to learn (Clark and Uzzell 2006; Lippman 2010a; Ramey and Campbell 1991; Ramey and Ramey 2004; Weinstein 1979; Weinstein and David 1987). Some of the common issues known to affect children with LDs at school are anxiety and stress caused by negative feelings such as low self-esteem and frustration (Mercer and Pullen 2005), regardless of the root cause of the LDs. The following literature from special needs education (including those with LDs) suggests that these issues of anxiety and stress may be linked to the social aspects of the school environment. Studies suggest that children with LDs:

- are at risk of bullying in both mainstream and special needs schools by peers without special needs (Norwich and Narcie 2004; Whitney, Nabuzoka and Smith 1992)
- could experience social difficulties integrating with peers compared to those without LDs or academically high-achieving students (Nowicki 2003)
- could experience difficulties with academic engagement and maintaining peer relations, with the subsequent effect of disliking studying in mainstream schools despite receiving academic support (McCoy and Banks 2012)
- are at increased risk of social exclusion by peers with no special needs (Humphrey and Symes 2010), with subsequent adverse effects of losing their sense of belonging at school, access to social experiences, motivation to learn and impeding school performance (Asher and Coie 1990; Ollendick et al. 1992; Koster et al. 2010).

The above studies suggest that mainstream school environments should include spatial affordances that offer children with LDs opportunities to cope with these socio-environmental challenges. The spatial needs of these children to withdraw, self-regulate and restore to escape socio-environmental challenges have been indicated in studies by Flynn and Rapoport (1976), Greville (2009), Hart (1979), Moore (1990), Mostafa (2008) and Scott (2009). In response to these studies on the potential socio-environmental challenges that children with LDs may experience in mainstream schools, questions regarding how school designs can provide opportunities for children to escape, gain respite and restore need to be explored as part of developing inclusive design strategies.

4.8 Discussion

The outcome of the review on how learning occurs and on the nature of learning experiences for children with LDs suggests that school environments (physical and social) not only play a role in facilitating learning processes, but can also have transformative influences on emotional states, motivation to learn and achievement levels for those with LDs. Section 4.7 explored the question of what it means for children with LDs to study in mainstream schools. This question highlights the dual aspects of schools' physical and social environmental influences on ability to learn.

Section 4.7 thus provided a foundation to understand the interrelationships between school environments and learning for children with LDs.

The review discussed interdisciplinary literature to highlight that transformative influences of school environments can be either adverse or supportive, and school designers need to consider these influences during the design process to ensure that school environments are supportive of learning processes while looking beyond fulfilling conventional standards of construction and safety. In discussing the importance of physical settings and environments, the review underlined the need from an architectural perspective to examine permutations and combinations of built environmental attributes so that learning processes may be positively influenced. However, a recent report on a review conducted in schools in the UK on the effect of built environments on learning concluded that 'there is an overall lack of empirical evidence about the impact of individual elements of the physical environment which might inform school design at a practical level to support student achievement' (Woolner et al. 2007, 47). The lack of a framework for designers suggests an interdisciplinary or intradisciplinary gap, as knowledge on the transformative influences of the environment exists in the disciplines of spatial design and education, but there appears to be an issue with its dissemination. Nonetheless, the influence of physical elements as catalysts in students' learning processes is unquestionable, even if the extent of each parameter's influence is unknown.

In tracing the development of the term LD, the review discussed the emerging nature of knowledge on LDs and the complexities involved in improving academic outcomes for these children. While there is an emphasis on medication strategies to enable better learning potential (Barkley and Murphy 2006), non-medication intervention strategies, while limited (Trout et al. 2007), are now considered necessary to form an integrated approach to support children with LDs. School designs could contribute in this area of non-medication strategies by giving educators the spatial provision to articulate academic support and facilitate learner–environment congruencies for children with LDs.

Section 4.7 examined issues experienced by children with LDs (e.g., stress, anxiety) related to the social and physical environments of their mainstream schools. In doing so, it highlighted that it is imperative that school spaces respond to the needs of

children with LDs, such as the need to withdraw, restore or receive respite. The review therefore drew attention to the need to provide spatial opportunities for children with LDs so they can cope with the challenges posed by socio-environmental factors in mainstream schools.

Literature examining questions regarding the nature of learning experiences from the perspective of children with LDs in mainstream schools is limited compared to those from the perspective of adults and educators, which mostly relate to the challenges of integrating the diverse needs of the two groups in mainstream schools (Davis and Watson 2001). Nonetheless, education studies concur that it is imperative that the perspectives of the special needs group, including those with LDs, with relevance to this study's subjects be considered when developing strategies from educational practices to align the mainstream school settings with inclusion policies (Davis and Watson 2001; McCoy and Banks 2012). A similar stance may be essential from the design perspective if school design strategies are to be developed to respond to the needs of children with LDs studying in mainstream schools.

4.9 Summary

The aim of this chapter was to first explore the history of school architecture to understand the present contexts of school design and provide the reader with the relevant keystones upon which the subsequent chapters have been constructed. In examining the literature on various models of teaching and learning—focusing on the Steiner and Montessori models, which emphasise the role of the physical environment in learning—the educational approaches that use space to facilitate learning were illustrated. The chapter also presented an overview of how learning occurs (e.g., from developmental, scientific and constructivist paradigms), combined with the nature of experiences for children with LDs in mainstream schools. Collectively, Chapter 4 provided an understanding for an analysis of the ways in which school designs provide opportunities to accommodate the needs of children with LDs so that designs are inclusive in nature.

Based on these foundations of knowledge, Chapter 5 will evaluate the literature on school environmental factors and how they impede or support learning for those with LDs. The aim is to examine specific literature on environmental attributes from intra-

and interdisciplinary contexts of school architecture, design, environmental psychology and education to gain insights into developing inclusive design approaches for mainstream schools.

Chapter 5: School Environments and Their Influence on Learning Disabilities

5.1 Introduction

Chapter 5 examines the space–behaviour nexus in the context of school environments and its influences on children's abilities to learn. Chapter 4 provided an understanding of the space and behaviour nexus through an exploration of theories of environmental stress (Altman 1975; Stokols 1985), sensory overload (Evans 1984), level of arousal and attention restoration (Bell, Fisher and Loomis 1978). Thus, it highlighted the relationship between school environments and learners' behaviour, performance and sense of well-being, and it iterated how they combine to influence better learning processes and abilities in children with LDs.

This chapter continues the exploration of environmental influences on LDs by critically reviewing interdisciplinary literature on various attributes of schools' built and interior environments and their influences on children's learning processes, performance and behaviour. The chapter is divided into two sections and focuses on understanding environmental aspects that adversely affect children with LDs. The key question examined was to understand whether the cumulative effect of schools' environmental variables could significantly affect the learning processes of children with LDs. If so, what are the implications for school architects and designers in designing schools to respond to needs for both groups of children?

The aim of this chapter is therefore to address the main thesis questions of identifying how school attributes can be purposefully designed to align with the needs of inclusion in education for mainstream schools.

5.2 Furniture and Spatial Organisation

School furniture ranges from storage for educational aids and equipment to chairs and desks for students. They are mostly procured from standards specified by relevant departments of education in most countries. This section explores whether

the available range of furniture is responsive to the needs of children with LDs and, if not, what needs to change to align them with their needs.

Today, children 'are no longer expected to sit still in rows of seats to listen and respond to the teacher' (Walden 2009, 89), as in the older industrial models of schools. Learning processes are more interactive and schools are consequently expected to be more responsive (Sanoff 1995, 2001a). The new pedagogies requiring responsive learning environments require corresponding designs in school furniture to allow the transactional activities involved in a learning space. For instance, Oxford (1969, 159) iterated the importance of school chairs for students' learning by arguing that:

> School chairs are not entitled to be 'educational' in character unless they are suited to the size of pupils using them, encourage good sitting posture, and aid the process of learning. Mere existence in a school is not enough.

As a result of this understanding in recent years, the indirect influence of school chair-and-desk arrangements on students' learning has been well investigated.

5.2.1 Effects on learners

School furniture is used extensively during children's critical period of growth and human physical development (Knight and Noyes 1999). Typical children in their growth periods seek movement that is necessary for muscle development (Walden 2009). Young children who are naturally inclined to be active find it painful to sit on uncomfortable chairs for the extended periods required at school (Murphy et al. 2004). A child with LDs co-occurring with other disorders (such as ADHD or ADD) find it difficult to focus or sit still for the duration of the school session if using an uncomfortable desk and seat. This causes further problems in focusing on the task at hand and behavioural responses such as fidgeting, rocking and other positional changes to alleviate discomfort (Oxford 1969). This may appear to teachers that they are 'acting out' or that their 'medications' are not working if they have previously been diagnosed as having learning problems. Uncomfortable furniture could also lead to misunderstandings about children without LDs who are trying to get comfortable (Wingrat and Exner 2005). Therefore, it could be a serious learning

impediment for typical children, as well as those with ADD or ADHD who are already at a disadvantage due to their condition.

In addition to the desk-and-chair setup, the provision of display and storage form important considerations in creating effective learning environments by giving learners better access to learning resources organised by educators. McLeod, Fisher and Hoover (2003) explained that visual displays are influential tools in facilitating learning by affording a sensory experience and conveying information visually. The availability of a visual display to exhibit students' work is construed to influence students' perceptions of school as a positive environment (Killeen et al. 2003; McGonigal 1999). However, Dudek (2000) cautioned that displays can add to visual clutter; hence, these must be placed with consideration of the overall coherence of the space. Further, for children with issues of inattention and impulsivity, overtly loud displays can cause overstimulation, and these must be placed away from where these children are seated; alternatively, subdued colours can be used to convey information without aggravating their condition (Carbone 2001). The provision of storage helps students of both groups to stay organised and focused on learning tasks. Nonetheless, special considerations, such as provision of personal storage, are necessary for students with ADHD who have difficulties organising themselves and who lose learning materials (Carbone 2001; Cherkes-Julkowski, Sharp and Stolzenberg 1997). Further, students with ASD benefit from an uncluttered personal space (McAllister 2010). Shared storage areas such as for shoes and coats also function as transition spaces for those with ASD, which allows them to prepare for the transition from the external environment into the learning environment (McAllister and Maguire 2012). Storage, visual displays and storage spaces thus need special consideration in terms of how and where they are placed to avoid being harmful to children with these disorders.

5.2.2 Influence on children with learning disabilities

In the specific context of children with LDs co-occurring with attention issues, impeded attention and a reduced ability to sit still for longer periods was observed when students sat for more than 50 minutes on unpadded chairs (Bullock and Foster-Harrison 1997). School chairs were rarely observed to be padded or upholstered (Walden 2009). Children who are prone to issues of impulsivity, inattention and

repetitive classroom-inappropriate behaviour (such as rocking) could deem this to be a major impediment to their learning, possibly negating educators' efforts in offering these students academic support. Evidently, the chair and table design in schools is a prerequisite to effective learning processes. Their design falls in the product design niche, and yet it has a crucial effect on the way children learn and access their environmental affordances.

Another important aspect is to consider aspects of function and aesthetics while designing furniture for mainstream schools. For those with ADHD or ASD, overstimulation due to environmental aspects such as excessive use of colours could aggravate their symptoms (Sánchez, Vázquez and Serrano 2011). Designers should therefore avoid the presumption that classroom furniture should be colourful without considering the effects of overtly colourful furniture on those with ADHD and ASD.

Different types of LDs (e.g., reading and maths disability) co-occurring with other disorders (such as ADHD and ASD) exhibit varying postural and behavioural tendencies among children. However, the symptoms that most commonly cause disruptions in the classroom are those that prompt them to be more mobile or engage in off-task behaviour,[47] impeding their own learning and the *teaching process* (see List of Definitions and Terminologies) (Greene et al. 2002; Whalen et al. 1979). Uncomfortable furniture may intensify these symptoms. Furniture designs thus need to be developed with an understanding that the postural and behavioural needs of this group of children differ from those of children without these disorders, and a corresponding response in furniture design is necessary to allow them to maximise their learning potential while being part of a mainstream classroom, as discussed below.

[47] Off-task behaviour in the context of this thesis refers to Baker's (2007) definition of the term, which refers to disengagement from the learning environment and classroom activities to engage in unrelated behaviour.

Figure 5.1: Therapy balls to suit varied ergonomic needs of classroom users is unable to be reproduced here due to copyright restrictions. Figure 5.1 can instead be accessed via http://catalogs.schoolspecialty.com/2875_ssi_i210/full.asp?page=22

Figure 5.1: Therapy balls to suit varied ergonomic needs of classroom users (http://catalogs.schoolspecialty.com/2875_ssi_i210/full.asp?page=22)

Alternative seating options such as therapy or stability balls (see Figure 5.1) or disc 'O' sit cushions—the use of which are being promoted based on limited studies from occupational therapy research, can be explored further as part of the standard school furniture range as a supportive option with special needs teachers. Therapy balls are heavy-duty air-filled rubber balls of about 20–30 inches diameter that are designed to be sat upon while also allowing movement. A study on the use of stability balls in special education classrooms supports the use of stability balls, stating that they allow 'students in classroom the movement they need without disrupting the classroom' (Bill 2008, 17). A smaller sample study by Schilling and Schwartz (2004) on 3–4-year-old children with ASD investigated whether stability balls affect in-seat behaviour and engagement in classrooms. This study approached the question from Ayres' SIT (Ayres 1972), positing that 'in order to address children with ASD and others with sensory processing problems, successful strategies for self-modulating sensory input must be afforded to them' (Schilling and Schwartz 2004, 424). The authors found that stability balls had significant potential for use as a sensory intervention strategy to facilitate better engagement and in-seat behaviour for ASD children in classrooms. Other studies found therapy balls could improve in-seat behavior (Fedewa and Erwin 2011) and legible word productivity (Schilling et al. 2003) in ADHD students in comparison to use of chairs. This might be a viable alternative worth investigating on a larger scale, as the initial findings also suggest a preference by teachers because these alternative seats seemed to be effective in reducing issues among children with hyperactivity and inattention. Further, teachers who are generally responsible for accommodating students with LDs would surely welcome any strategy that would assist their efforts and reduce their stress (Engelbrecht et al. 2003).

These recent studies seem to have high potential for arriving at holistic solutions aimed at physical changes to a learning environment, and they also suggest future development in the design of these alternative seats for schools. This would suggest collaborative efforts between designers, occupational therapists and ergonomic consultants to research and develop successful and commercially viable prototypes. However, the current literature is highly inadequate because, first, none of the findings can be generalised and used for all cases of LDs. Most studies were conducted on a small sample size, thereby limiting the possibility of establishing the average sum of effects across a broad range of children with LDs—specifically ASD and ADHD. Future research on these alternative seat prototypes is required to determine factors such as usability for extended hours of time, social acceptability and commercial viability.

While the provision of ergonomically compatible, flexible and engaging furniture design does not provide a solution for the needs of all children with LDs in mainstream schools, it could form part of the intervention strategies for educators by being purposefully designed to limit the aggravation of physical and behavioural symptoms experienced by children in this group. At the same time, it is necessary for other stakeholders, including interior designers and policy makers, in the schools' creation process to consider this aspect of appropriate furniture procurement to enable better alignment between their special needs and furniture design. Such solutions can be achieved sooner if partnerships between design and research are formed to develop prototypes that support children with LDs and test their viability until the best furniture design alternatives are conceived for schools seeking to mesh the needs of both groups of children.

5.2.3 Current trends in school furniture

Current standard ranges of chairs may be better than the rigid wooden desk-and-seat arrangement from the factory school model offering support to relevant spatial conditions and learning settings. For instance, the new design, in which chairs and desks are detached, offer better flexibility to teachers and students by enabling the organisation of the settings as per their teaching and learning needs (Walden 2009). This change in organisation using the same standard range of school furniture can occur irrespective of which educational philosophy the school follows. Further, this

flexibility enables teachers to arrange seating sociopetally (to encourage group work or communication) or sociofugally[48] (to encourage independent work or discourage communication) (Lippman 2010a; Osmond 1966). The standard chairs and desks currently used are light in weight and can be moved by the students, which offers independence to children and assistance to teachers when redefining their classroom space. Lippman (2010a, 181) explained that 'when learners are able to manage their environments, they shape them to support the manner in which they work best'. While these aspects of flexibility and lightness are important, the literature suggests insufficiencies in the current standard range of chair-and-desk seating in meeting students' needs in general and especially the needs of those with LDs.

Questions regarding what these deficits are and how they affect young users have been explored both in developed and developing countries. Several studies in ergonomics conducted in schools internationally have demonstrated that classroom seats and desks fail to match the anthropometric scale of children across the school (Cotton et al. 2002; Oxford 1969; Parcells, Stommel and Hubbard 1999). An Indian study by Savanur, Altekar and De (2007) on classroom furniture and anthropometric relevance to 10–14-year-old students found them to be incompatible with the actual anthropometric dimensions of Indian school students. The key issues reported by students were that the furniture was uncomfortable and failed to offer adequate space. This indicates a gap between the standard furniture manufactured and that supplied to the classrooms as a result of incongruity with students' anthropometric sizes. Other studies by Agha (2010), undertaken in Gaza (Egypt) on a sample of 600 primary school children and Saarni et al. (2007) undertaken in Finland, arrived at identical findings of mismatch between children's anthropometric dimensions and their chair-and-desk settings. These studies made recommendations to their respective furniture standard establishments to correct these deficits in sizes. However, the recommendations focused on correcting the sizes rather than aspects of flexibility of use, probably due to the structured pedagogies used in educational

[48] Concepts of sociopetal and sociofugal arrangements were proposed by Osmond (1966). They refer to seating arrangements that promote or discourage communication among users. Sociopetal arrangement refers to seating organised in clusters to encourage communication and socialization, such as for collaborative classroom activities (Sommer 1967; Weinstein 1977). Conversely, sociofugal settings are spaces organised to discourage communication (Hedge 2015; Vaux 2015), such as placing chairs and desks in rows so they are all facing the teacher (Wolfgang 1996). As discussed in Chapter 3, teachers require flexible spaces to afford both types of seating to respond to the needs of both groups of students in mainstream schools.

practice varying from one country to another. For instance, the introduction of progressive teaching styles in the UK required children to work collaboratively around tables rather than sloping desks (Knight and Noyes 1999). Further questions on whether these recommendations work with the educational practices in these countries fall outside the scope of the current research. However, these studies showed that researchers are pursuing the issue of mismatch between school furniture standards and children's anthropometric data globally, and that the corresponding change in the standard range appears to be limited in most cases. The lack of change in actual furniture standards and specifications in light of such data could imply that there is a delay in the dissemination of empirical evidence on the deficits of the standard range of school furniture.

The consequences of these incompatibilities have also been studied extensively. Other studies on the ergonomics of school furniture add that ergonomically flawed furniture could lead to back problems or musculoskeletal problems in adult life (Cardon et al. 2004; Floyd and Ward 1969). Contradicting this was a study by Chung and Wong (2007), who examined whether ergonomically mismatched chairs were a causal factor for chronic back pain among students in a Hong Kong school. Their findings did not indicate a causal relationship between musculoskeletal problems and furniture design, as shown in other studies, but it found that the existing range of furniture had significant room for further improvement and could contribute to better learning. A pilot study by Wingrat and Exner (2005) concluded that when students occupied chairs that fit their size and were also comfortable, they exhibited better on-task behaviour.[49] In any case, children spend a significant amount of time in school classrooms (Dillon 1976; Linton et al. 1994; Savanur, Altekar and De 2007; Wingrat and Exner 2005), and maintaining chronically uncomfortable postures is likely to cause difficulties in paying attention among children with attention deficits, as well as those without them. These studies demonstrate that school chairs have a prominent role in enabling children to persist in learning tasks for longer periods and, as a result, perform better to achieve their learning objectives.

[49] On-task behaviour refers to behaviours linked to assigned academic activities such as following teachers' guidelines, working independently and willingness to participate in class discussions as required for the completion of routine class activities (Chapman 2003).

Although it is under debate, the question of potential health risks due to incompatible school chairs is worth rethinking in relation to the current standard ranges of school chairs and desks. As discussed in Chapter 4, environmental influences can facilitate successful learning. Conversely, as per the person–environment fit theory, when person–environment matches fail to occur (such as when there are incompatibilities between students' anthropometric needs and furniture design), it could lead to stress (Caplan and Van Harrison 1993; Vischer 2007) and reduced motivation to learn. Subsequently, the reasons why the standard range of furniture falls short of the health needs of young children deserves serious attention from designers, manufacturers, the Standards Authority and educators who procure them.

The issues of incompatible school chairs may be due to a lack of variety to respond to anthropometric diversity in age group clusters. Diversity is considered due to the prevalence of students in a class showing different growth rates within the same age group and between genders of students (Oxford 1969). However, the standard range of chairs does not offer flexibility or variety to either match or adjust to this physical difference in a child's ergonomic needs. In a Greek study on school children aged 6–18 years, Gouvali and Boudolos (2006, 765), found 'that the limited provision of one size per cluster of grades failed to accommodate the variability of anthropometry even in children in the same age group'. They recommend identifying anthropometric variations occurring in similar age groups as a tool to develop better standards and specifications aligned to children's anthropometric data. Economics and budgets may also require due consideration, particularly in schools with low funding. Nonetheless, ignoring children's long-term potential health risks in favour of budgets would negate the purpose of designing furniture that is meant to support learning processes.

5.2.4 Discussion

The review established that school furniture design—specifically chair-and-desk settings—is vital to facilitate learning processes when supporting learners' ergonomic, anthropometric and perceptual needs. As learning occurs most successfully when optimum conditions for learner–environment transactions (social and physical) are afforded, it would benefit children with and without LDs if furniture designs were appropriate to children's scale and ergonomics. Further,

additional qualities that are relevant in alleviating challenges associated with conditions co-occurring with LDs[50] are necessary to avoid aggravation of symptoms of co-occurring disorders. Deficiencies in the availability of well-designed ergonomic school chairs has been attributed to a lack of up-to-date anthropometric data for school furniture design for children around the world, including Australia (Oxford 1969), Europe (Molenbroek et al. 2003) and India (Savanur, Altekar and De 2007).

The review explored how a mismatch between children's needs and furniture could impede learning for those with LDs. These consequences include diminished attentional capacities, aggravation of behavioural issues (e.g., fidgeting and rocking) arising out of a mismatch between learners' anthropometric (e.g., relevant back support) and functional needs (e.g., lack of padding on chairs enabling longer hours of use). Conversely, designs that match the special needs of children with LDs (e.g., impulsivity and hyperactivity disorders) enable learners to maximise their learning potential as a result of better on-task behaviour and engagement with the learning environment (Bill 2008; Schilling and Schwartz 2004). More importantly, certain aspects of visual displays (away from workspaces or subdued colours for those with ADD or ADHD) and storage (personal storage for those with ADD or ADHD and storage space as a transition area for ASD) requires special considerations of placement to respond to the diverse needs within the group with LDs. In exploring the literature on inclusive furniture design prototypes, the review establishes that in the specificity of children with LDs, there is room for further research to develop prototypes of alternative desk-and-seat arrangements, keeping up-to-date with fresh evidence and understanding of children with attention and hyperactivity issues.

The review demonstrates that there are issues in current design practices, as evident from the standardisation of designs—specifically the chair-and-desk setup, which fails to match students' ergonomic and anthropometric scales (Cotton et al. 2002; Oxford 1969; Parcells, Stommel and Hubbard 1999). As Walden (2009) justified, school chairs are children's tools for learning and need to be aligned closely with their users. Neglecting this aspect could have serious health (postural, spinal and musculoskeletal), performance and well-being implications for both groups of

[50] Co-occuring disoders in the context of this study were defined in Chapter 1.

children. He also argued that costs are often less prohibitive than considered and can be resolved by expert guidance. Similarly, Gouvali and Boudolos (2006, 765) argued that schools represent the work environment for children, and the furniture should receive the same attention from ergonomists as office furniture has received for many decades. Evidence on the mismatch of standard chairs with student anthropometry suggests the need for radical changes to school chairs and possibly desk designs, thus enabling better congruencies between children's ergonomic needs and furniture design. It also reiterates the need to search for answers within economical parameters to develop better solutions.

The review highlights that one of the most challenging tasks for school furniture design is to design an ergonomic desk-and-chair setup for children with constantly changing growth rates. Although standardised designs cannot be made to respond to diversity, strategies for inclusiveness can include prototypes based on adult office chairs with gas lifts and reclining backs similar to adjustable school furniture to address the variations in size between school children of the same age group (Zandvliet and Straker 2001). Industry partnerships between ergonomic consultants, furniture designers, occupational therapists and educators may be one alternative of developing prototypes to address the challenge of growth rates. Another would be to continue statistical studies to evaluate convergences of growth rates in specific groups such as age and gender-based. A combination of this practice and a research-based approach could help meet the challenge of designing chairs that include past strengths and offer new qualities of better back support and flexibility.

Chapters 3 and 4 highlighted that any factors that negatively influence the learning process have a corresponding influence on all children, but more so for those with LDs. Thus, well-designed, ergonomically sound and durable furniture could enhance learning aptitudes by enabling students to sit comfortably and be stress-free for longer periods, thereby preventing issues symptomatic of children with LDs (such as off-task behaviour).

Table 5.1: Recommendations for inclusive school furniture

Attributes	Objective for both groups	Additional consideration for those with LDs
Flexible	Allow change to match pedagogies and learners' needs. Adapt to anthropometric diversity.	Adaptability to anthropometric needs could act as a preventative strategy to limit stress due to physical issues caused by mismatched furniture.
Ergonomic	Be relevant to the anthropometric diversity of a specific group in a classroom. Be comfortable and supportive in response to users' needs.	Offer support to prevent discomfort and allow movement and positional changes to alleviate discomfort while sitting for extended hours to assist in better attentional capacities and on-task behaviour.
Engaging	Appeal to children's perceptual sensibilities.	Responsive to needs of children with LDs with co-occurring disorders, avoid aggravation of symptoms (such as by overstimulation) and maintain level of arousal (such as for those with sensory disorders) and engagement (such as those with inattention issues).

Table 5.1 summarises the key points that school furniture should be flexible, ergonomic and engaging to contribute to positive learning experiences for both groups of children. Similarly, when designed to be responsive to diversity among learners, furniture will afford better attentional capacities, motivation to learn and better on-task behaviour. However, there is no one-size-fits-all solution to respond to diversity of needs within the group with LDs. Affording alternatives in school furniture as relevant to the diversities among children with LDs is necessary. For instance, ASD students require group storage space to transit into the learning environment, whereas those with ADD or ADHD need personal storage to stay organised. However, to be able to reach solutions that are inclusive for both groups, future research is required to address known issues such as usability for extended

hours and commercial and social viability. Further, statistical studies on children of both groups are essential to develop prototypes aligned with their learning needs.

5.3 School's Built Environment Attributes

> In the knowledge economy, where learning is not only continuous but also more informal and serendipitous, anything that makes the experience more positive will also increase learning. (Cornell 2002, 42)

The term 'anything' in the above statement is noteworthy because it encompasses such matters as teachers' educational philosophies, location of the school, social background of students and, most importantly in the contextual framework of this study, environmental factors. This section examines how schools' built environment attributes could combine with furniture to support the learning potential of children in mainstream settings with a focus on those with LDs.

5.3.1 Colour

Researchers in the latter half of the twentieth century from various disciplines (Lewin 1947a, 1947b; Proshansky 1972; Sommer 1977) explored aspects of human response to variations in the conditions of their environment. Out of these elements of space, research in colour psychology and light was prevalent in the field of architecture and interior design, perhaps because human response to these two conditions was more evident than other conditions such as form, geometry, thermal comfort and acoustic design. Additionally, the results and inferences of research on the built environment and its perception has led to further research and practical application of the theories (Rapoport 1990) in the field of colour psychology and illumination design. This knowledge could be crucial in improving the quality of school spaces in terms of experiential value. As discussed in Chapter 3, the greater the perceived experiential value of school environments, the better the motivation to learn among learners of both groups.

Mahnke and Mahnke (1987, 180) defined colour as:

> …a sensation caused by certain qualities of light that the eye recognises and the brain interprets. Therefore, light and colour are inseparable, and the design of

> human habitat, equal attention must be devoted to their psychological, physiological, visual & aesthetic and technical aspects.

Their argument was based on similar studies that focused on colours and light (i.e., use of colours in design and effects of light and colour on the mental performance of elementary school children conducted by Dr Wohlfarth from Canada during September 1982 to June 1983). However, it must be noted that colour preference and perception is generally a subjective matter and varies from person to person, such as across individuals of different ages (Milne and Greenway 1999; Zentner 2001), genders (Khouw 2002), trends and culture (Cohen and Trostle 1990; Read, Sugawara and Brandt 1999; Read and Upington 2009). These aspects make the process of colour scheme selection a complex process in the context of design. In addition, it is generally assumed that young children lack the maturity or coherency to express valid and consistent information on their colour preferences in the context of built environments. This is one of the primary reasons that may make it seem impractical to allow children to choose colours (Walden 2009). Although seemingly impractical, it is necessary to understand children's colour preferences and possible perceptual differences among similar groups of children. As Read and Upington (2009, 491) stated, 'Young children are keen observers of the environment, as such, their reports of colour preferences are important to understanding their preferences for colour in their environments'.

Although there are differences in colour preferences and perceptions, colour forms an important aspect of influencing school environments' experiential value such that an environment devoid of colour and texture might make it appear austere and lifeless. Birren (1978, 180) explained that 'Colour for the sake of colour accomplishes little that is constructive, just as bleak environments accomplish nothing constructive either. Education leaders…must also understand that school's physical plant is a vital psychophysiological contribution to the study situation'.

While colour helps us make sense of our environments, it would be presumptuous to design overtly coloured environments based on the assumption that since children like colourful objects, they will also like colourful learning environments. Thus, it is often seen that this erroneous assumption results in spaces that are conspicuously more colourful than spaces for adults. Additionally, excessive use of colours in

children's environments can cause a sensory overload, especially for those with LDs, whereas austere spaces can be 'stressful and unproductive' (Gaines and Curry 2011). As a result, the aim should be to achieve a balanced and integrated approach to colour scheme selection for a complex environment such as a classroom, rather than one that assumes that colourful and complex colour schemes will match children's sensibilities of visual harmony and balance in their built environments.

Colours for school environments

Colour also helps us understand our environment while adding to or affecting its coherency, thus influencing our judgements towards a space. As Martinson and Bukowski (2005, 1) stated, not only is 'colour is the most dominant design element', but it is also 'the most relative aspect of design'. Colour can be one of the most powerful design elements in conveying affordances within school environments that are available to facilitate learner–environment transactions.

Nemcsics (1993) in Figures 5.2b and 5.2c illustrate a basic example of how colours can be used to highlight specific aspects of built environments or make spatial elements recede visually.

Figure 5.2: Colours in interior as a medium to define or obscure spatial perception is unable to be reproduced here due to copyright restrictions. Figure 5.2 can instead be accessed via (Nemcsics, Antal. 1993. *Colour Dynamics—Environmental Colour Design*, translated by G. Nagy. New York: Ellis Horwood) in Coloured Figures, Figure C51.

Figure 5.2: Colours in interior as a medium to define or obscure spatial perception (Nemcsics 1993)

Figure 5.3: Colour schemes in rooms with different wall, ceiling and floor colours is unable to be reproduced here due to copyright restrictions. Figure 5.3 can instead be accessed via (Nemcsics, Antal. 1993. Colour Dynamics—Environmental Colour Design, translated by G. Nagy. New York: Ellis Horwood) in Coloured Figures, Figure C50.

Figure 5.3: Colour schemes in rooms with different wall, ceiling and floor colours (Nemcsics 1993)

Figure 5.2 shows the colour palette of a hangar interior where the colour combination on the left appears to be undefined, influencing its perception as 'uncertain space'. Contrastingly, the right side of the image has a sharp contrasting colour palette highlighting spatial definition and adding spatial coherency to what Nemcsics (1993) refers to as definite spatial sensation. Figure 5.3 presents an example from interiors illustrating how colour can be used to reduce visual complexities, adding clarity and coherence to spatial settings. This is crucial in the design of classroom interiors, where the colour of finishes such as flooring materials, fabrics, textures, illumination and wall colours collectively assist students in understanding what the space may afford to facilitate learning. For example, colour can be used in school environments to assist students in negotiating school spaces, such as in wayfinding (Engelbrecht 2003; Helvacıoğlu and Olguntürk 2011; Jansen-Osmann and Wiedenbauer 2004), and successfully access its affordances. Prior to examining the influence of colours on children in mainstream schools, it would be necessary to understand first how we perceive colour and then what is currently known about the physiological and psychological influences of colour specifically in the context of learning environments and children. It would then be not only possible to evaluate its implication for school designs, but it would also answer questions regarding whether colourful school environments are relevant to the sensibilities of children with LDs in mainstream schools, or if they are triggers for their associated symptoms.

How do we see and perceive colour?

Colour is widely considered an important design element with significant potential to influence humans on a physiological and psychological level (Gaines and Curry 2011; Jalil et al. 2012; Küller, Mikellides and Janssens 2009; Martinson and Bukowski 2005). The perception of colour can be illustrated as a combination of physiological and psychological processes. For instance, Faber (1978, 2) defined the process of colour perception as a biological process that is 'a sensation caused by certain qualities of light that the eye recognises and the brain interprets'. Similarly, Gaines et al. (2016, 48) added that colour is perceived 'through subtractive theory where various wavelengths of light shine on an object and the surface absorbs or subtracts all the coloured light rays except for the ones reflected from the object'. To elaborate further, the human eye has receptor cells in the retinal walls, called rods and cones, which are crucial for 'seeing colour' (Kuehni 2012). Colour perception is also influenced by light, as these cells first receive the difference in brightness or illumination and then respond to different colours of light (Morton 1995; Walden 2009) specifically made of red, blue and green. A permutation and combination of various brightness levels with these three colours results in being able to decode the multitude of colours in our environment (Webster 1996). Simultaneously, other physiological processes occur where the brain impulses influence endocrine glands, causing further emotional and biological responses (Gaines and Curry 2011; Nielson and Taylor 1990).

Light plays a crucial role in distinguishing between colours because it acts on colour perceptions of hues and contrasts, thus changing the way colours appear in natural, artificial, bright and low light conditions (Webster 1996). Studies also show that in researching the influence of four built environment parameters, including colour on 'perceived spaciousness' of a built environment, colour showed the least influence compared to other parameters in the absence of light (Stamps 2011). In brief, colour perception can be explained as a biological response to what is seen and interpreted by the brain in the presence of light. This understanding of colour perception is relevant in designing school environments, as colour schemes need to appear harmonious and coherent to ensure environmental affordability of space and the amount of information conveyed by a space (Bright and Geoffrey 2010). From a

designer's perspective of the colour scheme and palette selection, colour placement plays a key role in colour perception, where permutations of light and colour can achieve the required design intent for a space.

A second aspect of colour perception is 'colour association', or meanings attached to colours. Colour associations display cross-cultural similarities (Faber 1978; Hupka et al. 1997) and contradictions in meanings in varied cultures (Jacobs et al. 1991). These colour associations are the resultant effect of multiple variables such as culture and social trends, adding another layer of individual differences in understanding colour. These associations also influence colour preferences, which in turn influence how individuals respond to colours emotionally.

Thus, designers must consider whether children perceive and experience colour differently from adults and between themselves based on the above factors of physiology (ability to see colour), light conditions and associations to develop colour palettes relevant to school environments. The difficulty in addressing this aim from a design perspective could be due to contradictory evidence from studies on colour perceptions and preferences, which have been attributed to potential differences in individual responses to colour. For instance, where one study observed colour preferential differences among male and female subjects (Read et al. 1999; Rosentein 1985), another contradicted this observation with findings that reflected no such differences (Ou et al. 2004). Similarly, studies on specific age groups of young children found that they preferred brighter colours against the subdued colours preferred by adolescents (Engelbrecht 2003), with Pile (1997) advising caution against using strong primary colours for young children. Subdued and warm neutral colours have been found to prevent overstimulation (Myler, Fantacone and Merritt 2003; Stokes 2001)—specifically for students with ASD and ADD or ADHD (Gaines and Curry 2011). Conversely, Peterson and Malven (2015) found that children with ASD preferred a cool colour scheme containing shades of blue and green over a warm or neutral colour scheme. Warm colours containing bright red palettes, pinks and purples did not elicit a favourable response when used in an interior space, contradicting previous studies and indicating that there are individual differences that must be considered in the design for those with ASD. While these studies may be contradictory in specifying exact nature colours—their shades and

hues—they highlight the fact that, when seen in totality, children's colour perceptions are not only different from adults, but also differ among themselves based on their age and gender.

Influences of colours on children with LDs

Colour stimulation in the environment has been shown to positively influence attention and motor processes, subsequently improving academic performance among those with ADHD (Imhof 2004; Kennedy 2005; Zentall and Dwyer 1989). Likewise, monotone colour schemes have been shown to elicit negative responses such as restlessness, loss of concentration and irritability (Engelbrecht 2003). In the context of children with LDs, colour preferences differ based on the type of co-occurring disorder. For example, those with LD co-occurring with ASD and ADHD are attracted to bright colours, while others find it overwhelming due to stimulation (Gaines and Curry 2011). Freed and Parsons (1997) suggested that such students may also be more sensitive to environmental colour due to their heightened sensory awareness and visual processing abilities. These studies suggest the need to understand that a balance is needed when approaching colour schemes for mainstream school environments, as bland environments can be as impeding to academic performance as overtly colourful school environments.

Table 5.2 summarises a review of the literature on colours and its influence on students ranging from young children to graduates, inclusive of children with and without LDs.

Table 5.2: Colour influences on perceptual, physiological and educational processes

	Typical children	**Children with LDs**
Perception and preferences	Preference for blue indicated in 7–11-year-old students (Terwogt and Hoeksma 2001). Pink preferred more among females than males (Boyatzis and Varghese 1994). Warm colours preferred by passive children (Torrice and Logrippo 1989) and preschool	Deficient perception of blue–yellow contributed to impaired naming of colour stimuli in tests on children with ADHD (Banaschewski et al. 2006). Children with ASD less accurate in colour perception than typical students

	Typical children	Children with LDs
	elementary students (Engelbrecht 2003). Warm colours related to effective wayfinding behaviour in complex built environments and in assisting in recall of spatial locations (Hidayetoglu et al. 2012). Cool colours preferred by active children (Torrice and Logrippo 1989).	(Franklin et al. 2008).
Physiological	Calming effect of blue colour on heart rate and respiratory system (Engelbrecht 2003; Torrice and Logrippo 1989). Lowers blood pressure noted when light-blue colour and light conditions (Full-spectrum Fluorescent Lights [FSFL]—natural daylight style) were modified (Grangaard 1995).	
Psychological (e.g., behaviour, mood, anxiety)	Blue considered relaxing, sleep-inducing (Pile 1997; Gimbel 1997). Blue related to sadness in fourth-grade students (Karp and Karp 1988). Pink related to influencing positive mood in preschool children (Hamid and Newport 1989). Light colours associated with positive emotions and dark colour with negative emotions across genders and ages (Boyatzis and Varghese 1994; Guildford and Smith 1959; Hemphill 1996; Park 2014; Zentner 2001).	Colour may have negative influence on ASD children's behaviour (Shabha 2006). Positive mood change observed in pink-coloured room compared to blue (Hamid and Newport 1989).
Education (e.g., attention, on-task behaviour, learning abilities)	Improvement of preschool children's cooperative behaviour influenced by quality of spatial height and colour (Read, Sugawara and Brandt 1999). Asian study in school: colour	22% reduction in off-task behaviour of 6-year-old students when white, glossy walls and fluorescent lights swapped to light-blue wall colour and full-spectrum lights (Grangaard 1995).

	Typical children	Children with LDs
	tone influential in enhancing reading abilities and sense of well-being among elementary students of both genders. Colour preference differences observed among students from primary, elementary and higher-grade students, with youngest preferring light, bright and fluorescent colours, and oldest group preferring pale, greyish colours. All age groups showed dislike for darker tones of colours (Hsu 2011).	Improvements observed in attention and reading abilities using coloured lenses and overlays for students with ADD and ADHD (Imhof 2004; Zentall and Dwyer 1989).

Source: as cited within Table 5.2

As indicated in Table 5.2, the influence of colours is evident in all areas relevant to learning processes among children of both groups. As one study indicated, if colour considerations were created as a response to those with ADHD with LDs, it would not have any adverse effects on those without LDs (Imhof 2004). Thus, it may be possible to select colours to respond to the needs of inclusion in school environments without disturbing the sensibilities of those without LDs. Studies on the influence of colour other than when it is an environmental attribute indicate improvements in attentional capacities and motor processes using coloured paper (Imhof 2004), reading among those with reading disabilities using coloured overlays and coloured lenses (Ludlow, Wilkins and Heaton 2006; O'Connor et al. 1990). These individual applications of colour to assist learning processes further reiterate the potential of colour in supporting the needs of those with LDs in mainstream schools.

Discussion

The outcome of the review on colour and its influences on children demonstrates that that due to its significant ability to influence our perceptions and interpretations of physical environments, colour is a powerful design element that can contribute to better attentional capacities, physical and psychological health, and accessibility to the affordances of a school environment. It is therefore imperative for designers to carefully evaluate colour scheme selection criteria while designing school spaces for children with LDs.

The review highlights that colour as a design element can be influential in defining learners' experiences within their school environments, such as enabling better wayfinding and interpretation of environmental affordances. The extent of these influences is common for both groups of learners, as evident in better focus, behaviour, health and sense of well-being (see Table 5.2). These influences contribute to learners being able to maximise their learning potential. Literature indicates that the identification of colours that are beneficial for those without LDs, but harmful for those with LDs, are yet to be made and are probably dependent on emerging data on LDs and co-occurring disorders.

The review also demonstrates that colour perception and response is a complex process differing from one individual to another due to factors such as age, culture and gender. Thus, there is a need from the school design perspective for an investigation of colour perception and the response of children with LDs within the context they are studying. Such an investigation would also need to focus on the specific type of LDs due to significant overlaps between certain types of LDs and other disorders of ADD, ADHD and ASD. For instance, children with LDs co-occurring with ADHD and ASD perceive colours differently to typical children (Freed and Parsons 1997).

As stated in Chapter 1, research into LDs is still emerging. The development of unambiguous colour schemes for school spaces, which are beneficial to students with severe LDs or covering a broad spectrum of LDs, is dependent on new data emerging from disciplines researching LDs. Nevertheless, the effect of colour on young children appears to be certain, and as such, colour scheme selection for school spaces should be an evolving and holistic process that considers the complexities in conjunction with students' needs for learning and well-being.

The following strategies emerge from the analysis of the literature, which may help designers develop a framework to respond to themes of inclusion and accommodate the needs of children with LDs in mainstream schools:

- Attention to colour placement in school environments, with a focus on using it in combination with light to improve experiential value and coherency of space. As discussed in Chapter 3, experientially rich school environments

improve motivation to learn, and therefore elicit responses that are relevant for learning to occur. These qualities would benefit both groups of children.

- Designers should avoid colour schemes with primary colours, as well as excesses in any form (such as too bright colours or monotones) to avoid corresponding overstimulation or inattention and irritability. Subdued colour palettes or cooler shades have been indicated by studies to prevent these issues, but they require further examination prior to application in real-world settings.
- Colour placements in school environments can be used to assist students with and without LDs in negotiating school spaces (wayfinding), thus ensuring accessibility to schools' affordances.
- Colour scheme selection for schools' spaces should be developed based on users' needs in terms of age and background. Designers also need to consider the intended use of a space and how colour schemes can align the needs of those with LDs within these spaces.

Excessively colourful environments are as harmful as bland colour schemes for both groups of children, but more so for those with LDs. The above strategies can help designers build a framework for colour schemes that are balanced and offer support to children with LDs. For other LDs co-occurring with disorders at the higher end of the spectrum, it would be necessary for school design practitioners to stay abreast of new and ongoing research into these LDs to develop relevant colour schemes as the data arise.

Studies on specific influences of colour on children with LDs in school environments appear to be either contradictory or limited. These studies are either focused on physiological or psychological aspects, but do not holistically link both. However, when reviewed as a whole, the literature presents empirical evidence that stresses the need to abandon presumptions about designing overtly colourful school environments specifically when seeking to accommodate the needs of those with LDs co-occurring with other disorders in mainstream school environments. Studies also indicate that colour palettes that are sensitive to the needs of children with LDs do not disturb the sensibilities of those without LDs. The review therefore shows that

it may be possible to select colours to respond to needs of inclusion in school environments and the diversity of needs among those with and without LDs.

Colour perception is influenced by multiple aspects of illumination, association, age and gender, which comprise a complex set of variables to apply to a single space catering to the needs of multiple individuals, such as a classroom with children with and without LDs. This suggests the need for further research into colour perception and preferences based on the specificity of learning spaces for a selected age group of users with LDs. Colour schemes for school environments seeking to be inclusive require careful consideration of evidence from interdisciplinary research, POEs and design practitioners in the context of school design to add value to learning spaces beyond superficial aesthetics.

5.3.2 Light

Light is an important modulator of brain function and cognition (Vandewalle, Pierre and Derk-Jan 2009). Theoretical constructs of environmental cues and meanings (Rapoport 1990), coherence (Kaplan and Kaplan 1982) and environmental affordances (Gibson 1986) highlight the role of light as an environmental variable that can influence our understanding of our physical environments and how we negotiate within these spaces. Similar to how colour defines environmental affordances, light enables us to understand the environment's affordances available to determine how person–environment transactions occur. The effects of light have been extensively studied for groups of individuals such as offices (Veitch et al. 2008) and schools (Allen and Hessick 2011; Grangaard 1995; Sleegers et al. 2013), with varied findings on ideal lighting systems and their efficacy in producing positive effects on the occupants of a space.

Architecturally, both natural and artificial light is used almost as a 'material' to better understand and define space and create an ambience to match the function of the space. Combined with colour, it becomes a dominant built environment variable in influencing students' perceptions of space and accessibility of opportunities in the learning environment (Hidayetoglu, Yildirim and Akalin 2012). Understanding the influences of light on students of both groups is therefore vital to create accessible and coherent mainstream school environments.

Table 5.3 presents a review of studies on lighting in schools and its influence on children's achievements, health, behaviour and sense of well-being, with studies on children with LDs highlighted. Light studies have explored the effects of FSFL simulating (or not) natural daylight conditions and variations with ultra-violet (UV) supplements.

Table 5.3: Illumination influences on typical and children with learning disabilities

Categories of influence	Light influence on children in general	Light influence on children with LDs
Achievement and/or task performance	Positive influence of certain light systems on students' concentration (Sleegers et al. 2013). School performance and achievement improved under full-spectrum fluorescent lamps with UV supplements (Hathaway 1995). Improvement in student performance with natural daylight (Plympton, Conway and Epstein 2000). Increase in ability to relax and be interested in classroom activities with reduction in brightness (Schreiber 1996). Daylight helps students to better retain information (Rittner and Robbin 2002). Effects of variable light on pupils when studied during classroom lessons indicated that concentrated light reduces number of errors and increases reading speed. No improvements observed in school motivation and classroom atmosphere (Barkmann, Wessolowski and Schulte-Markwort 2012).	Dyslexic students with light sensitivity find that standard fluorescent lighting impedes learning process (Loew and Watson 2012). ADHD students with visual perception disorders adversely influenced by fluorescent lighting (Kurtz 2006). Flickering fluorescent lights impede learning for ASD students due to sensory overload (Overton et al. 2005; Sainsbury 2009).
Physical/health	Dental health, growth and development influenced positively under full-spectrum fluorescent lamps with UV supplements (Hathaway 1995). Natural daylight positively influenced development, (Plympton, Conway and Epstein 2000).	Physiological effects of light on brain function may manifest as changes in behaviour (Vandewalle, Pierre and Derk-Jan 2009).

Categories of influence	Light influence on children in general	Light influence on children with LDs
	9% lowering of blood pressure in 6-year-old students in test using combination of blue walls and specific type of fluorescent lighting (Grangaard 1995).	
Behavioural	Sociability influenced adversely under the use of standard fluorescent lighting (Küller and Lindsten 1992). Quality of lighting linked to performance and motivation to learn among students (Samani and Samani 2012).	Repetitive behaviours increased among ASD children under standard fluorescent lights due to increase in level of arousal (Colman et al. 1976; Fenton and Penney 1985). Maladaptive behaviours decreased in frequency under indirect diffuse full-spectrum fluorescent lamps (Shapiro, Roth and Marcus 2001). Comparison between warm white, daylight and full-spectrum lamps for effects on attention behaviour indicated that hyperactive children were more attentive to tasks in warm white light conditions than under fluorescent lamps (Norris 1979). No effects of full-spectrum lighting (warm white fluorescent lamps, full-spectrum fluorescent lamps and cool white lamps) were noted on the distractibility of a group of children with LDs (Schulman 1989).

Source: as cited within Table 5.3

Table 5.3 summarises the numerous studies illustrating that both natural and artificial sources of light influence the physical and emotional states of occupants, as well as aspects that can influence their ability to learn. Daylight and artificial sources imitating daylight appear to have a consistently positive influence on students' performance levels, retention and behaviour. In another study, natural daylight and full-spectrum lights had the most positive effects on children's behaviour, memory and retention (Martin 2006). More importantly, some of the physiological positive effects were construed to be positive behaviour modifiers (Vandewalle, Pierre and Derk-Jan 2009). These findings suggest that daylight-creating features in school

buildings might be an important aspect of positively conditioning learning environments.

Medical science research also shows support for theories linking the positive effects of bright fluorescent lights with Seasonal Afflictive Disorder (SAD) when natural circadian rhythms[51] are disturbed (Pauley 2004; Yerevanian et al. 1986). Similar effects of low light due to weather conditions and related changes in temperature have been shown to influence behaviour and learning abilities in schools (Essa et al. 1990) with no SAD. This aspect of weather-related behavioural issues in a learning environment context has been discussed further in the section below on heating, cooling and air quality. Consequently, light also combines with thermal comfort elements in buildings to ensure that the perceptions and experiences of school buildings remains at positive levels of comfort and performance for occupants. This implies that light in any form in architecture elicits physiological and psychological responses from occupants and therefore has serious health implications for all users of school buildings. In the context of school design, these responses could dictate how space is experienced and its affordances interpreted by students. Where this fails to fulfil its function of adding coherence and definition to space and ambience, it could adversely affect spatial perceptions, cognition and behaviour among students.

However, some authors have argued that although evidence of one type of artificial system is weaker than others, development of new lines of lighting systems are important to enable multi-user spaces such as schools and institutions to be lit to allow 'a smooth visual, perceptual, and cognitive functioning' (McColl and Veitch 2001, 273). Nonetheless, the consensus among lighting researchers is that suitable lighting will positively influence performance, on-task behaviour and achievement levels among students (Schneider 2002). These aspects could subsequently enable students of both groups to maximise their learning potential.

Light influences on learning processes

It is undisputed that light influences human health and the mind; however, the mechanism of how it works and the nature and extent of the influence is not clearly

[51] Circadian rhythms are defined as the daily biological processes occurring even in the absence of light variations (OED 2006).

understood (McColl and Veitch 2001, 13). As evidenced in the research, positive influences on students using specific types of lighting can easily be negated when issues of person–environment mismatches remain unaddressed over prolonged periods, further impeding learning processes for those with LDs. Experiencing challenges in learning could manifest as adverse social behaviour for both groups of children, further impeding the social dimensions of learning processes. Light is therefore a key environmental attribute relevant in influencing aspects of behaviour, motivation, attention, physical health and socialisation behaviours, all of which could contribute to a better ability to learn for most children.

Educators consider light a key environmental variable of the 'visual environment' in a learning setting in addition to colour and personal displays in articulating learning affordances. The summative effect of the three elements of visual task, ambience and visual interest could be employed to influence and promote positive behaviour and learning for students (Allen and Hessick 2011). Studies also suggest that additional influences of light on students extend to physical aspects. Grangaard's (1995) study on the combination of blue walls and a specific type of fluorescent lights showed a reduction in off-task behaviour by 22% among 6-year-old school students, as well as a 9% decrease in blood pressure. This study, conducted in three phases, began the first phase with a combination of other colours and textures, such as visual noise and red and orange bulletin boards in a room with a white gloss wall colour and cool white fluorescent light fixtures. This was followed by a test phase using the same settings, but with walls with light-blue paint and full-spectrum Duro-test Vita light (simulating natural day light). The data comparison showed that light as an environmental variable of educational settings had a physical influence on students' health in the room with blue walls and natural light-simulating fixtures.

In contrast, Norris (1979) compared the effects of warm white, daylight and full-spectrum lamps on the attending behaviours of first-grade students and found that children were more attentive to tasks in warm white conditions than under full-spectrum lights. Similar findings were made in studies on the school performance of young children, with lighting conditions improving their concentration levels (Sleegers et al. 2013) and positively influencing physical development (Hathaway 1995). The quality of lighting in learning environments when supportive of learners'

needs has also been found to be linked to performance and motivation to learn among students (Samani and Samani 2012). These studies demonstrate that while arguments exist on the type of lighting that influences students, designers should consider that lighting has behavioural implications on all students, and these implications may be magnified for those with LDs co-occurring with other disorders.

Light influences on children with LDs

In previous light studies on individuals predisposed to an increase in levels of arousal (e.g., those with hyperactivity and ASD), commonly used florescent lighting has been shown to increase their levels of arousal displayed via an increase in repetitive behaviour (Colman et al. 1976; Fenton and Penney 1985), whereas it adversely influences sociability among typical students (Küller and Lindsten 1992). Schulman (1989) found no effects of full-spectrum lighting (warm white fluorescent lamps, full-spectrum fluorescent lamps and cool white lamps) on the distractibility of a group of children with LDs. However, improvements were noted after prolonged exposure to light, which researchers attributed to the expectancy effect on the part of some teachers. The two main studies on children with hyperactivity in classroom environments were conducted on a small sample size of students (Flynn and Rapoport 1976; Ott 1976) and used measures such as Conners' (1997) scale to examine behavioural changes while on medication. These studies stressed that more knowledge is needed to develop lighting solutions where light as an environmental variable can be part of the holistic academic support for children with LDs co-occurring with other disorders of hyperactivity, inattention and impulsivity. Further, while acknowledging limitations such as students in the sample group being on medication, the sample size and limited academic measures (Flynn and Rapoport 1976, 289), the researchers illustrated the importance of paying attention to lighting systems because of their undisputable effects on students of both groups. Although this was a small sample group of students, the findings were noteworthy for developing alternatives to designing supportive learning spaces for children with LDs, as there is currently a better multidisciplinary understanding and emerging evidence on LDs than in the period when these studies were conducted.

Recent identification of light sensitivity and visual perception disorders among students with LDs related to dyslexia and ADHD indicate that these students may

find standard fluorescent lighting uncomfortable and an impediment to their learning processes (Kurtz 2006; Loew and Watson 2012). Further, students with ASD were more sensitive to environmental stimuli (Hahn 2012). Aspects such as flickering fluorescent lights can appear magnified to them, causing sensory overload (Overton et al. 2005; Sainsbury 2009). However, solutions regarding exact specifications for appropriate lighting to meet the needs of this group are still developing. However, it is known that children with LDs co-occurring with other disorders have significant difficulties in learning when there are issues with the quality of lighting, such as flickering, glare and excessive brightness, which appear magnified to perceptual and sensory abilities. Literature indicates that teachers highly favour the ability to control lighting conditions to suit tasks through variable lighting alternatives (e.g., dimmable lighting and task lighting) instead of fixed lighting, as it would enable them to support the diverse needs of this group in a mainstream classroom (McAllister 2010; Walden 2009). Affording variable lighting in consultation with lighting designers and special needs consultants is thus vital to ensuring that lighting design is sensitive to the needs of children with LDs, while also being flexible to function effectively for those without LDs in mainstream schools.

Light in architecture

Light in architecture has been used for different lighting arrangements; by varying lighting intensities, the impression of clarity, spaciousness and order of a space can be created or enhanced. The provision for lighting in architectural practice is made based on building standards and specifications, which outline the minimum and ideal conditions relevant to the function of the space. However, these standards may not be the most appropriate level for a typical school day, as activities vary throughout the day (Lippman 2010a, 182). As occupants need change, providing flexible lighting solutions (dimmers, lights with sensors, blinds, curtains, louvres) could be one way to offer flexibility so lighting conditions can be altered to suit learning and teaching objectives while using standards as a guide to begin the design process.

Two main types of light sources are incorporated in built environmental designs: artificial light sources (e.g., compact fluorescent or FSFL, incandescent lighting systems) and natural light or daylight sources (e.g., from windows and skylights). Both types of light sources play a unique role in ensuring coherency and accessibility

of any space; hence, specialists of lighting design focus on developing illumination design strategies for spaces with the aim of responding to the function of a space. As Webb (2006, 721) explained, generally in lighting design, 'the key aim is to allow better vision, relevant to a space or enhance a function'. Consequently, in response to architectural aims of bringing into a space the relevant function-based ambience, definition and links between spaces, lighting designers develop configurations based on the following parameters (Ginthner 2002):

- visual task—enable completion of task by providing relevant brightness
- general or ambient conditions—set mood or encourage specific circulation by creating relevant ambient illumination systems
- visual interest—draw viewer towards points of interest by directing gaze using lights.

The above parameters can be articulated in school design using both artificial and natural light sources. There is also the option of using variable lighting or a combination of a variety of lighting fixtures to suit tasks. In a pilot study on the influence of variable light (VL: light that is adjustable in brightness levels and colour temperature), it was found that students and teachers rated these adjustable systems positively (Barkman, Wessolowski and Schulte-Markwort 2012). It was also noted that students made fewer errors and showed improvements in standardised tests relating to attention. Being a pilot study, the researchers considered this improvement was statistically insignificant, but they deduced overall that flexible lighting options can be a positive conditioning factor of learning environments. Variable lighting has also been shown to positively influence pro-social behaviour (lower aggression) and reduce restlessness in classrooms (Wessolowski et al. 2014). These studies demonstrate the merits of using variable lighting to optimise teaching and learning conditions.

Figure 5.4: Artificial lighting design to enhance spatial definition and energy efficiency is unable to be reproduced here due to copyright restrictions. Figure 5.4 can instead be accessed via (Thorn. 2007. 'Thorn Meets the Lighting Challenges of a Changing World'. Architecture Australia, The School Issue 32).

Figure 5.4: Artificial lighting design to enhance spatial definition and energy efficiency (Thorn 2007, 32)

Light in architecture is also considered a material, and its qualities of drawing focus and adding definition to architectural elements, as well as enhancing colours and influencing the ambience of spaces, is valued immensely by architects and designers. As one statistically significant study by Durak et al. (2007) demonstrated, a variety of lighting arrangements and lighting levels can be used to positively influence users' perceptions of the room in terms of its spaciousness, clarity and comfort. Figure 5.4 is an example of a lighting system designed to meet the objectives of correcting vision and definition issues, with the image on the left using an efficient and industry-conforming lighting system in an office space (Australian Standards, AS1680). The shadows, dark spots and low lighting issues have been addressed via design to create a better, non-gloomy and clear office space. Similar processes can be undertaken in school buildings. However, in the context of school buildings, the provision of light fittings requires consideration of the multiple functions of a school environment. For example, Walden (2009) explained that lighting in schools needs to

be flexible enough to be responsive to the variety of learning tasks, such as working with tools, sitting in groups or working at computer stations. Addressing the challenges of the diversity of learning tasks would therefore require industry and research partnerships and must be addressed in design conceptualisation stages.

Figure 5.5: Light as a material ('The Austrian Pavilion at the Frankfurt Book Fair' by Architect Adolf Krischanitz is unable to be reproduced here due to copyright restrictions. Figure 5.5 can instead be accessed via (Cheviakoff, Sofia. 2003. *Minimalismo/Minimalis,* page 424. Berlin: Feierabend).

Figure 5.5: Light as a material ('The Austrian Pavilion at the Frankfurt Book Fair' by Architect Adolf Krischanitz; Cheviakoff 2003, 424)

Figure 5.5 illustrates how natural daylight has been brought into the built space to create patterns of visual interest, acting not only as an aesthetic feature for the building envelope, but almost like material to afford context and environmental cues for users to highlight the building's function as a pavilion for a book fair. Using light as a material to afford environmental cues could be a viable strategy in school design to enable children with LDs co-occurring with perceptual or visual disorders to negotiate space and access its affordances.

Literature from architectural and lighting design practice discusses the visual effects of light—for example, using it to create patterns and effects (Lam 1977; Millet and Barrett 1996), address building specifications and standards, cost efficiency, materials, installation, energy efficiency and perceptions (Baker and Steemers 2014; Phillips 2000, 2004; Steffy 2002). These are important aspects because they address known global issues of economising construction time and costs, which also extend to school design.

From a design perspective, windowless classrooms devoid of natural light and those with excessive light are known to adversely influence well-being (Collins 1975). Windowless classrooms have also been noted to influence students' stress levels, growth, sociability and classroom performance; thus, they should be avoided for long-term use (Küller and Lindsten 1992). Similarly, while excessive illumination can cause issues of glare, dim incandescent lights have been shown to be a potential cause of loss of awareness and normative inhibition (Prentice-Dunn and Rogers 1980 quoted in Graetz and Goliber 2002). Deficiencies or excesses in available light are common issues arising out of lighting design that impedes learning (Allen and Hessick 2011, 13), such as blinds failing to reduce glare, inadequacy of illumination over students' desks influencing task performance, glare from other ambient aspects such as projector screens over whiteboards affecting visibility, and glare from filtered light through window patterns. Winterbottom and Wilkins (2009) studied a sample of 90 schools in the UK to examine the relation between issues posed by lighting (flicker, glare) and impediments to learning. It found that reading ability can be enhanced by reducing glare in illumination. It also found a mismatch between school lighting and recommended guidelines for design, which caused discomfort and impaired visual performance and thus demonstrated that environmental attributes can be a constraint or enrichment to learning processes. Educators in a small study (Northern Ireland) indicated a preference for adjustable lighting to accommodate the needs of ASD children in a mainstream classroom (McAllister 2010), while also being able to control change as relevant for special needs children, including those with LDs.

Therefore, getting the balance right is crucial to better behaviour and learning outcomes. But this raises questions regarding how designers can achieve this balance when occupants' behaviour poses challenges due to the inherent diversities of background (socioeconomic and cultural), gender, age and learning abilities. Some authors suggest that one potential strategy to address this issue could be to provide classrooms with both windows and artificial light sources with adjustable brightness (Barnitt 2003; Walden 2009). As educators might need to frequently change learning settings (such as seating arrangements and displays) to suit tasks, activities and learning objectives, such alternatives would give them flexibility and better control over their learning environments. Positive affordances of the environment in

combination with existing design elements of ambience and definition could elicit visible and positive behavioural changes among occupants, subsequently contributing to better abilities to learn for both groups of children.

Discussion

The outcome of the review on various aspects of the schools' interior environment demonstrates that light—both in its natural and artificial forms in architecture—can have implications in three key areas: performance, health and well-being of students. Yet this review of studies on children with LDs found limited evidence and continuity from past research to reflect the extent of influence on those with LDs co-occurring with ADD, ADHD and ASD. Of the various types of artificial and natural lighting sources, both have been indicated to have physiological benefits such as neurological influences on behaviour (SAD syndrome) and development. However, when it comes to transformative influences of artificial lighting (such as FSFL) on behaviour and performance of children—specifically those with LDs—data appear to be limited and emerging. As McColl and Veitch (2001, 70) explained, many of these studies are not replicable in real-life settings, further arguing in their review on the effects of fluorescent light systems:

> Contrary to some early reports, full-spectrum fluorescent light is not a panacea for childhood hyperactivity, nor does it control undesirable classroom behaviours. Of the well-designed studies, only one has found a statistically significant effect, and that only on one measure of attention. Windows, rather than the type of artificial light, may be more influential for classroom behaviour in children.

Despite these divergences in views, the review demonstrates the unanimous view among researchers that both artificial and natural light conditions in a school can play an important role in influencing students physiologically and psychologically, although the extent of these effects is unclear. There is also greater evidence on the influence of natural lighting on human health and performance, and this could be adopted in current approaches to design lighting solutions to support the needs of those with LDs. It may be seen that 'where these effects are positive, they manifest as an improvement in social behaviour' (Walden 2009, 83) and engagement with their learning environments, thereby contributing to better learning processes and abilities among both groups of children.

In relation to children with LDs, the literature, while limited, points to the aspect that these children are affected by the same light conditions as those without LDs. However, the challenges posed by lighting are magnified due to various visual, perceptual and sensory disorders that form part of their LDs, thereby intensifying their learning problems. Lighting design strategies that give educators better control of lighting conditions through variable lighting are therefore essential to support those with LDs and make the learning environment responsive and inclusive.

In current practices, there appears to be a commonality between architectural and educational practices on the positive use of daylighting in school building designs—one for aesthetics and ambience and the latter for benefits to teaching and learning processes. Lighting design also meets this aspect, where a range of artificial systems are available that meet industry needs of cost and energy efficiency, as well as educational needs of flexibility. However, costs can preclude factors of aligning lighting design with the needs of students with LDs. Costs in designing, procuring and maintaining both types of lighting systems are undoubtedly important factors to consider in school design, but being such a vital factor influencing children's physical and psychological health, it would be irrational to ignore it completely in favour of costs. Additionally, by using innovative design and resource strategies, the cost difference is marginally over conventional school designs, and the benefits to students' performance outweigh this difference (Plympton, Conway and Epstein 2000, 8).

The following strategies emerge for school design strategies that could benefit both groups of children and be a starting point to mesh the needs of the two groups:

- Designers need to acknowledge that there is a gap in knowledge on the extent of influences of light (artificial and natural) on children with LDs, which makes it difficult to develop inclusive lighting design strategies. This gap can be bridged by industry partnerships (e.g., between architects, designers and lighting engineers) while establishing the design based on evidence from multidisciplinary research from education, behavioural science and special needs literature. These partnerships and the integrated approach would enable the development of appropriate and relevant lighting scheme responses to

meet the needs of students with LDs and mesh the needs of both groups of children studying in mainstream schools.

- Designers must consider that standards and specifications in lighting are only guidelines for achieving safety and average levels of comfort. An additional dimension of child-centredness and associated needs (e.g., learning, behavioural, developmental, perceptual and experiential) must be considered to respond to user diversity present in any typical school space. Additionally, offering flexible options to allow users better control of lighting in their environment addresses the challenge of responding to diverse needs of learners with LDs in mainstream schools.
- When school designs are conceptualised by architects and construction professionals, designed elements for natural lighting (e.g., windows, perforated decorative screens, glazing and skylights) need to be placed so they are in sync with the artificial elements of light (e.g., ceiling lights and dimmers), which may be designed by lighting engineers and designers. The two design processes need to complement each other to ensure that the common group of users experience its effects on space as a whole rather than disjointed elements adversely influencing the coherency and experiential value of a space (such as issues of glare on whiteboards).
- Designers need to understand the transactional nature of learning environments and possible incompatibility of learners with illumination design. For example, lighting design mismatch with technological changes (addition of computers, smartboards) causing issues of glare would pose difficulties for students to access content (Lippman 2010a,b). Such issues can only be addressed as and when they arise, indicating that even additions and alterations of buildings must rely on evidence from new research and POEs while making changes to school environments.

The review demonstrates that light in school design deserves more attention in the direction of children's behaviour, health and learning abilities in addition to existing practical objectives of aesthetics, ambience and functionality. It may be found that the objective of influencing these aspects falls within the design parameters of vision, aesthetics and ambience in school environments while responding to the needs of inclusion in mainstream schools.

5.3.3 Noise

Children at school are exposed to different types of noise from external and internal sources. Ambient or background noise plays a significant role in causing stress and distraction to learning processes. Children are also believed to be more vulnerable to environmental stressors, including those caused by unwanted background noise, because of their limited capacity to comprehend environmental issues and anticipate stressors, as well as their lack of a developed coping mechanism (Cohen et al. 2013; Evans et al. 1991). Earthman (2002, 5) highlighted the importance of blocking unwanted background noise for effective learning in classroom stating, 'The ability to clearly understand what is being spoken is a prerequisite for effective learning. When this ability is impaired through unwanted noise students do not perform well'.

Additionally, environmental stress theory[52] posits that children's favoured coping mechanism for environmental stressors is by an adaptation process of tuning out unwanted ambient noise to prevent overburdening cognitive systems. This is construed to result in generalising auditory stimuli adversely, and this impairs other cognitive functions in children (e.g., attention, auditory discrimination and/or speech perception) (Haines et al. 2003; Klatte, Bergström and Lachmann 2013), which are required for learning processes. Thus, there is a risk of poor learning outcomes if children filter out necessary auditory stimuli (such as communication from teachers on learning activities) as part of their coping mechanism for unwanted ambient noise. The resultant feelings of frustration and stress could be an additional causal factor in aggravating behavioural issues in both groups of children.

In relation to children with LDs, the influence of noise depends on co-occurring conditions and disorders such as sensory and spectrum disorders in children with ASD and inattention issues in children with ADD and ADHD. For example, in the first case, extra sensitivities to environmental stimuli intensify the perceived source of environmental stressors impeding the learning processes (Baranek 1998), whereas

[52] Environmental stress theory is a broad subject of enquiry, with definitions of stress (psychological, physiological) framing the context to understand and apply this theory. The focus in this thesis is on the notion put forth by Evans and Cohen (1987), where environmental stressors examine the situation where physical attributes of the environment impede the psychological or physiological states of individuals, at times adversely influencing their physical and mental health. Chapter 4, Section 4.7 discussed the influence of stressors on learning processes, which furthered the understanding from an environmental perspective.

in those with a co-occurrence with ADHD, high levels of noise or white noise have been noted to be beneficial (Cook, Bradley-Johnson and Johnson 2014; Helps et al. 2014). Thus, the influence of noise differs not only between those with LDs and typical children, but also within the group with LDs depending on co-occurring disorders.

Chronic exposure to noise is also known to cause health issues related to blood pressure and the cardiovascular system in adults, although data on long-term exposure to noise among young children is scarce (Evans and Lepore 1993). One study conducted over a period of two years on chronic noise exposure from aircraft traffic found that children in the age group of 9–11 years showed increased stress levels (measured in terms of physiological changes) in a range far below those necessary to cause hearing damage (Evans, Bullinger and Hygge 1998). This combination of physical and mental stress is likely to affect both teachers and students. Noise distractions in schools can therefore pose a significant impediment to both teaching and learning processes.

An analysis of the literature on noise in classrooms and its known links to LDs was deemed necessary to understand the extent to which background noise can act as an impediment to learning processes in schools for both groups of children, as well as the extent to which the literature could be translated to inclusive school design solutions. The following image defines the terminologies used in the discussion on noise and its relation to learning at schools.

Figure 5.6: Terminology definitions used in discussion on noise and its relation to learning in schools is unable to be reproduced here due to copyright restrictions. Figure 5.6 can instead be accessed via (http://www.decd.sa.gov.au/docs/documents/1/AcousticPerformance.pdf).

Figure 5.6: Terminology definitions used in discussion on noise and its relation to learning in schools,

http://www.decd.sa.gov.au/docs/documents/1/AcousticPerformance.pdf

Effects of noise on learning processes

There are considerable data demonstrating the harmful effects of loud noise on performance and productivity, but some of these studies present contradictory evidence. For instance, some older studies suggest that the adverse influence of short-term exposure to environmental noise does not pose significant impediments to performance levels (Ellenburg and Russell 1976; Park and Payne 1963; Slater 1968), and another study indicated that chronic exposure to even moderate noise can be harmful to task performance (Hartley and Adams 1974). Similarly, some researchers believe that moderate levels of noise can be beneficial for rate of work, vigilance and reaction time (Poulton 1977). However, high levels of noise have been shown to be harmful to task performance by causing a state of mind known by behavioural theorists as 'state of over-arousal', which leads individuals to screen out information essential to the task (Broadbent 1971, 1978; Kahneman 1973). While some of the evidence is contradictory, the general indication is that long-term exposure to high levels of noise is detrimental to performance and productivity. These effects would intensify the challenges experienced by those with LDs, with visual, perceptual and sensorial disorders further impeding their learning processes and motivation to learn, as discussed below.

More recent studies have linked noise as being detrimental to learning outcomes by acting as a source of annoyance, posing difficulties in accessing learning content and consequently adversely influencing performance and achievement (Berglund and Linvall 1995; Institute for Environment and Health 1997). Regular learning processes and activities are also impeded by ambient noise. A study on attention and memory found that chronic noise exposure was highly detrimental to memory—specifically, 'recognition memory'—for chronically noise-exposed children (Lercher et al. 2002). Reading deficits were also mediated by chronic exposure to aircraft noise, which impaired speech perception and language acquisition in primary school children (Evans and Maxwell 1997). After extensive reviews of the issue of noise in school settings, some authors concluded that chronic noise exposure of young children could have significant adverse effects on their reading ability (Evans and Lepore 1993; Hétu, Truchon-Gagnon and Bilodeau 1990). Studies conducted on

children aged 8–11 years who were attending schools in areas with high aircraft noise similarly found that chronic exposure to aircraft noise is associated with impaired reading comprehension and high levels of noise disturbance (Haines, Stansfeld, Brentnall et al. 2001). Similar external noise factors such as transportation sources were found to be most adversely influential on performance—specifically among older children from the 7–11-year age group (Shield and Dockrell 2008). An extensive review of studies on the effects of noise on children at school concluded:

> that the general effects of chronic noise exposure on children are deficits in sustained attention and vidual attention; poorer auditory discrimination and speech perception; poorer memory for tasks that require high processing demands of semantic material; poorer reading ability and school performance on national standardised tests. (Shield and Dockrell 2003, 98)

The review also pointed out that most studies focus on the source of just one noise, when sources of unwanted ambient noise in classrooms can be from both internal and external sources. The above studies stress the significant challenges to learning processes at all levels (communication, reading, attention, memory) and in all cases (children with varying learning abilities, sensory or perceptual deficits). Another study with a significant sample size of children examined:

> the link between typical ambient noise levels (highway, rail, and road) and multiple mental health indices of school children considering psychosocial and biological risk factors as potential moderators, concluded that exposure to ambient noise was associated with small decrements in children's mental health and poorer classroom behaviour. (Lercher et al. 2002, 380)

This study was one of the investigations that highlighted the correlation between mental health, behaviour and unwanted ambient noise. Behavioural manifestations of disorders of ADD, ADHD and ASD can contribute to low achievement levels in children. Environmental noise can therefore pose significant difficulties for children with these disorders and potentially aggravate their behavioural symptoms.

An equally important aspect is that adverse effects of high ambient noise in classrooms can be seen in social and emotional interactions among students and between students and teachers. Teachers would feel less stressed with the ability to

communicate learning objectives without raising their voice to be heard in a noisy environment. The South Australian policy for school acoustic standards recommends 'the minimum (level) necessary for children to hear efficiently in a classroom is +15 dB with +20 dB adding that the louder the background, the louder the teacher has to be so the students can hear clearly' (Department of Education and Child Services 2009), which makes ambient noise levels a key element to be maintained in classrooms. Klatte et al. (2010, 684) argued that:

> teachers who feel stressed will hardly be able to interact as patiently and friendly with the children as teachers who do not. Teachers' misattributions of the indoor noise to a lack of the children's effort to behave calmly may also contribute to an unfavourable social atmosphere.

They speculated that the same principle may apply for the relations between the children themselves, with the study showing that children from reverberant classrooms expressed greater annoyance by the noise produced by their peers. Their study on the effects of classroom acoustics on performance and well-being among elementary school children found that reverberation in classrooms had a significant influence on short-term memory (verbal tasks) and speech perception, and it impeded phonological task performance, with children reporting greater problems due to noise in the classroom and perceiving peer and teacher relationships negatively—more so than those in acoustically treated rooms. Social interactions and the ability to socialise freely are an important and routine part of school experience and learning, as discussed in Chapter 3. When environmental factors pose a hindrance to these routine behaviours and activities, it could contribute to a negative sense of well-being and motivation for both teachers and students. While not visible, such effects cumulate to affect learning processes and abilities.

The above studies emphasise that negotiating with multiple sources of undesired, chronic ambient noises can pose significant challenges for both groups of children, as well as adversely affect memory, attention, behaviour, speech perception, sense of well-being and learning abilities in general. The adverse effects also extend to teachers, who are key individuals in articulating the learning content (Rivlin and Weinstein 1984). The adverse range of effects is therefore significant to make noise one of the key built environment variables to impede learning.

Noise—an additional challenge for children with LDs

As stated earlier, researchers in education have also established that, of the many limitations faced by children with LDs, distractions in the physical environment greatly impede their learning (Evans and Maxwell 1997) by affecting language, communication and cognitive skills in children in general (Wachs, American Psychological Association 1982), and causing difficulties in hearing and focusing on classroom content (Martin 2006). Excessive background noise in classrooms can also cause dissatisfaction towards students' learning environments and be stressful (Schneider 2002). The studies strongly agree that background noise can be a cause of significant distraction and stress in a learning environment; hence, strategies to limit or eliminate these would be highly beneficial and essential for any learning process. Children with LDs are potentially at a greater disadvantage in the learning process because of their learning problems, and additional environmental distractions could add another layer of difficulties to existing issues faced by these children.

A detailed study by Zental and Shaw (1980) on the influence of classroom noise on the activity and performance levels of hyperactive children in comparison to typical children reported a difference between the responses of hyperactive children when compared with the control group. Although hyperactive children were more active than typical students, they were more active in high noise environments than in low noise environment, which was the opposite of what was observed in the control group. Their study followed up on the findings, indicating that only specific types of 'auditory stimulation (i.e. auditory linguistic information) may be difficult to ignore, whereas non-linguistic stimulation has little effect' (Zental and Shaw 1980, 831). Table 5.4 traces the path of knowledge development on the effects of noise on children with LDs.

Table 5.4: Special education literature review

Treatment group	Study conducted by	Findings
Brain-damaged children[53]	Schlanger (1958)	No difference in performance observed among brain-damaged children in auditory discrimination task in the presence of varying conditions of background noise (38 dB room noise, 60 dB non-linguistic noise and 62 dB music).
Hyper- or hypoactive, brain-damaged children or familial retarded children[54]	Spradlin, Cromwell and Foshee (1959)	No difference in performance observed among hyper- or hypoactive, brain-damaged children or familial retarded children in the presence of either speeded language or non-linguistic information (music).
Hyperactivity	Sykes, Douglas, Weiss and Minde (1971)	White noise of up to 80 dB did not influence performance in either hyperactive or typical children when added to sustained attention task [Continuous Performance test, Rosvold et al. (1956)].
LD (visual and auditory reading disorders)	Patton and Offenbach (1978)	Increase in errors on recognition memory task with partial inclusion of 60 dB children's story in comparison with typical children.
LDs	Lasky and Tobin (1973)	Linguistic distractors (recordings of white noise and competing messages) in range of 64–76 dB disturbed the performance

[53] As explained in Chapter 3, terms such as brain-damaged, MBD and retarded were used when the definition of LDs was still emerging prior to 1962 (Harwell and Jackson 2014; Swanson, Harris and Graham 2013).
[54] As above.

Treatment group	Study conducted by	Findings
		of children with (undiagnosed) LDs, but non-linguistic white noise (74 dB) had no effect on either group of children.
Hyperactive placebo, hyperactive medicated	Whalen et al. (1979)	All groups of children, including control group of typical children, indicated increase in frequency in multiple behavioural categories under high noise conditions (e.g., popular radio station playing) compared to quiet classroom conditions.

Source: Zental and Shaw (1980)

Based on the above review, Zental and Shaw (1980, 831) concluded that '…auditory stimulation may be problematic only when it is meaningful (e.g., containing linguistic information). Such auditory stimulation may be especially detrimental when experimental tasks involve an auditory memory component'.

However, they also found methodological limitations in the study by Whalen et al. (1979), such as design issues and deficiencies in specificity on the subject matter and level of auditory stimulation influencing clarity of findings, as well as no comparative evaluation of data of pre-treatment measures of each behaviour study against behaviour measures during treatment. Consequently, their study further evaluated specific questions of tasks and quality of classroom noise to include high linguistic information closely aligned with actual classroom situations and a methodological improvement of administering high and low noise conditions in counterbalanced order. In addition to finding differences in hyperactive and typical children's responses, they found that when the difficulty of the task increased, performance was severely impeded in the presence of high auditory (music) and high visual stimulation conditions, with the performance of children in lower age groups (7–9 years) being impeded the most.

Recent studies demonstrate that task-irrelevant noise such as background music has been shown to benefit children with inattention issues such as ADD and ADHD, with improvements seen in task performance (Abikoff et al. 1996; Gerjets et al. 2002). White noise (e.g., humming of machines and ceiling fans) has also been noted to positively influence the performance of those with inattention issues, while no effects have been found on typical children and adverse effects have been found on those with high attention levels (Helps et al. 2014) and a reduction in off-task behaviour in ADHD students (Cook, Bradley-Johnson and Johnson 2014). Studies also show similar differences in cognitive performance between those with inattention issues from the ADHD group and the control group with high attention capabilities. Those with ADHD needed more noise to maximise their cognitive performance, whereas the control group fared poorly in high noise situations (Söderlund, Sikström and Smart 2007; Söderlund et al. 2010). These studies indicate the diversity of effects of noise among children with LDs, suggesting that the application of these finding to school design may not be an easy process.

Bradlow, Kraus and Hayes (2003) targeted particular LDs to isolate the precise factors that may adversely affect them and compared speech-in-noise perception abilities of children with LDs. The aim was to identify whether speech without embedded noise elicited a better perception in children with LDs. It reported that, while noise influenced sentence perceptions of both groups of students, it had a greater adverse effect on sentence perceptions of a group of students with LDs, who had greater difficulty perceiving sentences in the noise than the control group. Additionally, both groups showed positive change with naturally produced speech (without noise), where students with LDs showed an improvement in their performance to match the students in the control group.

Dockrell and Shield (2006) explored the influence of environmental noise and that created by classroom occupants on students' performance and found that from three test conditions (classroom noise, classroom and environmental noise, and control classroom), children in classrooms with both sources of noise performed significantly worse, with slower processing of tasks, than the other two conditions. Where verbal tasks were involved, classroom noise was the only impediment, but not environmental sources of noise. Most significantly, children with special educational

needs were influenced by classroom sources of noise. Children's attainments from both groups were seen to be influenced in varying aspects of learning tasks from either source of unwanted noise, but specifically for those with LDs. These studies clearly indicate that both groups of students would be influenced by noise in their ambient environment, which would impede their academic performance. However, differences exist in some cases, such as those with ADHD, who perform better than those without inattention issues in the presence of high levels of background noise. These differences suggest that despite large number of findings suggesting background noise is an impediment to learning processes, the findings cannot be directly translated to design strategies (Woolner and Hall 2010).

Sources of unwanted ambient noise

Noise issues in learning environments can be considered those that occur within the school building and classrooms, and those that originate outside the school building. Studies have assessed sources such as noise from aircrafts (Cohen et al. 1980; Shield et al. 2002; Stansfeld et al. 2009), trains (Bronzaft and McCarthy 1975; Hambrick-Dixon 1986) and vehicular and pedestrian traffic (Evans et al. 2001; Meis et al. 2000), as external sources of undesired ambient noise. Care should be taken in selecting sites for school buildings, and where this is not possible, design strategies should be identified in collaboration with acoustic professionals.

Internal sources of sound can originate from classroom conversations, use of unsuitable materials (e.g., hard floor tiles) and equipment noise (e.g., heating and cooling machinery). Built environment factors (e.g., design faults) can be a source of noise distraction—for example, transferring the sound of rainfall intruding into classroom interiors due to glazed roof lights and metal roofs (MacKenzie 2002) or the lightweight quality of the roof material (O'Neill 2002). From an extensive series of field studies of acoustical issues in school settings, the following sources of sounds (see Figure 5.7) were identified by MacKenzie and Airey (1999), who argued that while some of these sources are unavoidable, most of the issues caused can be eliminated through careful design or strategising on the selection of materials and finishes in school buildings (MacKenzie 2002, 87). While not exhaustive, Figure 5.7 provides an important framework for developing evidence-based questionnaires that can not only form pre-design analytical background, but also POEs of buildings after

they are built, which would align them closely with the diverse needs of users. This approach would also contribute to an interdisciplinary knowledge bank for the practice and research of future school designs.

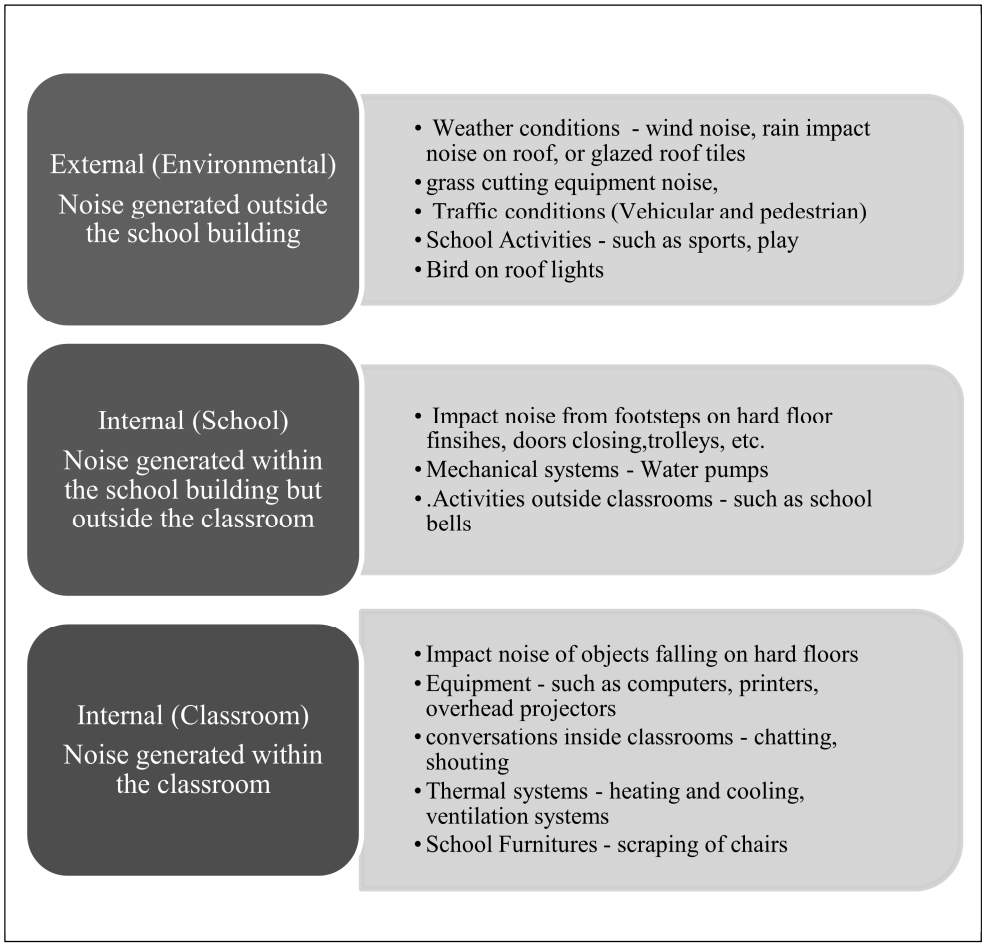

Figure 5.7: Sources of sound in school environments (Diagram by author to illustrate MacKenzie and Airey 1999)

Design standards for noise levels in school architecture

Verifying which design standards are specific to school designers' country of practice with regards to evidence on practical classroom conditions is a must to avoid situations where noise levels in classrooms may potentially exceed recommended levels for health and well-being. For instance, standards in Australia (AS 2107-1967) state that maximum levels should be maintained between 40 and 45 dB, which may not match practical conditions where the combination of sounds from multiple sources such as weather, site location, occupants' conversations, and heating and

cooling equipment raises sound levels beyond that range. This is close to US standards (ANSI S12.60-2002), which specify levels between 35 and 40 dB based on areas of learning spaces, and World Health Organization (WHO) guidelines, which specify maximum levels between 35 and 55 dB in small areas such as classrooms to larger areas such as outdoor playgrounds. Higher levels are unhealthy, and yet practical situations differ in classrooms and schools. In one study, a teacher's voice at low levels showed readings of 50–60 dB and at high levels of 78 dB (Maxwell and Evans 1999). Further, in Hong Kong primary schools, the mean 'occupied' noise level was 60.74 dB, 'with most classrooms exhibiting insufficient acoustic treatment to provide substantial noise reductions' (Yee Choi and McPherson 2005, 345). The implications for designers are to avoid complacency with the issue of acoustics by simply applying recommended building standards for schools and developing designs based on evidence from actual conditions on site, as well as interdisciplinary research on known classroom issues with regards to noise and LDs.

From the clinical perspective of language, speech and hearing, Siebein et al. (2000) compiled the following list of strategies that can be employed to achieve acoustically healthy environment in schools based on their observations and evaluations of poor compared to healthy acoustic learning environments from 56 classrooms in Florida, US:

1. Careful selection and design of any air conditioning unit for the school to avoid background noise caused by noisy systems.
2. Limit room volume or ceiling height (about 9–12 feet) to increase bad reverberation in rooms. If higher ceilings than this are needed, then consider sound absorbent material.
3. Provide sound absorbent materials in approximately equal proportion to floor area of room with materials such as acoustic ceiling tiles considered based on room function.
4. Install carpeting on floor to absorb sounds from routine classroom activities such as scraping of chair.
5. Highlight classroom furniture arrangements and teaching techniques that reduce the distance between the teacher and students enabling better speech perception and communication.

6. Use sound amplification systems as back up for situations when sufficient sound level cannot be achieved using conventional sound absorbing materials.
7. Site selection for school and its design should consider locations away from major sound sources such as airports and industries.
8. Design specific rooms with relevant acoustic elements such as gymnasiums and music rooms with function specific acoustic materials.
9. Collaborate with all experts, stakeholders in the design and planning of school such as audiologists, acoustic designers, teachers, consultants such as heating, ventilation and air conditioning specialists and assessors of communication skills for children to arrive at holistic strategies for acoustic solutions.
10. Support further technical research to get better insights into issues pertaining to speech perception and learning among children.

This is the second example of a schedule from an interdisciplinary perspective that could assist in the production of necessary pre-design questionnaires contributing to an integrated approach to school design. Such an approach would inadvertently need to draw upon other disciplines to ensure that the design solutions are holistic and based on what is known from the research at the time of the design on the issue of noise distractions and the best acoustic strategies to eliminate them.

Discussion

The analysis of the literature on the influences of unwanted ambient noise indicates that it can be a significant impediment to learning for both groups of children. However, there are exceptions to this within the group of children with LDs, which makes it difficult to apply the findings to mainstream school design. As Woolner and Hall (2010) argued:

> the reasons for this indeterminacy include differing understandings of the routes through which noise produces learning deficits, as well as relationships between noise and other elements of the environment … we suggest that solutions to noise problems will not be produced by viewing noise in isolation, or even as part of the physical environment, but through participatory approaches to understanding and adapting the structure, organisation and use of learning spaces in schools.

Further research is also required from education and special needs-related disciplines to obtain evidence clarifying the reasons for differing responses from the two groups to different, unwanted auditory stimuli. Nonetheless, until a new body of research answers specific questions on the issue of noise distractions and LDs, school designers can begin to develop designs that draw from what is currently known.

Designers have the technical knowledge to design buildings that respond to ambient conditions such as the location of the site (to address noise from transport and pedestrians) and weather conditions (noise from rainfall or hail falling on roof) using new materials and technology. Knowledge needs to be applied in practice to contribute to minimising potential noise distractions to learning. Then, to make the buildings truly responsive and customised to children's needs, collaboration with stakeholders (special needs consultants, teachers and students) is needed to base the design solutions on evidence from research. While appropriate materials and technology exist, a clear knowledge of the differences that exist in hearing perceptions is still largely unknown. This suggests that the key to designing acoustically sound buildings that support the learning processes and well-being of learners lies in staying abreast with research on the effects of noise and understanding how these effects can respond to children' spatial needs.

Implications for Architects and School Designers

Walden (2009) explained that even though the importance of good acoustics is being recognised as having a strong influence on learning, the effects of noise are not taken as seriously as the value of aesthetics of buildings or ensuring lower production costs. He further stressed that since speaking and hearing are still the basic activities involved in teaching and learning, it is essential to ensure that schools have good acoustics for successful academic outcomes. School architects and designers need to abandon disciplinary attitudes of being either pragmatic (focus only on aspects of costs) or egotistic (focus only on aesthetics and making a design statement) (Ackerman 1969 in Mitchell and Lang 1974), disregarding evidence from research or users' needs. Good acoustic design will not only improve student–teacher communication processes while learning, but also limit distractions and reduce anxiety for children with LDs co-occurring with sensorial and perceptual disorders, as well as children in general. For the group with inattention issues co-occurring with

LDs, design solutions could be developed in close collaboration with special needs researchers, consultants and educators due to their unique response to white noise in school environments, which can be detrimental to highly attentive students, but beneficial to them.

The review suggests that architects and school designers need to ask relevant questions as part of a holistic approach to achieve child-centredness and inclusiveness in mainstream school designs. Knowledge exists on what can be done to better soundproof buildings. Nonetheless, the significance of using this knowledge for soundproofing school buildings and meeting the criteria for inclusion in school design is yet to be acknowledged in school design approaches.

The following list of factors based on the analysis of literature is recommended as a response to known sources of noise distractions in and around schools, which could assist learning for both groups of children:

- Site and its proximity to known sources of noise such as train stations, industries and airports should be avoided. Second, designers should note and evaluate the typical weather patterns that could act as a source of noise annoyance, such as windy conditions causing undesired sounds through structural openings or rainfall on thin roof material. After examining these aspects, plan and design buildings with landscape (green areas, play areas, gardens and walkways) in a way that incorporates strategies for noise barriers based on site conditions (topography, weather) using features on site.
- Materials and identification from school building standards, which need to be aligned with the needs of students with inattention issues. For instance, carpeted flooring is listed as essential to absorb sounds from scraping chairs or foot tapping (as seen in some students with impulsivity or hyperactivity). However, carpeting materials could differ in their sound absorption qualities; hence, they must be tested to ensure they are in fact absorbing sounds as needed by actual classroom conditions and for those with LDs. More importantly, if problems arise where it is seen that the highest possible sound absorption materials have been used, and yet the issue of noise distraction for children with LDs persists, then design strategies such as quiet corners could be explored further.

- Exterior openings and locating them in a way to allow air exchange and provide the best view, but block out unwanted noise sources.
- Structural elements and identifying the best possible structural elements to soundproof sections of the building that have been identified as having the most issues of noise distraction. For instance, providing double glazing on windows with correct gaps between glazing panels and seals to limit airborne sounds could reduce sounds significantly on windows and skylights near confirmed sources of noise.
- Users: This is the most complex aspect while designing buildings to meet diversity. The two types of primary users are the teachers and students in the learning process. It is important to clearly understand the pedagogical needs of both from schools' spaces (exteriors and interiors) and associated activities. For example, considering placement of high noise spaces after landscaped buffer zones in addition to soundproof materials applied to both learning areas and play areas of school will allow better exchange of information between teachers and students in classrooms, as well as students engaging in recess activity. Second, since the literature suggests that noise perceptions could differ among various age groups, designers also need to pay attention to designing spaces with materials acclimatised to differing age groups. As a source of classroom noise can also be within the classrooms itself, depending on the activities carried on by students and teachers (Shield and Dockrell 2004), understanding activities involved in the learning process is necessary so relevant soundproofing materials such as acoustic ceiling tiles may be considered. Another strategy to respond to diverse user needs is to involve users in the design and planning process to inform and educate them on noise issues that are part of their school environment (Lippman 2010a, 183), and the design elements that are being provided to curb these issues, such as windows that need to be closed to avoid noise from traffic in the vicinity. An issue could also arise where economic constraints may not allow a building that is totally acoustically treated, and this would necessitate a dialogue—both pre- and post-occupancy of the school—to ensure that the best strategies can be used to respond to issues as they come up post-occupancy. For instance, where carpeted flooring as per standards (AS 2107-

1967) is difficult to obtain, rugs and carpet remnant alternatives could be considered to receive the benefits of sound absorption where budgets require economisation.

Figure 5.8 shows a floor plan from a case study of the conversion of a design and technology space to music accommodation (Department for Education and Skills 2003). It illustrates the acoustical treatment of a space to modify it to function as a music room—that is, ensuring that noise travels correctly and is not transmitted to adjacent areas via the use of various structural elements such as acoustic double glazing, angled panels and the provision of a lobby acting as a spatial sound buffer. A similar acoustical treatment can be applied to the design of school buildings after identifying the areas of school buildings that need soundproofing against sources of unwanted noise. Asking relevant questions as part of the pre-design case study exercise could help to obtain the answers needed to design buildings that respond to site conditions and users' needs from a school space.

Figure 5.8: Acoustical treatment to music is unable to be reproduced here due to copyright restrictions. Figure 5.8 can instead be accessed via (http://webarchive.nationalarchives.gov.uk/20130402164558/https://www.education.gov.uk/publications/eOrderingDownload/BB93-Acoustic_Design.pdf)

Figure 5.8: Acoustical treatment to music room (Department for Education and Skills 2003)

5.3.4 Thermal factors: heating, cooling and ventilation

Thermal comfort refers to the 'condition of mind which expresses satisfaction with the thermal environment. Dissatisfaction may be caused by the body being too warm or cold as a whole, or by unwanted heating or cooling of a particular part of the body (local discomfort)' (Hensen 1990, 309). Numerous studies have been conducted on the influence of poor thermal conditions on children's health, well-being and performance in school environments. The current review examines the effect of these influences on learning processes of children with and without LDs and areas that require focus by school designers to afford optimum conditions to support learning in mainstream school environments.

Uncomfortable thermal conditions have been noted to have a negative influence on children's well-being and performance (Mendell and Heath 2005; Wargocki and Wyon 2007). Systems (air conditioning and exhausts) and architectural elements (windows and ventilators) need to be designed so that heating, cooling and adequate ventilation are facilitated within the school environment to enable comfortable conditions for learning to occur. Authors argue that schools need better ventilation because children appear to breathe greater volumes of air in proportion to their body weight in comparison to adults (Kennedy 2001; McGovern 1998), they have greater user density per space unit compared to other buildings (e.g., offices used by adults) and there are multiple sources of pollution, such as 'chemicals, cleaning supplies, chalk or dust' (Martin 2006, 98) and art and science supplies (Ata, Deniz and Akman 2012, 2036).

A US study reviewing 31 criteria for public school facilities in Maryland, with the aim of determining the key school building factors known to influence student achievement, reported that temperature, heating and air quality were rated as the most important elements capable of influencing student achievement (Earthman 2004). While the report acknowledged that such evaluations exploring relationships between school facilities with student performance requires further consideration and studies (Earthman 2004, 15), it reiterated the importance of prioritising heating, cooling and ventilation systems for the health and safety of users of school facilities. An early study showed that out of four classroom environment qualities of carpeting,

fluorescent lighting, pastel wall colour and air conditioning, statistical analysis of the data consistently showed that the presence of air conditioning significantly influenced students' achievements in comparison to the previous three elements (Chan 1980). Uncomfortable temperature conditions and unhealthy indoor air quality can not only influence typical children, but also contribute to aggravating symptoms associated with LDs. Understanding how these comfortable thermal conditions influence learning processes in children, including those with LDs, is vital to developing child-centred and inclusive school environments.

Heating and cooling

Regulating hot and cold air via designed systems (e.g., air conditioning) in response to internal and external climatic conditions within a school environment ensures that conditions remain comfortable for students to learn. A lack of air conditioning and conditions influenced by weather could be influential in aggravating classroom issues of aggression and off-task behaviour based on 'heat hypotheses'. As Anderson (2001, 33) explained, 'the heat hypothesis states that hot temperatures increase aggressive motivation and (under some conditions) aggressive behaviour'. This hypothesis explained findings from studies exploring the influence of weather-based temperature conditions on children's behaviour and emotional states. Laboratory studies have connected heat with aggression and a rise in anti-social behaviour (Goranson and King 1970; Rohles 1967 cited in Bell and Greene 1982, 92; Sells and Will 1971). Another study exploring temperature–behaviour links found that cooler temperatures, rain and wind improved attention and activity, whereas hot conditions were seen to be related to decreases in concentration, inattention and student activity (Humphreys 1976). Although these early studies failed to confirm causal factors due to methodological problems or a lack of modern statistical tools, they reiterated the significance of the causal issues and of maintaining thermal comfort levels to reduce aggression-related behaviours in institutional settings such as schools (Anderson 2001, 33). The studies also suggested that maintaining comfortable temperature levels inside classrooms could prevent aggravation of behavioural issues for children with LDs—some of whom are sensitive to environmental stimuli.

Weather

The influence of weather conditions on children's physical activity levels is also noteworthy, as gross motor activity levels (activities such as jumping and running, involving the use of large anatomical muscle groups) were seen to be highest in summer and decreased with seasonal decreases in temperatures to the lowest gross motor activity level observed in winter (Poest et al. 1989). Essa et al. (1990) observed that preschool children reacted to changes in weather patterns. Better engagement with learning activities and less social behaviour was observed when weather conditions were stable (sunny and moderate). However, less on-task behaviour and more social interactions were observed when weather was unstable (cloudy, unstable barometric pressure, high wind velocity). Another study showed a correlation between disruptive behaviour in classrooms and minimum and maximum seasonal temperatures, with minor indications of wind velocity also being a causative factor (Badger and O'Hare 1989).

Humidity has also been related to lowering on-task behaviours influencing students' concentration and academic performance (Howarth and Hoffman 1984), increasing aggression and lowering pro-social behaviour (Lagacé-Séguin and d'Entremont 2005), and causing irritability (Lagacé-Séguin and Coplan 2001). More recently, a study conducted on children (two years old) of both genders showed that weather conditions can be used as a predictor of young children's emotional and behavioural states using readings of relative humidity and solar radiation (Ciucci et al. 2011). The same study also found that sunny conditions influenced children's behaviour and emotional states positively. These studies first suggested that school designers should incorporate both natural and artificial features into designs of school spaces. Providing features such as windows and skylights to improve air exchange and bring in warmth from the sun in winter are as important as artificial heating and cooling systems. Second, school buildings must allow permeability with outdoor spaces for children to benefit from stable weather conditions, which have been shown to be conducive to positive behaviour and emotional states, which could potentially influence better learning outcomes.

Ventilation and air quality

In addition to temperature controls, indoor air exchange and ventilation are important factors relevant to the health of students' health and well-being. Emerging studies support the hypothesis that poor indoor air quality arising out of ventilation limitations may influence learning outcomes (Shaughnessy et al. 2006) by adversely affecting attendance (Shendell et al. 2004) and cognitive functions related to attentional capacities (Coley, Greeves and Saxby, 2007). A US study on a group of 10–12-year-old students tested the effects of moderately raised classroom temperatures and classroom ventilation on their academic performance and found that comfortable temperatures and indoor air quality enhanced task speed (Wargocki and Wyon 2007). The researchers also pointed out a key issue; when indoor temperatures rose above comfortable levels, such as during warm weather, provision for cooling the indoor temperatures and improving air quality was a must to ensure learning abilities were not adversely affected. Bakó-Biró et al. (2012) noted that low ventilation rates significantly reduced students' attention and alertness and impeded memory and concentration. When ventilation rates were improved, a corresponding improvement in students' performance was observed.

Second, there are health ramifications for both children and adults using school facilities where a lack of air exchange can affect individuals with health concerns such as allergies and asthma (Annesi-Maesano et al. 2013). For example, indoor air quality can be influenced by interior finishings in the classroom (e.g., furnishings and textiles), which may be significant sources of irritants and allergens (Arbes et al. 2005; Chatzidiakou, Mumovic and Dockrell 2014; Salo, Sever and Zeldin 2009). While air exchange might appear to be the obvious solution to improve air quality, it may not be an adequate strategy in places where outdoor air could be contaminated or polluted. Filtration of outdoor air could address airborne contaminants, while close monitoring of chemical pollutants might be necessary to maintain air quality within school environments (Chatzidiakou, Mumovic and Dockrell 2014). Planners and developers need to ensure selection and placement of school sites are far away from environmental sources of pollution such as industries.

While higher costs for installing artificial systems can prove prohibitive in some cases, the benefits of designing buildings that have healthy 'microclimatic'

conditions with recommended temperature ranges far outweighs the costs. Alternative eco-sustainable design alternatives, such as passive heating and solar sun-path designs, may be explored further to ensure compliance with optimum performance temperature ranges and healthy air quality. In situations where environmental pollutants limit the possibility of natural ventilation usage or socioeconomic factors prevent the installation of modern technology, green barriers (e.g., trees, shrubs, grass) that are planted strategically can positively affect air quality (Givoni 1991). These are considered effective because natural filters from larger dust particles, such as natural dirt, dust generated by vehicular traffic and coal production when designed to form a perpendicular wall to wind direction, deflect the dust particles (Givoni 1991, 6). Designing these barriers and their correct placement could cause variations in placing effective pollutant filters around a school site. However, it is an option worth considering in school design when socioeconomic and low environmental factors (such as in developing countries) pose challenges to healthy and thermally balanced buildings.

While there are multiple benefits of natural ventilation in moderate to mild climatic regions, such as cost effectiveness, no requirement for a plant room and low maintenance needs, there are also challenges with the efficient control of conditions within a building due to the random and unpredictable nature of use by occupants (Allard 2002). The ability to control thermal comfort elements such as natural ventilation features appears to have implications for users' satisfaction ratings of their built environments, as shown by Yun, Steemers and Baker's (2008) study exploring links between façade design, thermal performance, occupants' perceptions and control Their pilot study on user behaviour aimed to evaluate the potential of being able to predict occupants' behaviour in using windows to achieve thermal comfort in office buildings (survey conducted in the UK). One of the findings relevant to this research in terms of positive experiential perceptions of buildings was that greater success in being able to open windows to achieve thermal comfort and ventilation was related to increased user satisfaction towards their built environments. Further, greater accessibility to open windows was reflected in better perceived control over the environment, which was further related to positive behaviour. The UK-based study also indicated that these findings were applicable for statistical analysis, which provides promising pathways for similar research in

understanding children's perceptions of control, accessibility, satisfaction and consequent positive behaviours in school environments.

Perception of thermal discomfort

Wargocki and Wyon (2007) found that improvements in task performance and comprehension occurred when the temperature was reduced from 27 to 20 degrees Celsius among 11–13-year-olds, but not in the 17-year age group, indicating that thermal preferences may differ across age groups. A more recent study on primary school children (9–11 years old) investigated their preferences of thermal comfort and its parameters and found differences in children's perceptions of thermal comfort when using an older, Fanger's (1970) Predicted Mean Vote-based method (Mors et al. 2011, 2461). The study concluded that further investigations were required on the issue of thermal comfort of children, as the existing assessment methods for adults appeared to be inapplicable for children.

Similarly, studies on children have demonstrated that their thermal preferences differ from adults as they are not only able to understand the notion of comfort, but they are also able to coherently define parameters of perceived and preferred thermal comfort levels (Fabbri 2013, 202). Globally, case studies have indicated similar findings on children's perceptions of thermal comfort differing from adults (de Dear et al. 2015; Haddad et al. 2014; Trebilock, Soto and Figueroa 2014), suggesting a deeper examination is required of the thermal needs of children for performance and well-being in school environments.

The above findings suggest that school designers need to examine the perceptual understandings of thermal comfort based on age groups. In the context of designing mainstream schools, special considerations must be made to understand the needs of those with LDs who are sensitive to environmental stimuli and who have existing disorders such as those related to behaviour, inattention and impulsivity. These disorders can be aggravated due to thermal conditions further preventing them from maximising their learning potential.

Thermal comfort and effects on children with learning disabilities

Children with LDs experience challenges in learning either to due deficits (e.g., visual or cognitive) or co-occurring disorders. Other challenges can also coexist among children with LDs with sensitivities to heat and cold temperatures. For example, tics or Tourette's syndrome can coexist with hypersensitivity to sensory stimuli or ADHD with symptoms of tics aggravating with exposure to uncomfortable thermal conditions (Leckman et al. 2006; Scahill et al. 2001). Hypo or hyper temperature sensitivity to heat or cold has also been noted in children with ASD due to sensory processing irregularities causing problems with body temperature regulation (Gaines et al. 2016). This heightened or lowered sensitivity causes children to be unable to regulate their body temperature to respond to environmental temperature changes. Despite significant evidence pointing to the effects of thermal discomfort on performance, health and well-being, limited empirical evidence exists on these environmental factors that can be translated into design criteria for inclusive school environments for those with ASD (Martin 2016). Similarly, while numerous studies show cause–effect relationships between thermal conditions and children's behaviour, health, well-being, productivity and learning processes, empirical evidence of specific effects on children with LDs is yet to be developed. Consequently, further research on children with LDs is needed to understand the effect of thermal conditions on their learning processes and associated disorders or deficits.

Discussion

The outcome of the review on the extent of the influence of thermal factors (heating, cooling and ventilation) in school environments highlights that uncomfortable conditions caused by an imbalance of thermal factors such as heat and humidity can have adverse psychological and physiological influences on children in general. However, literary data illustrating a direct correlation between thermal comfort factors and LDs are limited. Despite this limitation, it is argued that an imbalance of temperature conditions can act as an environmental stressor for children with LDs, further impeding their learning processes.

School environments, when uncomfortable due to heat and humidity, have been demonstrated to have a negative influence on behaviour, aggression and performance levels. Indoor air quality can also be affected by buildings with inadequate ventilation and openings to allow the exchange of fresh air. Consequently, the review highlights that school buildings need both natural (windows, skylights, louvres, ventilators) and artificial systems (air conditioning, insulation, heating elements) to maintain indoor temperatures and air quality at levels conducive to children's health and behaviour needs. Such a combination would ensure that the users of school buildings have better control over microclimatic conditions in schools' interiors, regardless of weather conditions outside the building. Ensuring the school building has both artificial (air conditioning, exhaust systems) and built-in architectural features (windows, louvres, ventilators, ducts) would also offer alternatives to users should one system fail.

In relation to children with LDs, the literature review indicated that data on the exact nature of links between thermal discomfort and learning abilities are scarce. However, numerous studies iterate the importance of affording the relevant temperature conditions and controls to prevent the cause and aggravation of numerous psychological issues (e.g., behavioural and emotional), lowering of attentional capacities, physical discomfort and motivation to learn for children in general. Based on these data and the discussion in Section 3.2 on the physical and social challenges experienced by children with LDs, it is argued that affording comfortable temperature conditions could greatly benefit those with LDs.

The review also highlights that children's thermal preferences differ from adults, and they are not only able to understand the notion of comfort, but also able to coherently define parameters of perceived and preferred thermal comfort levels (Fabbri 2013, 202). This age-based preferential difference is vital to designing child-centred school environments—the understanding of which could help designers to develop school designs that are closely aligned with the needs of specific age groups of users.

The gaps indicated by the review suggest the need for further studies, first to build on the data on relevant temperature ranges that would support better on-task behaviour and attention and lower disruptive behaviour, and second to investigate specific thermal sensitivity needs of children with LDs. The review also shows that there are

still differing views on the relevant and most reliable method to derive data on specific temperature ranges that would benefit the diverse needs of children with LDs. The following recommendations emerge for further research, which could help to bridge the gaps in responding to the needs of children with LDs:

- Questions on whether the thermal comfort levels of children with such impediments differ from typical children must to be resolved to identify whether there is a need to design spaces with variable temperature zones in a single classroom.
- If these differences in thermal responses and perceptions are too high, then architects and school designers need to explore strategies to keep the school architecture inclusive, as per educational requirements, such as by creating zones within classrooms that are visually inclusive but thermally customised.
- Better opportunities to control temperature, whether by artificial (heating, exhaust systems) or natural (ventilators, windows) means, must be afforded to offer users the ability to align their needs with the temperature conditions of the school environment. The literature indicates that an ability to control environmental temperatures encourage positive behaviour among users.

The potential health ramifications of ineffective thermal comfort (heating and cooling) and air exchange systems cannot be ignored in favour of the appearance of buildings or costs. School designs that ignore these aspects of health and their effect on learning abilities fail in their core function as spaces for learning.

5.4 Conclusion

The outcome of the review of various aspects of schools' interior environments demonstrated that each element influences learning processes and thus the learning potential of children, including those with LDs. Building on the review of the nature of experiences of children with LDs in mainstream schools, the discussion summarised each element from the following perspectives to understand each element's attribute/s that is/are:

1. favourable to children with and without LDs
2. favourable to those without LDs but unfavourable to those with LDs

3. current practices in design for each element.

The aim is to recognise how these differences should shape design approaches in mainstream school design to make them inclusive in nature.

Table 5.5: Summary of environmental attributes and their effects on learners

Conditions	Element (interiors and built)
Favourable to both children with and without LDs.	Furniture: flexible, ergonomic and aesthetically engaging designs. Colour: subdued colour tones, pink and blue. Colour coding in school environments enables wayfinding. Light: daylight and artificial sources imitating daylight appear to have a consistently positive influence on students' performance levels, retention, behaviour, motivation and socialisation behaviours, with physiological positive effects manifesting as positive behaviour modifiers. Standard fluorescent light adversely influenced children of both groups (sociability for non-LD and repetitive behaviours for ASD students). Noise: learning processes, task performance, achievement levels, mental health behavioural issues—both groups adversely affected by unwanted noise distractions from the environment, with some exceptions noted in the LD group. Thermal comfort: most influential aspect of affecting students' achievements, behaviour, sociability, mental and physical health and performance.
Favourable to those without LDs but unfavourable to those with LDs.	Furniture: conventional chairs meeting the above criteria were unfavourable for those with LDs with co-occurring disorders of inattention and impulsivity. Colour: palettes sensitive to the needs of the LD group did not disturb the sensibilities of those without LDs. Monochromatic and austere palettes have been shown to prompt negative off-task behaviours in students. Light: minor issues of glare and flickering lights can intensify LDs for those with co-occurring visual, sensorial and perceptual processing disorders. Noise: white noise (humming of air conditioning, ceiling fans) and irrelevant background noise such as music is beneficial to attention in those in the LD group with ADD and ADHD, no effects on typical students, but harmful to high-achieving students. Thermal comfort: aggravation of symptoms for the LD group, with sensory processing disorders heightened or lowered to sensitivity to thermal conditions. Limited

Conditions	Element (interiors and built)
	empirical evidence to show cause–effect relationships between thermal conditions and LDs.
Current practices in design.	Furniture: room for further research to develop prototypes of alternative seat–desk arrangements, keeping up with emerging data. Issues in current design practices as evident from the standardisation of designs—specifically the desk-and-chair setup, which fails to match with students' ergonomic and anthropometric scales (Cotton et al. 2002; Oxford 1969; Parcells, Stommel and Hubbard 1999).
	Rethink current notions of providing excessively colourful or bland environments in favour of schemes that match the perceptual, cultural and aesthetic sensibilities of both groups and the special needs (sensorial, perceptual, visual processing deficits) of those with LDs.
	Mismatch between school lighting and recommended guidelines exist in practice. Serious consideration needed. Adjustable (variable) lighting and provision of natural and artificial light alternatives recommended for meshing the needs of typical children with those with LDs.
	Effects are recognised but do not form a priority in school design approaches: knowledge is emerging on the LD group and diversities within the group in terms of response to noise posing challenges. There is a need for an integrated/reiterative approach.
	Variety of systems essential to regulate temperature conditions in school buildings, including landscape design, artificial systems for heating and cooling, mechanical systems such as ventilators, windows to cater for weather patterns and indoor air quality changes. Data unavailable for direct translation to design solutions for the LD group. Development of systems ongoing from practice, but inclusive design strategies are dependent on availability of new data.

Two key aspects emerge from Table 5.5. First, the effects of environmental attributes can be seen on the behaviour, performance, motivation, mental and physical health, and sense of well-being for children with and without LDs. A range of behavioural effects have been noted, including learners' sociability, on-task behaviour, attentional capacities, aggression and cooperative behaviour. These effects associated learning processes with a consequential effect on perceptions of affordances available for learning. It is argued that each environmental attribute works holistically to offer students relevant affordances and person–environment matches.

They are interconnected; hence, each attribute plays a contributory role towards enabling children to reach their learning potential. The analysis thus suggests that a significant cumulative effect of all built environmental variables could have a corresponding effect on the achievement levels of both typical children and those with LDs. From an architectural design perspective, this implies that spatial design could contribute towards non-medication interventions for children with LDs. Education Researchers suggest that non-medication interventions for students with LDs such as ADHD are limited and require further investigation (Trout et al. 2007). The current study supports this notion by adding that non-medication interventions could include the school's built environment aspects addressing the adverse effects of unwanted environmental stimuli such as noise and thermal discomfort. These environmental aspects could then act as an important contributory factor to assist learning for children with LDs in cases where empirical evidence confirms benefits to learning processes.

Second, while literature on the effects of environmental attributes on children in general are sufficient to develop design strategies to respond to the needs of typical children and some children within the LD group (such as those with inattention), the data to respond design-wise to diversities within the LD group (e.g., co-occurrence with sensory processing disorders) and between the LD group and typical children is either emerging or absent. For example, literature on furniture design demonstrates the ongoing development of prototypes to suit the LD group, but data are absent or perhaps developing to establish the cause–effect relationship between LDs and thermal conditions. This raises questions regarding how designers can create inclusive and child-centred designs when relevant data are unavailable.

Nonetheless, the intent to design schools to be inclusive spaces rather than only economical, technologically equipped, attractive buildings must be a serious consideration despite the emerging nature of knowledge in some sectors. School designers could develop an understanding of user-centred design combinations of these collective elements based on data that are currently available to create spaces that are not only perceived as functional, but that also support the various aspects of the teaching and learning processes. However, as Carbone (2001, 81) pointed out:

> No single recipe of structural changes can be applied to all students with attention disorder. The far ranging success of the child with attentional problems in the general education setting depends on a multi-modal approach to intervention, using instructional and physical accommodations, as well as medication, positive home-school partnerships, and proven behavioural strategies. Only then will the apparent 'fog' surrounding the child with ADHD begin to evaporate.

This is true for all students with LDs that arise out of their symptoms of ADHD, ASD and ADD. It may be concluded that school architecture cannot be truly inclusive for children with LDs unless an ongoing iterative process is undertaken to continuously draw upon interdisciplinary research and refine ongoing design initiatives. Nor can they be nurturing and enriching learning spaces unless schools' pedagogical objectives and the diversities of learning needs among the LD group and typical children are supported by the school buildings in which learning takes place.

Chapter 6 continues the exploration of the same questions, but from the perspective of schools' exterior environments and how elements of site, landscape and nature are linked to the learning needs of children with LDs in mainstream settings.

Chapter 6: Schools' Exterior Environments: Site, Nature and Landscape Features

6.1 Introduction

This chapter examines the role of schools' natural environments, including playgrounds, gardens, landscape features and circulation pathways, in facilitating learner–environment transactions. As discussed in Chapter 4, learning occurs as a result of the interplay of various learning processes, including experiential aspects. Schools' exterior elements play a valuable role in affording continuity of learning experiences for learners. This chapter aims to further understand the role of schools' exterior environments in assisting learning processes for children with LDs, and to analyse what it means for designing inclusive school environments.

School grounds are an integral part of children's learning environments, not only as places to play, but also as places to learn from the opportunities these environments offer. A growing number of studies have shown that children benefit from the processes of play and interaction both in mind and body, while engaging and negotiating with novelties and challenges in their school grounds (Fjørtoft and Sageie 2000)—specifically in green settings (Bell and Dyment 2008; Fjørtoft 2004; Taylor et al. 2001). This can prove to be conducive to effective learning, and consequently, it necessitates the need to pay as much attention to the quality and amount of time children spend outdoors as indoors (Hendricks 2011, 167). The design of schools should therefore be conceived with a combined focus on the building as well as the site on which it sits.

In the specificity of children with LDs, school environments have been shown to contribute to better learning by encouraging better behaviour, alleviating stress and anxiety, and enhancing motivation to learn. For instance, a growing body of research has found a crucial relationship between children's ability to play freely at school and to benefit behaviourally from symptoms associated with ADHD (Jarrett et al. 1998; Ridgway et al. 2003), urging educators to consider the possibility of using environmental variables to complement pharmacological treatment (Denney 2001). Panksepp (1998) criticised conventional practices of medication interventions for

ADHD students and urged educators to consider the simple strategy of playtime allowance. Other studies have also found that nature-based features of school yards have a positive influence on the symptoms of ADHD (Taylor et al. 2001; Taylor and Kuo 2011). A balance combination of built and natural environments could therefore be the key to designing schools that are supportive of inclusive pedagogies in schools.

6.2 'Special' Places in Schools: Exterior Spaces and Their Meanings

Children's expectations of schools' exterior spaces and their corresponding influence on learning processes run far deeper than is possibly understood by school designers. In a key study exploring the potential of landscapes as learning spaces, Titman (1994, 58) found that children seek specific attributes from places in school grounds arising out of their physical and emotional needs, as outlined below:

> A place for doing, which offered opportunities for physical activities, for 'doing' all kinds of things, and which recognized their needs to extend themselves, develop new skills, to find challenges and take risks.
>
> A place for thinking, which provided intellectual stimulation, things which they could discover and study and learn about, by themselves and with friends, which allowed them to explore and discover and understand more about the world they live in.
>
> A place for feeling, which presented colour, beauty and interest, which engendered a sense of ownership and pride and belonging, in which they could be small without feeling vulnerable, where they could care for the place and people in it and feel cared for themselves.
>
> A place for being, which allowed them to 'be' themselves, which recognized their individuality, their need to have a private persona in a public place, for privacy, for being alone with friends, for being quiet outside of the noisy classroom, for being a child.

These 'place-making' predispositions could play an important role in maintaining a sense of belonging and influencing perceptions of school environments as nurturing spaces for learning to take place.

Empirical studies exploring and investigating similar concepts have suggested that children's place use (Hart 1979; Moore 1990) is defined by strong emotions and, when positive, these places offer feelings of privacy, control and security. Additionally, place preferences[55] can be influenced by factors such as prior experiences in different environments, upbringing, cultural conditioning and peer preferences (Malinowski and Thurber 1996; O'Brien et al. 2000), which can elicit different emotional responses from one child to another. Thus, place preferences are unique to individual perceptions. However, in the context of children's preferences within school grounds, when given a choice about where to play, children chose natural or green areas of the school site over other spaces or built play equipment (Lucas and Dyment 2010; Sargisson and McLean 2012), indicating a clear preference in younger children for natural/green aspects of outdoor areas.

Additionally, Ata, Deniz and Akman (2012) claimed that children benefit from all places that allow them to use their imagination and that offer a sense of freedom and personal control and socialisation. Their 'well-being rests on a subtle balance between healthy human processes (mental, physical, spiritual) and healthy environments (built, natural, social)' (Cosco and Moore 2009, 159). Designing outdoor environments could result in better performance and a positive emotional state for children of both groups if the school site responds to children's needs of imagination, expression and engagement while maintaining the balance essential for their development. Further, 'the aesthetical value added to school grounds with green settings, helps foster a sense of belonging that may translate to enthusiasm for learning' (Jarman, Webb and Chan 2004, 37).

Pedagogical constructs of both alternative and traditional schooling systems in most developed countries such as Australia, the UK and the US follow a policy of inclusiveness, as outlined and stated in policies of the United Nations Children's Fund (UNICEF) and UNESCO (1994, 2005). In light of data on various exterior space aspects being beneficial on children's physical and mental well-being, designs of exterior spaces in schools can be considered a source to complement educational

[55] As defined by Korpela (2003, 363), 'place preference' refers to 'psychological dynamics underlying young people's preferential relationships with places'. As discussed in Chapter 2, place preference studies recognise that children would prefer to use only environments that they relate to positive emotional and behavioural states, and to reject those that failed to meet their expectations of function, use or coherency.

interventions and enhance the learning experiences of special needs children. Although methodological limitations and the complex nature of LDs make it difficult to make generalisations using available data for application into design, current evidence make school yards the most likely element that could be designed to respond to users' diverse needs compared to built environmental aspects such as colour and light. This is because the exterior spaces of a school site usually have multiple features ranging from play areas for formal sports to vegetable patches for exploratory learning. This inherent multiplicity offers a more diverse range of opportunities than an internal environment that is meant for specific learning tasks. These spaces around the school form micro-ecological units of behaviour settings that elicit behaviour as a result of the designed environment (Cosco and Moore 2009). As a result, it could respond to the diverse nature of its users more than any internal environment. Additionally, this diversity is mirrored in the range of benefits to children's mental and physical health, which could manifest as positive classroom behaviours and learning abilities.

6.3 Affordances of School Grounds

As per Gibson's (1986) theory of affordances, affordances of school grounds refers to the factors, resources and opportunities offered to the users of a school site. The theory provides a framework to understand the relationship between environmental affordances and human behaviour. All elements of a school site, including green settings, circulation areas and formal play areas, allow children to fulfil their 'place-making' tendencies such as of 'doing' (activities to develop new skills, find challenges) and reflecting (discover and learn about themselves, peers and environment). As Cosco (2007, 128) explained:

> Children learn about themselves and their environment by reading information from environmental stimuli and by engaging in developmental activities such as climbing, balancing, catching, clinging, crawling, hanging, hopping, jumping, leapfrogging, rocking, rolling, running, skipping, sliding, spinning, walking and so on. However, the environment must be designed to afford these activities.

Malone and Tranter (2003, 96) argued that there is a corresponding developmental aspect to the design of school grounds. They reasoned that children's physiological

and psychological developmental abilities change as they grow. For instance, as children grow older, they can climb higher; therefore, they need play equipment that offers the opportunity to do so. Consequently, environmental affordances must also reflect the change in children's behavioural, cognitive and mental abilities (Uzzell 1991) by offering diversity in affordances for the different age groups of children using these external environments. By designing environments that respond to changes in users' physical and mental needs, they would act as an extension of learning spaces from the interiors of the school building to the site on which it sits.

A growing body of research has presented strong evidence that the use of outdoor elements for play improves social, emotional, behavioural, cognitive and educational levels in young children. Researchers have raised questions regarding better ways to design school sites—specifically in terms of what and how these unique schoolyard affordances can be designed to respond to the cognitive, developmental, behavioural and emotional needs of children with and without LDs, and whether the needs of children with LDs are vastly different from their typical peers in the context of outdoor spaces. Moore and Cosco (2007, 86) argued that this might not be the case because children in general 'have special needs defined by their levels of maturity and skill levels with the exception of a small group requiring environmental modifications due to their special needs (physical, mental or sensory impairment)'. Consequently, even though special needs children may require additional design features and the guidance of special needs professionals, it may not mean that the design of outdoor facilities needs to be fundamentally different (Cosco and Moore 2009, 161). Nonetheless, successful designs require interdisciplinary partnerships between designers and educators, as well as a process that includes children and special needs consultants, so that 'unknown' aspects can be extrapolated towards inclusive schoolyard designs.

Diversity in environmental opportunities is a dimension that designers can bring into outdoor spaces using a relevant mix of hardscapes (e.g., paved areas, pathways) and softscapes (e.g., flower beds, tree promenades, lawn). As stated earlier, collaboration with educators and special needs consultants is essential to gain an understanding of the key elements that should be incorporated to create school areas that are relevant to the cognitive and developmental needs of children of both groups. An extensive

study of 56 schools conducted by Boston's Education Development Center (2000, 10) found strong evidence that green settings in school grounds can have a significant positive influence on students' learning, behaviour and outcomes if developed such that the school ground is:

> **Multi-use and Multi-task[56],** suitable for innovative learning and creative-play activities as well as traditional recreation where… the site design and procedures are flexible and adaptable to changing and evolving usage… begins with an **inclusive design process**… **facilitates and encourages developmentally appropriate play and learning activities through its design**, which means that experts on principles of cognitive development and age-appropriate play work with architects in the design phase. Further, the design phase **emphasises community participation**, allowing the broadest possible range of potential users to give input. Through this process, the design responds to local needs and creates a sense of local ownership of the schoolyard.

The idea of forming a partnership using a holistic approach to address questions on how to design learning environments that respond to users' diverse needs, how to be flexible in their use and how to support children's behavioural tendencies at school appears to mirror a similar need across all aspects of school design. However, the conventional process of school ground design takes place without an integrated approach or analysis of users' learning and behavioural needs and educational practices, which limits their potential. In light of overwhelming evidence on the effects of green settings on children and the gap in the creation of effective school grounds, Johnson (2007, 299) reiterated the need for a collaborative nexus, stating that 'students, teachers and local communities know and understand their schools uniquely so must be active participants in all stages of the design, creation, and maintenance of school environments'. Forming collaborative partnerships between key stakeholders such as users (students and teachers), designers (architects, interior consultants and landscape designers) and special needs consultants will help create design solutions that offer a balance of opportunities to play and learn, as well as an improved sense of well-being.

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[56] Researcher's bold emphasis to highlight relevance to current thesis

6.4 Landscape Features and Their Influence on Learning Processes

Studies in a school environment context outside the classroom have indicated the importance of outdoor spaces on mental and physical health (Ozdemir and Yilmaz 2008), enhancing social connections with communities and enriching students' sense of well-being (Department for Education and Skills 2002, 95). Similarly, a higher quality and quantity of outdoor spaces have been shown to influence the quality of students' learning experiences at school (Bowker and Tearle 2007; Dyment et al. 2009). Literature on landscape elements of a school site have been analysed in the three key areas of natural/green settings, play areas (with play equipment) and circulation spaces to illustrate how the design and incorporation of these features are important to children's learning experiences, behaviour and performance at school.

Circulation spaces: The role of landscape elements in schools' exteriors are relevant to positive environmental experiences and can be articulated by aspects such as pathways and geometric orientation of a building on site. For instance, Tanner (2000, 315) explained that pathways can be considered the 'highway' of a school site, connecting different areas between classrooms and through the building and acting as a point of reference for children to orient themselves and interact with the school facilities (cited in Alexander Ishikawa and Silverstein, 1977). Similarly, he described how the geometric orientation of a school could be crucial for bringing natural light into the building (which, as discussed in Chapter 5, affects learning processes, health and well-being), stating that:

> Proper orientation provides, for example, a cool side and a warm side, a calm side and a windy side, and views of nature. Good design ensures access to the sunny side of the structure and makes outdoor space usable (positive outdoor space—flower and vegetable gardens, for example). (Tanner 2000, 315)

Another set of six case studies by Ogden et al. (2010) explored the influence of architectural features of school buildings on students' social interactions and identified six themes that were examined against Alexander Ishikawa and Silverstein's (1977) pattern language for school spaces. These themes embodied both social and architectural qualities and included gathering spaces, aesthetic features, greenery and water. Of these, the theme on 'movement patterns' was

considered to play an important role in users' social transactions in the building, which occurred while moving freely through the spaces. Examples of elements that promote movement patterns are hallways, arcades and pathways. Ogden et al. (2010, 153) argued that since students spend many hours in spaces outside the classrooms, such as hallways, outdoors and entryways, 'moving from space to another, the time spent outside the classrooms, while often informal in nature, also contributed to the overall school experience. Consequently, these spaces were important for social interactions helping them to create their sense of place' (emotional connections, ownership). Enabling accessibility and well-designed circulation paths could provide backdrops for peer interactions and informal socialisations for both teachers and students. Social interactions are part of knowledge construction; circulation spaces could therefore link built and natural spaces to facilitate interactions to fulfil the social dimensions of learning.

Further, numerous authors have considered that impediments to social interactions due to architectural design could be a major factor causing stress (Baum and Valins 1977; Conners 1983; Epstein 1981). The design of circulation paths inside the building (corridors, foyers) as well as outside (pedestrian pathways, entryway, colonnades) should give the user a sense of continuity—either visually or experientially—resonant of the schools' values and pedagogical ethos. Difficulties in understanding the school building or site due to illegible and disjointed architectural and landscape design could pose accessibility issues such as with 'wayfinding', which may manifest as feelings of frustration, anxiety and stress in users.

Green settings help to restore attention and remove stress arising out of continued focus (Kaplan 1995), which could have an indirect positive effect on behavioural manifestations of ADD and ADHD, such as inattention, aggression and impulsivity, which impede achievement levels of students with these disorders (Taylor, Faber, Kuo and Sullivan 2001). Such affordances from green settings could have positive behavioural implications for all children, irrespective of behavioural issues. Research on green settings and students has found significant positive effects on the attention of children with ADD (Taylor, Kuo and Sullivan 2001), and better cognitive function in urban children living in proximity to green settings compared to those away from green settings (Wells 2000). As stated earlier, when given a choice, children prefer

other exterior spaces such as play areas. This appears to be the most promising element of school landscapes and is worthy of further research towards complementing conventional interventions for children with LDs.

Various studies have shown that play areas, or a lack thereof, affect behaviour and physical health. While many studies have found that an abundance of versatile accessible outdoor areas influences students' perceptions of quality of life (Bowker and Tearle 2007; Dyment et al. 2009), a growing number of studies have offered strong indications that there are behavioural implications of having play areas in schools. Rivkin (1995) argued that one of the key causal factors of bullying in schools was boredom. This was supported by Malone and Tranter (2003), who found that providing a rich outdoor environment with diverse opportunities to engage and play reduces bullying behaviour. Many authors also support the notion that quality and quantity of opportunities to play and interact with peers reduces aggressive behaviour in schools (Brett, Moore and Provenzo 1993; Evans 1995). While aggressive behaviour is not typical for all children with LDs, it can be a normal part of school yard play and socialisation during recess or lunch breaks. Diversity in environmental features of play areas could be enhanced by the addition of natural aspects, consequently influencing positive social behaviour, reducing negative bullying behaviour and alleviating behavioural symptoms associated with ADD and ADHD. As children spend a significant number of their formative years in school, their preference to play freely amidst green settings, as well as the fulfilment of this preference via the design of school yards, could assist in conventional intervention strategies for ADD and ADHD and related behavioural issues (e.g., inattention, hyperactivity, anxiety), with positive lifelong implications.

Suggestions from educational psychology on accommodating the needs of ADHD children state that such students need regular opportunities to release pent-up energy via recess breaks and physical education (Ormrod 2000, 184). This is based on the surplus energy theory proposed by Herbert Spencer in 1898, suggesting that 'physical activity or play was the opportunity that allowed for the use of surplus energy' left over after the completion of routine activities when one was habitually sedentary in one's activities (Ridgway et al. 2003, 5). Many studies on the effects of recess on classroom behaviour for typical children and those diagnosed with ADD

and ADHD have found that recess in the school curriculum is benefited by reducing off-task behaviours (inappropriate vocalisations, fidgeting, out of seat, playing with objects and looking away from curricular materials for more than three seconds) in classrooms for both groups of children (Jarrett et al. 1998; Ridgway et al. 2003). Some of the studies by Jarrett et al. (1998) and Ridgway et al. (2003) had methodological limitations because the sample subjects were under medication and were also contradicted by other findings that children engaged in high levels of activity were in fact less attentive after recess (Pellegrini and Davis 1993). The studies also had relatively smaller sample sizes, and further statistical investigations would be needed to evaluate the exact nature of school ground elements that can respond to the diverse nature of children with and without LDs. However, they also point to a relationship between recess and classroom behaviour, as well as green settings positively influencing cognition, attention and emotions.

Experiencing recess in green settings could see the combined effect of balancing behavioural and emotional states manifesting as improved ability to learn. As school grounds offer a venue for recess, their careful design is as important as the design of the school building itself and could be an extension of the internal learning spaces (classrooms) into the exterior surrounds of the building (play areas and green settings). It is also evident that green settings are not passive, aesthetic backdrops to play areas with built equipment, but they play a significant role in influencing attention and cognition. Conversely, the lack of such areas and natural features as part of schools' outdoor spaces could aggravate negative behaviour among children and symptoms of LDs for those with sensorial or developmental deficits.

6.5 Design Implications for Schools' Exterior Spaces

The design of school grounds can be seen in two general categories of hardscapes (paving, concrete pathways, decking, retaining walls and other hard surfaces for sports and seating) and softscapes (lawn, water bodies, vegetable patches, flower beds, trees, hedges and similar green elements). Both can play a role in affording opportunities of play, solitude, expression and engagement. Moore and Cosco (2007, 86) highlighted the importance of designing socially, culturally and physically enriched environments for children, stating that 'Design has an obvious role in

helping to create spaces where such richness and diversity of experience can happen—especially for children living in deprived or stressful circumstances'.

They reasoned that designing inclusive outdoor spaces in schools offers children opportunities to experience and benefit from their school environments. As coherency of settings is important in forming positive perceptions of schools and the ability to orient one spatially, elements such as pathways would make school spaces more accessible and coherent for those who have cognitive impediments. Further, designing attractive landscaped settings might add to the coherency of navigating through school grounds and, as some authors have suggested, 'help project a positive and caring image to its users' (Strickland and Chan, cited in Jarman, Webb and Chan 2004, 38). However, there are deeper connotations of creating landscapes that are not only aesthetically pleasant, but also equipped with experiential and sensorial contexts to support children's developmental and learning needs in school grounds.

Design-wise, the exterior and interior aspects of a school building should be developed as one whole concept, with an equal focus on how the school building connects with the school site and establishes a dialogue of learning via expression, engagement and restoration.[57] Design-based research in the design of play areas reiterates the above recommendations for play spaces to include nature or green settings, pleasing aesthetics, and spaces for active play with spatial and structural elements to promote socialisation and imaginative play (Wood, Christian and Martin 2011), while offering security and challenges in play (Norðdahl and Jóhanna 2014). Studies have also noted that spaces designed from an adult perspective failed to respond to children's needs and expectations of outdoor play spaces (Martin and Wood 2014; Wood et al. 2011).

School designers including architects, interior architects and landscape designers need to acknowledge that children may not perceive that learning is limited to classrooms. Teachers may also need to incorporate elements from nature as part of the teaching curriculum, such as plant-life cycles and the sun path, based on

[57] Restorative environments such as spaces to withdraw are spaces that offer opportunities to recover from psychological and cognitive fatigue as part of learning processes (Hartig 2004; Kaplan and Kaplan 1989; Trancik and Evans 1995). Based on Kaplan's (1985) ART, such restorative environments positively influence attentional capacity (Berto 2005) and hold the premise for designing physical environments for children with attention issues.

pedagogical foundations. For instance, Dewey's philosophy (alternative educational model) requires experiential learning offered from children's schoolyard experiences for learning literacy and scientific subjects (Dewey 2007). US research on 40 schools exploring questions on integrating school yards as part of the educational process of K–12 schools found that when outdoor environments formed part of the educational curriculum, achievement levels on standardised measures improved in reading, writing, mathematics, science and social studies (Lieberman and Hoody 1998). In another example noted from education, Larkin and Rakimov (2006) suggested task-based interventions via physical education classes to encourage movement skills to influence better learning skills for children with motor learning difficulties. This need to have the alternative to incorporate schools' external environment to extend learning outside the classroom is a noteworthy aspect for school designers. Additionally, as Malone and Tranter (2003, 95) explained, the act of 'playing' in school differs from playing outside school campuses, as 'supervised play in an educational context has an attachment to a hidden curriculum that tells a story to the children about culture and ethos of the school'. They added that school yards can be valuable resources for formal learning via nature-based experiences such as bio-diversity and food webs. Consequently, designers need to understand that school yards are not simply venues for recreation and play, but an extension of teaching and learning processes requiring inside–outside links. Further, obtaining insights into the pedagogical needs of both teachers and students is crucial to the design of spaces that allow movement and flexibility to conduct learning both inside and outside the classroom.

Armitage (2005) explored findings from research on the effect of school building design (UK) on children's use of outdoor areas for play and made a key argument relevant to the need to establish inside–outside links in school buildings. The nature and profile of a school's outdoor spaces are dictated by the design and profile of the school building on the site in relation to the play areas. As a result, changes to the school's built environment over time can cause a corresponding change to the playground environment. The school's site should not be a by-product of design changes to a school building, but a result of a conscious design process to include it while making changes to an older school design.

The following images from a case study of schools examining the relationship between school building features and influence on socialisation behaviours (Ogden et al. 2010) provide insights into how outdoor elements are designed in continuum with the interiors of the building to afford students their preferences towards nature-based elements. Figure 6.1 shows the foyer of the Köln Freie Waldorfschule School in Darmstadt, Germany, and Figure 6.2 shows a pond adjacent to the library at the Gelsenkirchen School-Bismarck, Germany. These were assessed by Ogden et al. (2010) as an example of Alexander Ishikawa and Silverstein's (1977) pattern of naturalised aspects in design (trees in foyer, accessible gardens, climbing flowers and waterfalls). The key idea was that there should be permeability between the building and earth by incorporating natural features such as plants and water into the building envelope. The authors of these case studies narrated the element of surprise when visiting Köln Freie Waldorfschule; the simple entryway opened into a three-storey-high foyer topped with a skylight and decorated with a water feature and green features. It gave the visitors a sense of entering a grand space that was enriched with green features, which evidence indicates is high on students' preference lists for school environments. Similarly, at Gelsenkirchen School, the use of water was noted to be prominent, and it connected the indoors with the outdoors using bridges built over water to connect classrooms and libraries.

Figure 6.1: Foyer in Köln Freie Waldorfschule, Germany
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(https://www.renaupitis.com/wp-content/uploads/2010/01/20_2_06_EnteringSchool.pdf).

Figure 6.1: Foyer in Köln Freie Waldorfschule, Germany (Ogden et al. 2010, 165)

Figure 6.2: Pond adjacent to library at Gelsenkirchen-Bismarck, Germany is unable to be reproduced here due to copyright restrictions. Figure 6.2 can instead be accessed via (https://www.renaupitis.com/wp-content/uploads/2010/01/20_2_06_EnteringSchool.pdf).

Figure 6.2: Pond adjacent to library at Gelsenkirchen-Bismarck, Germany (Ogden et al. 2010, 166)

There is an overwhelming amount of evidence from educational research on school grounds and their influence on learning processes as an indirect consequence of the school sites' effect on physical and mental health. Changes in policies relevant to designing school yards have been emerging, initiated by organisations supporting play-and-learn strategies (Play England Freedom to Play 2014; Boston Education Center 2000). Australian school yard design practice has been trending towards similar ideas based on industry partnerships and designers (Conrad Gargett Landscape Architecture n.d.). Governance and policy issues exist, such as the reduction of school playtimes in Australian schools (Malone and Tranter 2003), which is outside the scope of this research. However, the emerging trends mean that there is an impetus from an educational perspective to bridge the design of the school building itself with the school yard design for better behaviour, physical health and learning outcomes. While children may prefer outdoor areas and activities associated with being outdoors, these environments are known to have an indirect influence on their learning. As a result, questions on how to ensure permeability between indoor and outdoor spaces while respecting curricular requirements need to be explored. To achieve holistic school environments, an integrated approach is essential to bridge architectural design with landscape design practice while forming partnerships with educators and special needs consultants. The primary users of the space (children and

teachers) should form the centre of the design brief and analysis to ensure that both the built and natural environments act as a cohesive learning environment and are closely aligned with users' needs to learn via expression and engagement.

6.6 Discussion

This chapter aimed to provide an understanding of the value of the exterior elements of school environments (e.g., green areas, play areas and indoor/outdoor circulation paths) in assisting the learning processes (e.g., experiential, perceptual, social and cognitive) of children in general. In examining the literature on the value of school exterior environments, the review highlighted that exterior spaces in schools play a pivotal role in assisting learning abilities as a result of positive influences on the psychological and physical needs of children of both groups. These positive influences are specifically noteworthy for children with LDs. As discussed in the review, positive changes were evident in behaviour, attentional capacities and a reduction in off-task behaviour, enhanced motor skills, developmental abilities and sense of well-being as a result of interactions with schools' exterior elements. These positive influences combined to assist learning for those with LDs co-occurring with ADHD, ADD and ASD, making school sites a valuable component of enabling children with LDs to learn better in mainstream schools.

The review highlighted that school grounds and their features are an important part of children's learning experiences. The design of school grounds can offer relevant stimulation or solitude to match the diverse needs of users, ranging from the release of surplus energy to the need for restoration. Subsequently, this could help with the reduction of off-task behaviour in classrooms, such as fidgeting, inattention and impulsivity, and contribute to better learning outcomes for students and a better sense of well-being for teachers and students. Good design of a school's site will enable better accessibility to school facilities, encourage positive social behaviour by offering opportunities to engage and allow an extension of children's personalities. The landscape of a school site thus offers more to its users than just a venue to play. When they are designed while acknowledging evidence from research, they become spaces for reflection and restoration for both groups of students. Their role could potentially extend to support non-medication intervention alternatives for those with ADD and ADHD.

The review further outlined how the exterior elements of a school site, including play areas, gardens, frog ponds and veggie patches, can offer a variety of learning experiences for children. They offer venues for the children to meet, opportunities to play and places to de-stress from anxiety. Simply being able to play without restrictions is beneficial not only for fitness, but also for emotional well-being. Hendricks (2011, 8) argued that play and a playful attitude towards life are crucial to a healthy emotional and physiological state of being, enabling growth in 'spiritual, intellectual, creative, social and emotional' contexts because it assists in the development of balancing or motor skills. Again, the school's landscape, if designed with this understanding, would enable children to nurture their inclinations to play while benefiting physiologically and psychologically. Chapter 5 illustrated how the built environmental factors (e.g., colour and light) influenced users' physiological and psychological states, with further positive effects seen in behavioural aspects such as a better sense of well-being, motivation to learn and reduced irritability and aggression (Gaines and Curry 2011; Nielson and Taylor 1990). These positive influences subsequently contribute to enabling children to maximise their learning potential. The same can thus be considered for the role of schools' exterior elements in assisting learning for both groups of children, but more so for those with LDs.

In highlighting the value of school sites and landscapes, the review outlined the design implications for schools' exterior spaces. It questioned whether school designers take advantage of the potential of school sites as a source that can promote positive behavioural and academic outcomes for learners while enabling teachers to respond to diversity among learners' needs. Hendricks (2011, 167) argued that one of the issues with school environments is the standardisation of school designs leading to missing connections with outdoor settings—specifically in public school systems—by asserting:

> For too long now the public educational systems have seen to be training workers rather than citizens… But have the school system and the adult society provided adequate conditions for the children to fully explore, expand, practise and demonstrate their abilities?

Subsequently, if designs are developed holistically, it may be seen that the school buildings and their environs work in sync with the learning and behavioural needs of

the children of both groups. From an architectural perspective, this review found limited literature on establishing connections between the inside and outside of a school building to offer users a sense of continuity in their learning experiences. However, the limited reviews and case studies offered school designers valuable models to understand the above issues and develop new user-centred strategies focused on the needs of children with LDs in mainstream schools.

Chapters 3 and 4 discussed the diversities within a group of learners (e.g., perceptual, cognitive and learning) and the challenges in addressing these diversities in a mainstream school. It was argued that establishing a dialogue between a school building, its site and the young users would be crucial to realising design solutions that are unambiguous and supportive environments for both groups of children in mainstream schools. Addressing the challenge of bringing together the multiple aspects of learners' needs and translating them into design features of school grounds requires collaboration between designers, educators and special needs consultants. However, the key issue here is not that school sites or landscapes are being designed without any strategies, but there is a need to start viewing the design of schools as the sum effect of schools' architectural, interior and landscape design exercises.

Chapters 5 and 6 combined to offer a discussion and analysis of what is required from design perspectives to make mainstream schools more inclusive and child-centred. Chapter 7 examines the aspects that poses challenges in achieving these aims, and it explores potential strategies to be able to design inclusive learning spaces for those with LDs in mainstream schools.

Chapter 7: Achieving Child-centredness and Inclusiveness in School Design: Examining the Issues and Gaps

7.1 Introduction

Chapters 5 and 6 established how both the built and natural parts of the school environment have transformative influences on learning processes and the development of abilities in children more generally. Some of these influences have been shown to increase the challenges experienced by children with LDs in mainstream schools, further impeding their ability to learn. From enabling better interpretations of environmental affordances to limiting socio-environmental challenges, each school environmental attribute plays a role to a varying degree in aiding the learning of those with and without LDs. Based on established data, it can be surmised that school design approaches should be more user-centred and focused on the needs (psychological, behavioural, developmental, sensory, perceptual and experiential) of both groups of children. Such approaches have considered how meeting the needs of children can manifest in better behaviour and learning outcomes (Altmaeir and Hansen 2011; Holland 1997). Thus, Chapters 5 and 6 questioned why mainstream schools are designed to place the onus on educators to reorganise learning spaces to meet the needs of children with LDs.

This chapter seeks to address the above question by exploring the issues and gaps that exist in broader design practices that are preventing the development of inclusive school designs. It further explores the literature to examine child-centred approaches in the creation of school spaces that hold promise for developing inclusive school design strategies. By examining these approaches, the aim is to identify potential pathways that designers could follow to develop a framework for inclusive school environments. This chapter seeks to contribute to an understanding of the methods that will enhance the design of schools that support those with LDs and afford a seamless meshing of the needs of both groups of children studying in the same school environment.

The global review of building codes and standards, including Building Codes Australia (Australian Building Codes Board 2014) and the International Building

Code (International Code Council 2011), indicates that although there are specifications and standards set for designing different types of school buildings that specify the rules for ensuring the safety, ergonomics and quality of materials, there are no specific data available to designers from behavioural or perceptual perspectives that are applicable to school design. This by itself is highly unusual, when recent research trends and evidence clearly point to the importance of our environments in influencing human minds and behaviours. Further, organisations devoted to EBR, such as the Centre for Environment–Behaviour Studies (CEBS, Malaysia), Environmental Design Research Association (EDRA, the US) and the Academy of Neuroscience for Architecture (ANFA, the US) have been providing a range of analytical models, theories and emerging evidence that reiterates the space–behaviour nexus hypotheses through studies conducted over almost a decade. However, its influence is yet to be seen in the wider practising architectural community. The availability of data from behavioural perspectives and the lack of a coherent framework for school designers and architects to apply these data suggest that intra- and interdisciplinary gaps exist. Thus, it is time that the fallacy of the 'one-size-fits-all' or generic approach for school designs is abandoned in favour of a more integrated and holistic model focused on the needs of children. The next section examines these gaps, the factors that have caused them and how they can be bridged to meet the aims of an inclusive school environment.

7.2 Gaps: Interdisciplinary and Intradisciplinary

Chapter 3 explored the learner–environment transactions that occur as part of the learning process and the environment–behaviour relationships that need to be acknowledged as part of meeting the notions of inclusion. It examined the intersections of interdisciplinary perspectives (e.g., environmental psychology, education and neuroscience) for environment–behaviour relationships in the context of education. In examining these intersections, Chapter 3 illustrated the value of understanding these relationships for bridging the disciplines of school design and education and subsequently designing inclusive school environments for children with LDs.

Chapter 4 further introduced the notion of child-centredness in education, which places the child at the centre of the schooling process. Based on this concept, various

theorists share the common pedagogical objective of aiding the development of children through the engagement and exploration of their learning environments. The chapter illustrated that to create inclusive school space designs that enable children to maximise their learning potential, it is necessary to emphasise the spatial needs of children, situating both groups of children at the centre of the school design process.

Based on the above foundations set by Chapters 3 and 4, the following discussion examines the issues and gaps that exist in the larger context of design ranging from twenty-first-century needs for the economisation of costs to ingrained disciplinary attitudes in design practices that influence school designs. It highlights the need for radical changes in the way designs are conceptualised for schools, as well as intra- and interdisciplinary collaborations to design inclusive school environments. Lastly, it proposes an integrated framework to bridge the intradisciplinary gaps and potential pathways derived from existing practices in design practice and research to create designs that are responsive to the diverse needs of both groups of children studying in the same school environment.

7.2.1 Responding to twenty-first-century changes

As a discipline, architecture has responded to socioeconomic, cultural and environmental changes such as those seen in the nineteenth century, when there was a transition from ornamental styles to a new style of architecture matching the advancing needs of the Industrial Age and the discovery of new materials and technology. Chapter 3 discussed how these changes influenced the formation of school environments (such as monitorial and factory schools). Likewise, responding to twenty-first-century socioeconomic factors, the world has sought to construct more cost-effective buildings using the most efficient production methods or those that are sustainable economically. The key project driving and defining elements are cost-control measures in these instances. For example, a recent US government report encouraged greater control of design and procurement procedures to cut construction costs (Gallaher et al. 2004), thereby limiting reliance on design-based professions. Similarly, the Centre for Effective Learning Environments (CELE) of

the Organisation for Economic Cooperation and Development (OECD)[58] has been promoting 'modular school' building techniques as 'cost efficient, sustainable and flexible' design solutions that respond to schools' needs to replicate building parts in more economical ways, thereby limiting reliance on designers, architects and associated time and costs (OECD CELE 2011). These standardised building prototypes, or 'kits-of-parts', allow schools to add or modify school buildings according to their needs, generally for one-time costs associated with the initial stages of the design, and consequently reducing design-related costs in the school building process. However, critics of this type of prototypical approach include architectural practitioners (American Institute of Architects [AIA] 2012), who say that this 'cookie-cutter' approach will increase costs as a result of the need to customise prototypes to site-specific conditions such as climate and topography (Knapp 2010). These architectural practitioners argue that an approach in which crucial factors, such as individual and community needs or the effectiveness of learning environments, take precedence over costs is essential.

Conversely, the OECD, which promotes policies linked to economic and social welfare on a government level, supports the standardised school prototype approach, stressing that the solutions it proposes are evidence-based and related to social and educational contexts. However, the aims of these evidence-based strategies are more inclined towards the cost-reduction aspect of creating schools, which is not in itself a negative objective. However, this should not be the only focus—particularly in the presence of other compelling evidence supporting the need to incorporate a holistic approach to school design that emphasises the way school environments can provide relevant opportunities to facilitate learning and align with the needs of children with LDs.

When questions about the validity of the prototypical approach are contradicted by practitioners of architecture on the grounds of its being cost-effective, their educational counterparts identify the pros and cons of the model, stating that it might work if it is produced on a larger scale in less time, rather than used for small-scale projects (Wernick et al. 2007). These standard prototypes address socioeconomic and

[58] CELE, an education branch of OECD, has a research group the Centre for Educational Research and Innovation (CERI) that conducts research on cost-effective strategies for education and learning environments.

sustainability principles, and opinions differ about their potential advantages and disadvantages. Questions about the viability of one approach against the other remain shrouded in ambiguity, implying intra- and interdisciplinary gaps produced by disagreements over their cost effectiveness. These tend to command attention, which can cause problems when there are more significant issues in designing school environments that require customisation to accommodate the needs of children with and without LDs who require focus. Second, in addition to the current availability of specialist disciplines and areas to assist in building design and construction, cost-cutting efforts have threatened the traditional roles of architects as interpreters between clients and other individuals (Maher, Nelson and Burry 2006). This consequently increases the gap between the educators as clients and the designers. It is important to bridge this gap because educators organise the environments where learning takes place; therefore, they are valuable sources of information and can respond to the essential elements required for school design.

The third factor influencing school design is ingrained disciplinary attitudes towards the design process, which can be either pragmatic or egotistical (Ackerman quoted in Mitchell and Lang 1974). The pragmatic approach seeks to be practical and provide the client with the design requested, while the latter ignores the client brief entirely, using the design to satisfy a creative, egotistical attitude (Lang 1988). Each of these approaches is inadequate, since the first often results in buildings that lack expert disciplinary perspectives, such as those on the form and function nexus. Similarly, an egotistic approach may result in buildings that are formed around the notion of making an architectural statement, thereby obscuring the human aspect of design and its inherent meanings and experiential value for users. This limited and binary design approach also leads to 'architectures' where 'architects' designs fail to relate to vision[s] of non-architects causing individuals to turn to other alternatives in the construction industry with the hope of finding someone more responsive to their needs and aspirations' (Nicol and Pilling 2005, 44). Such disciplinary attitudes may be why school models designed by non-architects are dismissed as buildings that are unworthy of exploratory pursuit or validation by architectural practice because they have not been 'designed', but merely 'built' by individuals with non-architectural backgrounds. Rather than dismissing these alternative schooling models, designers must study them to understand why some of these environments, which may not be

architecturally designed, are more successful as learning environments than the so-called 'architect-designed' schools that are built at higher costs.

Studying non-architect-designed environments to understand their strengths and weaknesses as learning spaces requires focused investigations that draw upon the educational and behavioural sciences to assess why some of these buildings work while others, which are 'designed', are not as successful. However, most practising architects focus solely on the design and building aspects of their profession, preferring to leave the investigative aspects to researchers from disciplines such as sociology and pedagogy (Maher, Nelson and Burry 2006) rather than integrating architectural research into practice. As Duffy (2005, 1) iterated:

> Design is not research and can never be. Nor is research the same as design… both design and research are vitally important to the profession and teaching of architecture. However, conflating these two essentially different activities is to say the least, confusing and unhelpful.

However, examples of school designs where architectural practitioners have incorporated innovative approaches primarily involving potential users' feedback and visions—for instance, in the case of the Brindishe Community School (Taylor 2000)—are few and far between. These are the results of what one would call an 'unconventional' approach to design and generally do not form the guidelines for behaviour-based alternative design strategies or part of any architectural training, education (Lang 1994; Mitchell and Lang 1974) or design standards (Sanoff 2001a). This raises the question of why the 'norms' for school designs have not been adapted and have not evolved to match new evidence derived from other disciplines, such as education and neuroscience, in the context of spaces for children. This lack of change again reveals the gap between research and practice, where design approaches are based solely on technical design standards and fail to acknowledge evidence from research that may allow architects and designers to stay abreast of change occurring in the context of children with LDs and their school environments.

Designers need to change their design approaches to holistic processes that incorporate both multidisciplinary research and practice-based evidence into the design. A gap between research and practice results in schools that rate highly in terms of aesthetic value, but poorly in terms of experiential value. Addressing these

gaps will enable architects and designers to create more responsive, inclusive and child-centred environments. As research that includes architectural research draws upon other disciplines to fill gaps and seek new knowledge, a collaborative nexus between architectural practice and research will enable individuals to fulfil and sustain their maximum potential (Barrett and Barrett 2010). Thus, inclusive school space designs can result from a multi-modal, continuing process. This would include research applications as part of the project brief, stakeholder inputs and building specifications during the phase of design conception where the architect's role changes to that of the researcher, designer and facilitator (Sanoff 2001a). However, the creation of inclusive spatial designs would be incomplete without subsequent POEs of the success or failure of the design to meet the evolving needs of its users (Zeisel 2006). The results of the evaluation of the research could then inform practice about what worked or did not work in the design, which could either be rectified or used in other projects. This nexus would also help to update specifications, thereby forming a part of the design brief.

7.2.2 Issues with disciplinary attitudes in design practice and the need for an interdisciplinary collaborative nexus

Critiquing architectural design doctrines of determinism and functionalism, Sime (1995, 163) used the metaphor of a design for ball-bearings to describe 'caricature designs which attempt to impose control of [a] building's users treating them as if they [are] non-thinking objects or ball-bearings like elements of the building structure'. The key argument here is against obsession with the form of the building rather than respect for the nature of built environmental experiences that offer frameworks 'for patterns of experiences, social relationships and activities'. This suggests that there might be crucial gaps in the way architects are trained to think, which is consequently seen in design approaches that focus on superficial aesthetics or budget-driven prototypes. The experiential value of design solutions is further weakened under social, economic and legal constraints. It might be argued that achieving a design outcome that is satisfactory to all stakeholders—specifically children—is a challenging and complicated process. However, this reiterates the necessity for design professionals to form a collaborative, multidisciplinary nexus to

study in-depth evidence of the capacities of built environments to influence behaviour and sense of well-being.

This nexus is also important because researchers from within design disciplines are aware of the need to pursue knowledge about built environments and their different interpretations by users. Additionally, these researchers are beginning to correlate these data with data from the behavioural sciences understood from cross-disciplinary perspectives. These include reports by Moore and Lackney (1994) relating school buildings to academic performance, theoretical discourses by Canter (1974, 1975, 1977) offering insights into the nexus of architecture and psychology, and relatively recent discussions about theoretical models to better examine children's perceptions of their built environments (Spencer and Blades 2009).

By drawing parallels between various disciplines in the context of architectural and spatial school designs and the science of children's behaviour and education, it might be possible to limit uncertainty in the design choices made by architects and interior architects or designers when designing a multi-user complex environment such as a school. Therefore, it is essential that an unambiguous theory of architectural design based on human perceptions is developed that can be applied to school design. The development of such a theory would require the results of collaborations between design practitioners and researchers in various disciplines spanning education and the behavioural sciences. Collaboration is essential because vital knowledge for resolving the issue of supportive learning spaces lies fragmented by and within these various disciplines. Consequently, school designers fail to arrive at solutions that provide holistic and unambiguous models for developing inclusive school designs for children with LDs. If such a nexus were formed, it would become clear that interpretations of good school designs will differ vastly among design practitioners and potential users, and more so when the primary users include children with LDs.

Second, as Higgins et al. (2005, 6) explained, 'Different users have different perceptions and needs, which often differ from [an] architect's perspective'. This difference in the understanding of a learning space is reflected in situations where educators are seen to be struggling to adapt to architect-designed buildings. Such school buildings, which are aesthetically brilliant but experientially meaningless, may result from the absence of a common language between architects and

educators—specifically those who challenge the norms of conventional models of educational practice (Lackney 2015). As Rudduck and Flutter (2004, 11) observed, 'most children will continue to be educated in buildings where the messages of the architecture need actively to be neutralised'. Further, the educational specifications that are created for the architect's design brief and meant to bridge this gap often fail, mostly as a result of practical aspects such as budget or time constraints, or because they may not be true reflections of the realities of teaching and learning processes (Lackney 2015). Gaining insights from children of both groups about what they need from their school environments is vital for developing solutions that seamlessly mesh the needs of both groups.

Third, school designers must acknowledge building standards when designing school spaces, such as providing adequate illumination and ventilation to ensure the physical health and safety of the end users. Nevertheless, it is also important to include an environment–behaviour nexus, including children's notions of what a school environment means to them, their expectations and their spatial engagement tendencies. This user-responsive design approach would enable designers to gain valuable insights into developing design strategies that are accessible to, and meaningful for, its users. As Johnson (2007, 303) explained: 'Students, teachers and local communities know and understand their schools uniquely [and] so must be active participants in all stages of the design, creation and maintenance of school environments'.

Finally, progress in technology and the Internet has seen schools rush to upgrade their spaces to keep up with the latest devices, such as smartboards. However, optimal learning can only be achieved if there is a balanced approach to the design process, whereby school spaces incorporate functional, pedagogical, educational and psychological aspects in addition to the budgetary and technological elements of a school building. Such a complex list of factors indicates the need for a focused and multidisciplinary approach to designing schools, especially if they are meant to be inclusive in nature for those with LDs. Justifying the disciplinary complexities of architectural practice, as well as their inherent limitations and the importance of research, Duffy (2005, 1) stated that:

> Buildings are often very large, complex entities… the mental processes involved in conceiving buildings and the mental processes that are necessary to understand their properties, potential and impact on people are so different… Even more different is research into such fascinating questions as how people use buildings over time, what effect buildings may or may not have on organisational performance or how buildings can be used to convey values and ideas. Research into how buildings perform, what they contribute and what they mean is very different from both the design and the management of buildings. Of the three, research, in my opinion, is the most demanding and yet, in architectural practice and even in Schools of Architecture, probably the most neglected.

The above discussion highlights that design research can play a valuable role in enabling design practitioners to address the complexities of designing schools that are responsive to learners' diverse needs. Until design research and practice form collaborations, school environments as nurturing, responsive spaces to facilitate learning will continue to be limited.

7.3 Research-based Design Approaches and a Proposed Model for Inclusive School Design

Design research uses various approaches to obtain answers about the spatial issues that are considered to influence human life, ranging from urban to built and landscaped spaces that are used to create better designs. However, not all approaches offer the data sought, and many require further refinements. One such research-based design approach is evidence-based design (EBD), which not only addresses the issue of disciplinary gaps, but also provides a basis for innovative building design strategies that could base practical design decisions on empirical knowledge and evidence drawn from research (Vischer 2009). Citing the example of POE research and the design process as having a 'hit-or-miss' character, Vischer and Zeisel (2008, 57) argued that the huge quantum of evidence from POE research either remains unused by researchers or is published in academic journals that are rarely consulted by design practitioners. Additionally, POE data is only one element, whereas an EBD process necessitates a demanding, rigorous procedure to answer project-specific questions. Such an approach has potential to elicit a positive response about occupying a building where the primary users have an opportunity to engage with

and contribute to the conceptual design process (Preiser and Vischer 2005). Similarly, to address the complex processes involved in the life of a building (psychological, social, economic and architectural), design research needs to play a bridging role, evolving 'not only as a technical craft, but also as a domain of knowledge and endeavour which is uniquely interdisciplinary in focus' (Sime 1995, 167). Such a bridging model may hold the key to developing strategies from an architectural perspective for designing better schools for children with LDs.

POE is a tool used to evaluate the performance of a building after it has been occupied (Zimring and Reizenstein 1980), 'including if and how well it has met expectations and how satisfied building users are with the environment' (Vischer 2001, 23). Conversely, the EBD method is a research-based method undertaken by design professionals to evaluate how the built environment influences human behaviour and subsequently use the data to guide design decisions (Lippman 2010a, 1). Both methods rely on data collection and feedback processes.

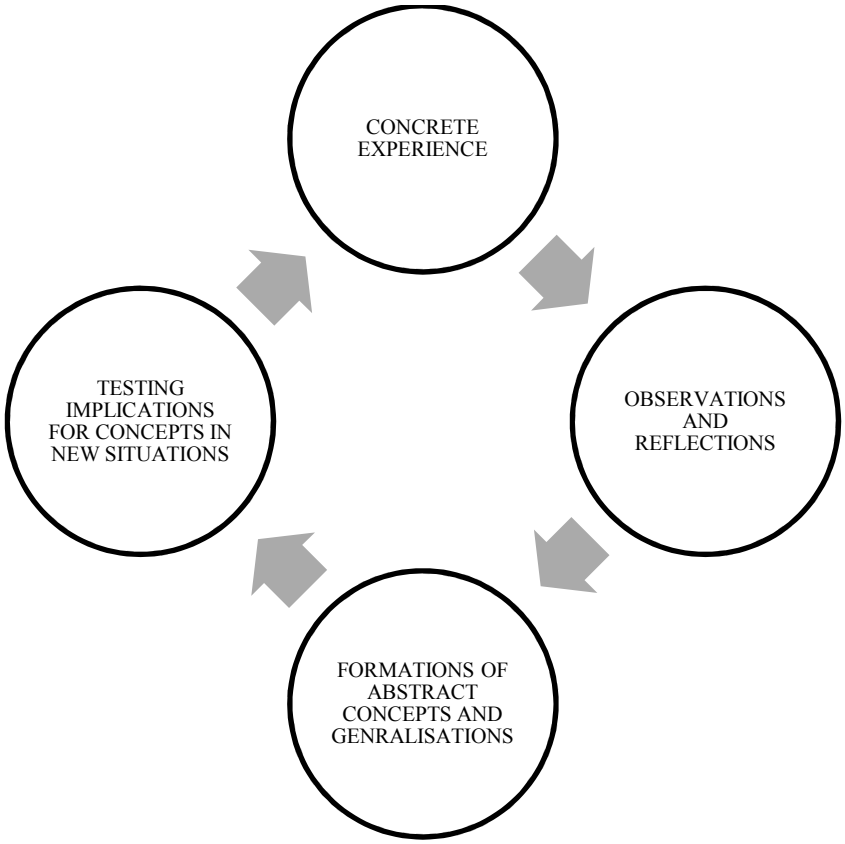


Figure 7.1: Kolb's (2014) experiential learning model

The following model is proposed based on Kolb's experiential learning theory, which emphasises concrete experiences, assessments and applications to obtain knowledge and solve problems. If the above EBD and POE methods are combined based on Kolb's experiential learning theory model,[59] it would result in the model shown in Figure 7.2. The value of this proposed model for bridging interdisciplinary gaps is explained below.

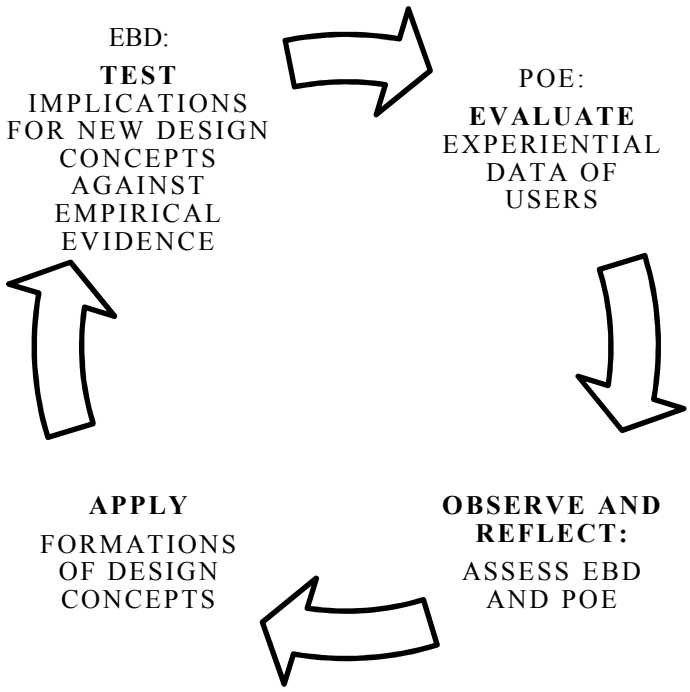


Figure 7.2: Proposed model for school design based on Kolb's model of experiential learning

The research-based EBR and POE models would provide data to balance issues arising as part of innovative design approaches and make it possible to avoid generalisation errors. They would also enable the evaluation of conventional approaches to develop design strategies that are integrated within disciplinary evaluations of human responses to environmental factors using observations and reflections to assess evidence before its practical application. The resultant data would be fed back into the above model for refinement, ensuring that the design process and solutions constantly evolved to meet the changing needs of education

[59] Both of these architectural methods rely on data collection and feedback processes similar to the experiential learning model. Kolb's experiential theory (see Chapter 3) is used in contemporary educational practices to provide concrete experiences in real-life settings and engage in and experience physical environments as part of learning (Burroughs 2015; Itin 1999).

and emerging data on LDs. This framework aims to bridge architectural practice with research, grounding its approach in 'concrete human experience' and developing user-centred design (see List of Definitions and Terminologies) solutions.

However, the implementation and success of the above framework would require both intra- and interdisciplinary collaborative nexuses. Thus, the importance of intradisciplinary collaborations between architectural practice and research must be realised if an innovative design approach to the complex issue of designing learning spaces that are architecturally and educationally inclusive is to be resolved.

7.4 Achieving Child-centredness in School Design: Challenges and Solutions

Issues of standardisation, cost-cutting and disconnection from research-based data on environment–behaviour perspectives have resulted in environments that are often disconnected from the spatial needs of children in general, as well as the specific needs of those with LDs. As Dudek (2000) explained, the design of many twenty-first-century educational buildings still seems to be focused on control and discipline—a perspective that is perhaps in sync with educational philosophies or the choices of stakeholders for schools' formative processes. Such approaches, which fail to match children's understandings of space (their aesthetic, perceptual and experiential sensibilities) would hardly encourage or motivate children to learn. In contrast, in some children it would only create resistance to learning and towards the education system.

Thus, standardisation or generic school designs fail to aid learning in those with LDs who require specific affordances and opportunities from a school environment. Further, achieving inclusive spaces would begin with designing spaces that assist the learning of children in general. This suggests that standardised approaches and generic school designs would essentially fail to act as inclusive spaces, and that the notion of child-centredness needs to be incorporated as part of inclusive design strategies to assist learning for those with LDs. However, this raises the question of what it means from a design perspective to create child-centred solutions. What are the potential difficulties of meeting such an aim? The following section examines

these questions to further an understanding of the challenges and pathways to solutions for inclusive school environments for those with LDs.

7.4.1 Unique perceptions necessitate unique design approaches

The inherent uniqueness of humans, including prior experiences and cultural or economic backgrounds, results in differences in how individuals perceive and rate their physical environment (Rapoport 1990). The way humans respond, and the factors that influence their responses to their environments, form the crux of EBR. As such, they also form part of the theoretical underpinnings of this research. Central to this premise is that an individual's response to their environment is governed by what meaning the environment holds for them (Rapoport 1990). Rapoport (1990, 15) explained this further:

> On the basis of the view that the human mind basically works [by] trying to impose meaning on the world through… the use of cognitive taxonomies, categories and schemata and that built forms, like other aspects of material culture, are physical expressions of these schemata and domains.

Rapoport's (1990) assumption is that built environments hold both tangible and intangible cues that convey specific meanings to users, who further decode these meanings based on multiple factors, such as their associational, perceptual or socio-cultural backgrounds or the symbolic aspects of the environment. Thus, the interpretation of a school environment by its users defines their response. Further, the permutations and combinations of the above multiple factors result in unique differences in the ways in which individuals perceive a particular environment. If every individual is unique in terms of a response to their built environment, then a classroom or built space may theoretically evoke a unique response from each occupant or individual. This further suggests that the responses of children with LDs could differ from those without LDs, depending on the type of disorder co-occurring with their LD, such as ADHD, ADD or sensory processing disorder. Understanding these unique differences and similarities in responding to school environments for children with and without LDs is vital to developing learning spaces that assist learning and are inclusive in nature.

Children are spontaneous and imaginative, and their perceptions differ from those of adults (Day 2007; Evans 1980; Piaget and Inhelder 1963). Consequently, learning spaces designed for or assigned to them should not only appeal to their levels of perception and aestheticism, but also to their sense of perception to fuel creativity and complement their sensibilities of space (developmental, sensorial and perceptual). However, in the context of school buildings, the nature of the built environment rarely incorporates physical expressions of young children's 'schemata and domains', even though they are the key users of the learning environments.

The imprints of past systems of the standardisation of space and behaviour can still be seen in current school design approaches (Dudek 2000). This 'one-size-fits-all'[60] approach was at the core of the evolution of school architecture and resulted in generic spaces lacking an understanding of the spatial needs of children—specifically those with LDs. While there is currently a better understanding of the special needs of children with LDs, there still exists in design practice the tendency to adhere to standards that are rigid and reflective of the 'one-size-fits-all' approach. Consequently, meshing the needs of two groups of students with differing spatial needs becomes a challenge. For instance, those with LDs have additional requirements for spatial contingencies, enabling them to cope with the routine challenges of studying in a mainstream school (including social challenges and an associated need for restorative environments). As Higgins et al. (2005, 36) explained:

> Once basic standards have been met there is often no clear guide to priorities, and evaluating the effects of the physical environment in relation to multiple factors is difficult owing to the interplay of factors.

In the absence of a clear guide on how to proceed beyond the standards, customising school designs to respect the psychological and unique perceptual needs of young groups of users and those with LDs becomes an immediate challenge. The lack of a coherent guide and an understanding of the links between environment and behaviour will prevent the creation of child-centred and inclusive school

[60] The dictionary meaning of the term 'one size fits all' refers to a procedure that caters to a wide range of tastes or needs (OED 2006). Used in the context of clothing, this can also be extended to mean ideas, objects or methods that could 'apply to or suit everyone, regardless of individual differences' (OED 2000).

environments. Subsequently, school designs that result from this unawareness are nothing more than colourful, cost-effective, sustainable 'industrial sheds'.

7.5 Integrated and User-centred Approaches Towards an Inclusive School Environment

Designing inclusive school buildings can be a challenging process for school designers because of the myriad of complexities involved in addressing the diverse needs of children with LDs. Nonetheless, innovative models are emerging from architectural practice that have abandoned obsolete notions of determinism or functionalism as design paradigms and embraced integrated and holistic methods for school design. These methods address the key idea that built environments are important in influencing children's mental and physical health; consequently, newer approaches are needed that are user-centred and responsive to children's learning needs.

As discussed in Chapter 4, the notion of user centredness requires an emphasis on the needs of primary users to understand how and what is required from school environments to facilitate learning. In the context of this thesis, user-centred approaches further refer to design methods that emphasise the spatial needs of the three groups of primary users: teachers, children with LDs and those without LDs. The practice of engaging teachers emerged in the 1960s and 1970s in an effort to respond to the cost-cutting measures imposed in the 1950s (Woolner et al. 2007). As the values and challenges of teacher consultations have been well researched (Cooper 1981, 1985; Martin 2004; Woolner et al. 2007), this review focuses on the value of engaging children—specifically those with LDs—in creating school environments that assist learning by being supportive and inclusive in nature.

A user-centred approach emphasises children's needs to develop design strategies; it enables the creation of inclusive school environments. These types of approaches that involve consultation with primary users further an understanding of how to apply theoretical (e.g., derived from EBR) and empirical evidence (e.g., gleaned

from education for those with LDs) in creating environments that assist learning for those with LDs.

Numerous models of user-centred approaches have been explored as a way of responding to the complexities of designing multiple user spaces. These include models such as the complexity science framework in mathematics (Upitis 2004), pattern language (Alexander, Ishikawa and Silverstein 1977) and the participatory design method (see Sanoff 1978). However, the review focuses on the challenges of a user-centred approach to examine the weaknesses and strengths of using such approaches in design practice involving children with LDs, some of whom who may have difficulties expressing their views.

7.5.1 Children as participants in the design process

Despite being the primary users of a school space, children are generally excluded from the design process (Walden 2009), perhaps because of the view that they would lack the ability to express coherent opinions about environmental aesthetics that could be translated into practical applications for school design. Based on the findings of pilot studies integrating preschool education and architecture, Şahin and Türkün (2012) conducted further research on the possibility of collecting viable data for design from children in the age group of 5–6 years about their experiences and ideas of their physical environments. Their findings confirmed that children could be an important source for valuable information and assist in the design process of their physical environments. In another study that aimed to gain insights into children's views of their paediatric hospital environments, Adams et al. (2010, 658) found that 'children's [insights] can be valuable as agents of architectural knowledge, reporting on and recording their observations of hospital architecture with remarkable sophistication'. Bland and Sharma-Brymer (2012, 86) reiterated the importance of differing perspectives on children's conceptions of learning environments, citing the example of the inclusion of nature in schools by stating: 'In their bright and colourful learning spaces, filled with creative possibilities, interacting with the natural world away from drab classrooms, students are likely to feel a greater sense of belonging and engagement'. They added that school designers could benefit from children's 'imaginative contributions' in the school design process. The ability to independently

judge the specifics of the built environment is a crucial aspect of pre-design research that needs to be addressed when designing school environments for children.

From an educational perspective, school environments that are designed to be aesthetically positive and experientially rich for learners provide a wealth of information sources for learning and have positive influences on learners' sense of place (Adams 1991; Barrett and Barrett 2010; Day 2007). These influences on learners' senses of belonging, engagement and place contribute to better learning abilities. However, the argument that aesthetics are abandoned in favour of budget and social factors (Adams 1991) contradicts practical situations where a generous budget results in aesthetically balanced school buildings, but aesthetic according to designers' and adults' perceptual senses. To design school environments that respond to and resonate with the needs of children—specifically those with LDs who experience a range of social and physical challenges in mainstream schools—it is necessary to obtain their insights into what constitutes aesthetically positive and nurturing spaces for learning.

However, there are only a limited number of schools globally where design and planning have been a result of community participation and children's insights into their desired school environments—for example, the Brindishe Community School in Lee, South East London (Taylor 2000). Student participation is not the standard procedure for designing school buildings in general. There are two debates around involving children in the process of design. The first, as stated previously, arises from concerns about the ability of children to provide viable data for the design development process (Hill 2005; Walden 2009). An exploration of methods to address this issue indicates that the extent of the effectiveness of student participation for gaining viable data is variable (Middleton 2006). The second issue is rooted in arguments about the process of consulting students, which it is claimed could be merely cursory or managerial without a genuine understanding about whether the data gained would affect the design solutions (Clark and Percy-Smith 2006; Woolner et al. 2007). The challenge is further exacerbated by the case of children with LDs who may have difficulty verbalising their feedback. Nonetheless, these issues need to be addressed, as school designs cannot respond to the needs of children and be

supportive of their learning processes without understanding the factors that facilitate or impede their learning.

Interdisciplinary collaborations with special needs consultants and educators to obtain data could help to eliminate some of the uncertainties about gaining viable data from those with LDs. Bridging the intradisciplinary gaps between design research and practice would further enable analysis of the data collected and could also draw on existing frameworks in research and practice that have already tested participatory processes involving children. Parnell, Cave and Torrington (2008, 211) explained that there is a 'need to acknowledge the opportunities which lie within the process and to not just be fixed on the product—the finished school', justifying the need to encourage users to participate in the design process. Involving children, although considered cumbersome, time-consuming and adding to the complexities of the design process (Lippman 2010a; Woolner et al. 2007), is essential to better understand how designs can resonate with the needs of those with LDs based on their perceptions and understandings of space. This is especially important because LDs is a fast-developing field, with co-occurring disorders such as ADHD, ADD and ASD further adding differences within this group and diversifying understandings of the environments.

7.5.2 Using architecture as a three-dimensional tool to facilitate learning

A clear understanding of primary users' expectations—in this case, young children with LDs—of a learning space is essential for designing spaces that help achieve teaching and learning objectives while acknowledging diversity in the learning and behavioural needs of the students in the school and classroom. Consequently, architectural and design practitioners need to embrace holistic approaches when designing learning environments that will influence 'motivational and perspective-changing benefits beyond… specific problem-solving' (Higgins et al. 2005, 37). Taylor (2010, 32) pointed out that to bridge disciplinary and procedural gaps:

> Architects must integrate their design knowledge with an understanding of interdisciplinary learning and the developmental needs and learning styles of students, while at the same time educators, parents and students must broaden their awareness of the built, natural and cultural environment and its potential as a learning tool.

A model grounded in such an all-encompassing design approach is seen in the design practice led by a team of environmental designers and architects/aesthetic educators specialising in school design. Taylor and Vlastos (1975) present a holistic conceptual approach to school design, which they refer to as 'architecture as 3-D textbook' (Taylor and Vlastos 1975). Having pursued and researched strategies to improve built, natural and cultural environments for children, they arrived at the conclusion that rich learning experiences can be created by designing inherent elements of the building and site to function as 'learning tools' in themselves, thus making the whole learning environment 'an active, not passive set of spaces' (Taylor 1993, 106). For them, architecture (comprising built, natural and cultural environments) may be considered a valuable teaching tool for designing an optimal and useful learning environment. The learning environment comprises the physical and social environments and their users. The design of a learning space forms part of this holistic and integrated approach to the creation of a learning environment, as illustrated in Figure 7.3.

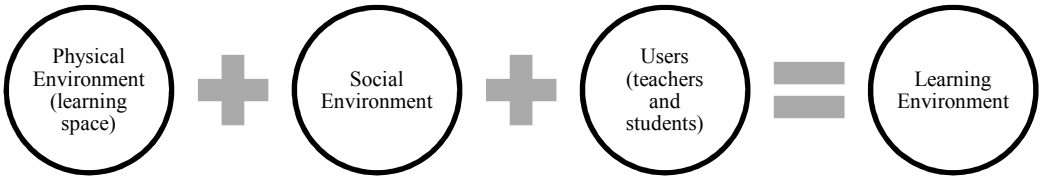


Figure 7.3: Model illustrating 'architecture as 3-D textbook' design approach (Created by author to illustrate Taylor and Vlastos 1975)

Examples of this concept, in which students' developmental and pedagogical needs were placed foremost in the design of learning spaces, can be found in two US schools—Trout Lake, Washington and Stockton, California. Citing these schools as examples, Taylor (1993) argued that architecture can be a valuable and powerful medium for teaching. While stressing the importance of the built and natural forms of the environment, she argued that there is a paucity of 'optimal and supportive' learning environments for children on a wider scale, despite available knowledge with regard to 'what needs to be done' in the creation of learning environments. She

speculated that this might be the result of a lack of understanding with regard to 'how to do what needs to be done' (Taylor 1993, 105).

Thus, designers need to closely examine how school environments can be designed to facilitate learning by working closely with the primary users (educators and children) to first understand what needs to be done to design a space that enables educators to organise settings to include children with LDs in mainstream school environments. Second, designers should seek to understand how mainstream school environments can provide relevant, meaningful opportunities for learning processes for children with LDs. Based on environment–behaviour theories (such as sensory overloads, levels of arousal, affordances and person–environment fit) relevant to the over- and under-stimulation of learning processes in children with LDs that co-occur with other disorders, these strategies must focus on designing spaces that respond to their spatial sensibilities and provide agreeable challenges and positive experiences (sensory, cognitive, experiential, social) relevant to their learning processes. More importantly, contingency spaces for children with LDs must be created to enable them to cope with the physical and social challenges experienced as a routine part of learning in mainstream schools.

7.6 Discussion

Chapter 7 highlighted the difficulties that occur when multiple factors of architecture, education and spatial design come together in the formation of a school building. The first problem is that, even though knowledge exists in the contexts of both education and architecture regarding the ways in which schools can shape behaviours and minds, there appears to be a deficiency in its dissemination and use in the practice of architectural school design. Consequently, in the absence of a coherent dialogue between design and education, pedagogy strongly dictates space, as architecture appears to be disconnected from the pedagogical needs of learning spaces and the spatial needs of those with LDs in mainstream schools. The second issue is that there appears to be a disconnection in disciplinary perspectives on how to apply child-centred principles of learning to design processes while maintaining twenty-first-century challenges of cost and time efficiency. Resolving these issues could begin with a review of the process of school design by incorporating

knowledge from research in architecture and drawing on evidence gathered by the education and behavioural sciences. This chapter has provided such a review.

The review demonstrates that in the specific context of school environments, most conventional design approaches to schools focus on health and safety standards—so much so that the environment–behaviour nexus between users and their environments is often overlooked. The issue here appears to be that while these factors, such as safety and cost efficiency, in design approaches are beneficial and important, they are incomplete in terms of methodology, where design customisation ceases at the point that it adheres to standards and guidelines. Designers of school environments should question approaches that fail to look further than the building and safety standards of design. Presumptions must be abandoned in favour of innovative design strategies that are developed to address the complexities of multi-occupant spaces for users with diverse spatial needs.

Based on the above, this chapter identifies that collaborative research efforts are needed to further inform the design process from both intra- and interdisciplinary perspectives. As Mitchell and Lang (1974, 17) stated, while professional training shapes aspiring architect minds to follow what will establish their 'professional credentials', it neither encourages input from behavioural science nor highlights the value of forming a collaborative nexus with other related disciplines. An integrated approach between architects and educators is essential to arrive at solutions based on environment–behaviour perspectives. These environment–behaviour-based school designs will then be able to offer children with LDs experiences and engagements that are most relevant to them to achieve person–environment fit and learner–environment transactions, thereby assisting learning.

Barrett and Barrett (2010) argued that despite the quantum of research and literature on specific aspects of building performance, a framework is needed that will enable designers to apply these findings in practice. This adds to the difficulties of designing spaces that will respond to the needs of both groups of children studying in the same school environment, especially when data about LDs are still emerging. While this thesis acknowledges that data from research into children with LDs specifically related to limited attention spans and hyperactivity are scarce, it also considers that the proposed strategies (such as research and practice-based collaborative models)

will provide an analytical framework for further research and its application to the design of school environments for children with LDs. In this regard, the review outlines future areas for study. Existing examples of school designs based on the idea of using architecture as an active tool to facilitate learning, such as using pattern language in school architecture (Alexander, Ishikawa and Silverstein 1977) and architecture as a 3-D model for learning (Taylor 1993), could pave the way for research on innovative, holistic school buildings. These examples show promise for further research in their attempts to create school designs with the objective of supporting learning by creating experientially engaging spaces that are relevant to learner–environment transactions. However, these are unconventional design approaches and should be included in guidelines for school design informing school design professionals about options for designing supportive learning spaces.

The review also indicates, via an examination of research-based design strategies, that the creation of an optimal learning environment is an ongoing metamorphic process that requires gaps to be bridged by forming a symbiotic interdisciplinary nexus between education and architecture and an intradisciplinary nexus between design practice and research. Nonetheless, to generate designs to help specific LDs, such as those co-occurring with other disorders, a further summation of findings from both architecture and education research needs to be examined and, more importantly, applied in practice. In response, this review proposes a reiterative school design approach based on Kolb's experiential model, where practical applications of design can again inform research on the success or failure of previous findings, thus providing a clearer image of the specifics of school design that would assist learning abilities. This would be an evolutionary and transformative process for design, as the findings on LDs specifically co-occurring with other disorders are still in the developing stage. Thus, designers would need to remain informed about research findings to be able to design inclusive learning environments.

The review highlights the value of child-centred approaches in responding to the needs of those with LDs in mainstream schools. As spatial perceptions and responses differ based on a variety of factors (e.g., perceptions, associations and cognitive and sensorial abilities)—specifically among those with LDs that co-occur with other disorders, school environments cannot be designed on the assumption that what

works for one group of users will work for another. For children with LDs, these understandings of school environments need further examination based on co-occurring disorders (e.g., sensory processing disorders) that can affect how learners perceive and negotiate space. Thus, it is important for designers to understand what the children of this group construe as supportive spaces. Without this understanding, mainstream school environments will continue to be passive backdrops to learning and, in many cases, to act as impediments[61] to those with LDs.

Thus, this review concludes that there is a crucial need for fresh disciplinary perspectives in school design that depart from generic design solutions for schools and encourage children with and without LDs to participate in the design process. This does not imply abandoning economical models such as standard prototypes, but it requires developing these models further according to evidence-based strategies from practice and research. This will help designers to avoid issues related to the fallacious 'one-size-fits-all' approach (involving a disconnection from the distinct spatial needs of children with LDs) that results in school buildings that fail to respond to users' diverse spatial needs and that will assist the learning of those with LDs studying in mainstream schools.

7.7 Summary

Chapter 7 highlighted the intra- and interdisciplinary gaps that pose challenges for designers seeking to develop child-centred and inclusive school designs. It also proposed a reiterative research-based model drawing on a cyclic process of experience–feedback–testing and its application according to the literature, which suggests the need to emphasise users' spatial needs, intra- and interdisciplinary collaborations and the refining of school designs based on research and users' feedback. Considering the gaps in the existing knowledge and, specifically, the need to further knowledge about children's perceptions of supportive spaces for learning, Chapter 8 examines spatial understanding from real-life studies in three mainstream schools in Perth, WA. These schools include children with and without LDs, thereby

[61] Chapters 3 and 5 highlighted the theoretical underpinnings of EBR and education, demonstrating that unbalanced environments (e.g., excessively coloured or colourless) can impede task performance by causing inattention and fatigue among learners. Providing balanced environmental conditions in school spaces is therefore vital to assist learning in children in general, and more so in those with LDs, as their difficulties with learning could be intensified by unbalanced environmental conditions.

enabling a collection of insights to be obtained from both groups regarding their notions of school environments, and thus contributing to an understanding of child-centred and inclusive school design.

Chapter 8: Exploring Children's Notions of Learning Environments: Data Collection from Three Schools in Perth

8.1 Introduction

Chapter 2 outlined the supplementary roles of case studies and theoretical frameworks that could be applied to further an understanding of the spatial needs of children with diverse abilities studying in mainstream schools. Chapters 5 and 6 highlighted the effects of the built and natural elements of school environments on children with and without LDs and the value of understanding children's diverse abilities and unique spatial perceptions. Based on these, Chapter 7 examined the challenges of achieving child-centred and inclusive school designs and related issues from design practice and research. This chapter describes the data collected from three primary schools in Perth, WA, to further investigate children's perceptions of their learning environments based on the foundations set by the previous chapters.

As outlined in Chapter 2, the case studies used a combination of questionnaires and other open-ended surveys (mixed method with triangulation approach) to determine specific place preferences in schools and the associated factors (emotional, behavioural, cultural) that affected these choices. The key objective of the case studies was to gather data on children's experiences and perspectives of their learning environments in the naturalistic setting of a school environment and to compare these observations with the theoretical component to further an understanding of the creation of child-centred and inclusive school environments.

The first survey was the students' insights questionnaires (see Appendix A), which noted their views of their school environments. This was followed by the image survey,[62] which used a selection of images of school spaces (see Table 8.1) and examined the factors that influenced participants' ratings of these images to further understand their expectations of their school environments, which differed from typical Australian schools (e.g., aesthetics, materiality and affordances).

[62] The selection of images of school buildings for the image survey (see Appendix B) was mainly based on buildings that differed at various levels from conventional school environments.

Lastly, the wish poem and art surveys sought to gain additional insights into participants' expectations of their learning environment, while also providing an alternative medium of expression for those who found it difficult to express their views verbally or in written form.

The passive observations ran in parallel, with data being collected through:

- field observations
- photography
- architecture research forms
- behavioural observations.

The aim was to gather data on existing school facilities regarding:

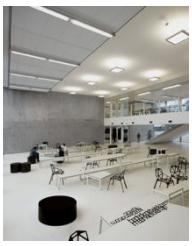
- spatial design—exteriors and interiors
- patterns of spatial use by children with and without LDs
- variations in the environmental affordances of the formal and informal learning spaces and their effect on participants' behaviour and spatial engagement.

The images used for the image surveys are outlined in Table 8.1.

Table 8.1: Descriptions of images from image survey[63]

Images	Description
 	Images B1 and B2: Selected as examples of typical Australian schools with a prefab structure. Differs in aesthetics, appearance and materiality.

[63] Details of the selection criteria and image sources for the images used in the surveys can be found in Appendix B.

	Image B3: Differs in appearance and materiality—structurally bigger, unique roof profile and reflective surfaces.
	Image B4: Stark contrast to schools in the Western world in aesthetics, materiality and facilities.
	Image C1: Open-plan classroom with spatial arrangement that differ from traditional classroom settings.
	Image C2: Colourful, yet structured and uncluttered, which differs from typical classrooms.
	Image C3: Deviates from typical classrooms in physical aspects—spatial organisation, materiality (textures and warmth of wood) and the openness of the space.
	Image M1: Supplementary space. Deviates from typical school space—circular seating arrangement and views towards nature.
	Image M2: Circulation space—multi-storey interiors, openness and transparency.
 	Images M3.1 (left) and M3.2 (right): Supplementary and circulation space. Minimal colour palettes—‘extremes’ of colours and materials in school spaces.

Based on the aims and methods defined above, the first school studied is described below.

8.2 School 1 (Montessori)

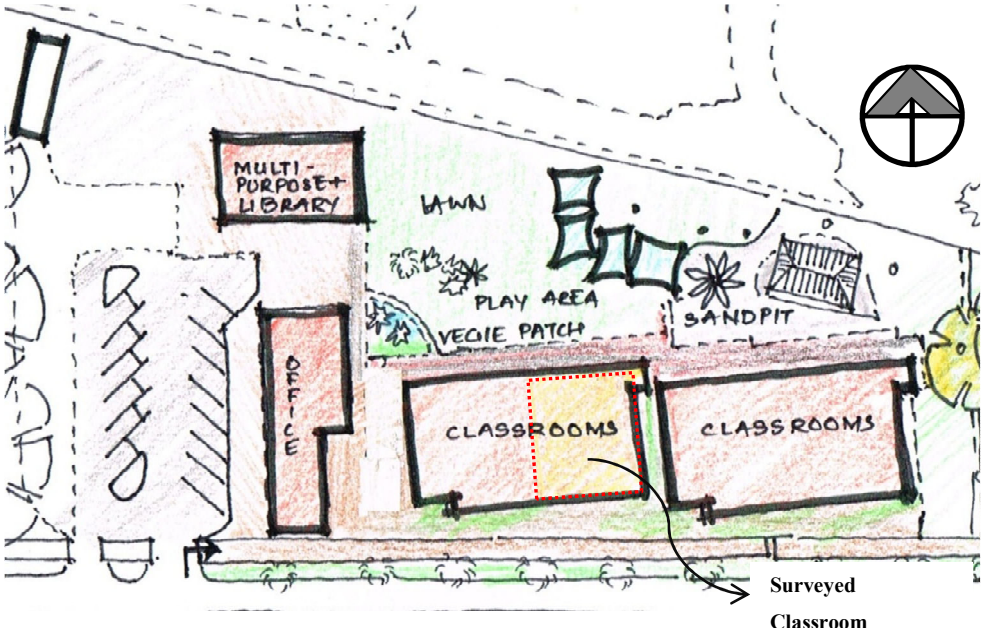


Figure 8.1: School 1 (Montessori)—schematic site plan

Case studies in School 1 were conducted over ten school days, and 14 out of 17 students from one class opted to participate in the study. The prefabricated building was one of several that formed 'learning clusters'. There were two classrooms in each cluster, and they were arranged along the perimeter in an L-shape. The remainder of the site comprised play areas and assembly space.

8.2.1 Passive observations

The passive observations in School 1 comprised data on classrooms occupied by students, as well as school exteriors that were part of their routine school activities. Interior spaces approved for School 1 were limited to the classroom space because other spaces were not part of the scheduled lessons for the period of the case study.

1. Entrance deck
2. Main foyer and bag storage
3. Teacher workstation
4. Toilets
5. Special needs student desk
6. Teacher desk
7. Storage
8. Group discussion area (floor seating)
9. Undercover area for meals
10. Veggie patch
11. Towards lawn and play areas
12. Kitchen counters

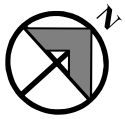


Figure 8.2: School 1—schematic floor plan

Figure 8.3: Classroom (view from special needs desk)

Figure 8.4: Classroom (view from teacher's desk)

Interiors

The classroom was rectangular and had a small L-shaped extension that formed an area for bag storage and served as an entry area (see Figure 8.2). The main entry to the classroom acted as a drop-off point for parents and had provisions for students to leave their bags and personal belongings. This led to a computer niche and a small workspace for the teachers. While the classroom had space to accommodate multiple pieces of storage furniture accessible to students, as well as a storage room for the teachers, these were aligned against the wall and not used for spatial segregation or variations, as per Montessori philosophy.

No special design features were provided, such as privacy corners for medication or quiet corners for children with inattention issues.

Classroom organisation and furniture

The classroom had a variety of group seating arrangements that were created using standard school furniture, except for one student with a diagnosed learning problem who was seated adjacent to the teacher (see Figures 8.2 and 8.6). However, the arrangement exhibited little variation in the types of furniture used. A dedicated section of the classroom had one large area with a floor rug for group discussions and a smaller area for a reading corner. The spatial arrangement did not reflect diversity in terms of the Montessori pedagogy; for example, it did not contain space to allow for pacing as per aptitude. However, furniture was scaled to the children's size, and the essential study equipment was accessible for student use.

The room was being used to its full capacity and appeared visually saturated and slightly cluttered. However, children's perceptions in the questionnaires showed that the 'clutter' for typical students added to a sense of pride and ownership, with one

(typical) student stating that their work displayed on the classroom walls and ceiling was its best feature. While the space had been organised technically as per Montessori pedagogies, with all furniture accessible to children, the typical characteristics of free movement, engagement and self-guided learning were not very evident here. This may have been because of spatial constraints or pedagogical interpretations regarding the layout of the classroom space.

Two kitchen counters were provided—one for teachers and a smaller one for students—based on the Montessori philosophy of creating accessible environments relevant to the sense of spatial scale of young children. This accessibility is an important feature, wherein the objective is to enable independence and self-guided learning among children of both groups. However, it was not a very good example of a model where dialogue occurs between education and the built environment; this was primarily because of deficits in spatial size along with interpretational differences in the implementation of the pedagogy. For instance, interpretation and articulation of the Montessori model's experiential learning theory (where self-guided learning and freedom of spatial engagement are encouraged to facilitate learning) were not very evident in this classroom, although the literature (Lillard 2012) suggests that it frequently occurs in practice. The deficit in spatial size was noted by teachers as a key impediment to them being able to experiment and be innovative with educational intervention strategies.

Figure 8.5: 'One for teacher and one for me' (kitchenette)

Colour palette

The interior palette of materials and colours was a subtle palette of blue vinyl flooring with light walls and timber and plastic furniture. The wall colour of the classroom was a subdued pastel shade of pink (see Figure 8.6) that lent a backdrop to the eclectic display of student work and study materials, such as wooden blocks and beads. The questionnaire responses indicated that most students, including a student with LDs, preferred this classroom's colour palette to be different and colourful. Others pointed out that the classroom would be better with more colourful objects, such as those already displayed on the walls and hanging from the ceiling. One non-LD student recommended that the rug's colours be changed to add colour to the interior palette. From a designer's perspective, the researcher observed that the subtle palette may have added coherence to the settings by offering a base to display the students' colourful art and activities, as well as the warm wooden furniture and eclectic assortment of Montessori study equipment. Alternatively, an environmental colour (such as blue) might be recommended for behavioural and physiological improvements for those with sensory deficits, as well as for typical students. The current colour scheme did neither, which was pointed out by two students out of the six who participated in the questionnaire surveys.

Figure 8.6: Special needs student desk for solo work

Learning space

From a design perspective, the space lacked any prominent features that would distinguish it from a structured school setting. While the organisation showed options such as rugs and equipment recommended by the Montessori pedagogy, these were not accessed or explored fully, in contrast to expectations discussed in the literature on Montessori learning environments.

Aside from the furniture being arranged close to the teacher and teaching assistant, which is recommended as a structural intervention in educational literature (Carbone 2001; Mostafa 2008), the classroom lacked any distinct spatial or design features to suggest a space dedicated to addressing the needs of children with LDs—for example, secluded work zones for those with inattention issues, specialised chair-and-desk sets for organising study materials, and study carrels to enable students who exhibit inabilities to locate frequently misplaced study materials (Carbone 2001; Weinstein 1977). The organisational complexity posed a problem for the student at the higher end of the autism spectrum, who experienced difficulties staying in the dedicated space adjacent to the teacher and participating in class activities. The teachers commented that they found it challenging to apply a structural intervention to enable this student to meet learning objectives, citing spatial constraints as a major impediment. However, they also observed that a larger space would make it difficult to watch over children with needs at the higher end of the behavioural spectrum, such as those with ADD/ADHD and ASD.

Figure 8.7: Rugs and child-sized bookshelves organised into a reading corner, and a larger rug for group discussions

Figure 8.8: Teaching aid desk next to special needs student (left) and entry foyer with bag storage (right)

Figure 8.9: Fixed glass viewing window to toilet

Pedagogical attempts to organise the space in line with Montessori philosophies were seen in two areas that provided rugs as alternative seating options to chairs and desk sets. One of these areas was a reading corner, and the other was a group discussion area. However, children were not seen to take the initiative to engage with this limited space, even though the questionnaires showed that at least two out of the six students preferred the areas with rugs to the chair-and-desk seating. Again, this may be an indication of differences in implementation dictating spatial use, which is outside the scope of this thesis. However, it is important to note the need to afford spatial provision in terms of scale and size to give educators the opportunity to experiment without spatial constraints.

Adjacent to the classroom was a toilet provided for children of both genders. An observation window was provided for teachers to monitor children from within the classroom in case they needed help—for example, if they were sick. Teacher narratives added that this helped them to manage the class in session while

addressing the needs of any sick students using the toilet with the help of the teaching assistant. While the window seemed intrusive, it was perhaps considered necessary by the educators to ensure that the young children's safety and health were monitored in cases of illness or injury that occurred while the teachers were busy in class. Such customisations could form part of design briefs developed from users' perspectives of work efficiency and safety.

Thermal comfort settings were effectively managed, as were the natural and artificial light provisions. There was also no unwanted noise transference from outside the school campus (from traffic), within the school building (from adjacent classrooms) or within the class (from conversations within the classroom). This observation was supported by the students' and teachers' responses, which cited no issues with noise, temperature or ventilation.

Exterior spaces

A second set of wider glass doors led to the inside of the school campus through a shaded pergola area that also acted as a meals area with seats (see Figure 8.10). This semi-open area with a view of the green areas seemed insufficient for student interactions while eating. Additionally, the width of the patio was considered insufficient to prevent rain splatter onto the chairs and tables. This narrow space provided little opportunity for students to circulate freely or engage in any forms of communication. This was also commented on by one of the students during the surveys.

Figure 8.10: Outdoor semi-open meals area outside the classroom

The play area had a variety of material textures, such as artificial and natural lawns, a sandpit, mulch, and a hard-concreted, semi-open area used mostly for assembly and

play by higher-grade students. Each of these textual surfaces had elements for play and exploration. The sandpit had a wooden dinghy with rubber tyres, and similar items were dispersed in other areas (see Figure 8.11). To the researcher, it seemed minimalistic and uninteresting. Nevertheless, the questionnaire survey responses reflected that the children engaged with all available objects in the play areas, including the large concrete pipes (see Figure 8.12), enabling them to enact their needs, such as playing hide and seek or hiding away when they required quiet time. They had incorporated each of these limited elements and parts of the natural settings into their make-believe games, even though the play areas lacked size and a variety of play equipment.

Figure 8.11: Sandpit play area

A mulched area with the beginnings of a bush garden was already eliciting responses from children in the various activities and games they played, and they referred to this area as a 'bush garden'. This shows that the children not only adapted to the environmental limitations, but were also able to engage with such spaces using their fertile imaginations.

Nestled in a corner of the play area was a 'frog pond' made out of an old bath tub (see Figure 8.13). It looked relatively small with respect to other landscaped elements and went almost unnoticed until the children were seen walking in and out of this small area and examining the flowing water and aquatic organisms. It had clearly been built to suit the scale of the children, and to a child it might feel as though they were in a small garden or forest. This was perhaps in keeping with their whimsical imaginations. To an adult, this would hardly form an impression about the experiential value of a place, but to a child it might be a cherished feature of the school environment. The extent to which this was the case can be determined from the questionnaires and surveys. The pond was also visible from the main entry foyer

(see Figure 8.14) and was secured by low gates. It provided a partial view into the schoolyard, but limited access for visitors.

Figure 8.12: Circular pipes for 'hideaway' games

Figure 8.13: Frog pond

Figure 8.14: Outdoor waiting area outside main office

Figure 8.15: Entry—foyer to classroom

Figure 8.16: Pathway from main entry to classroom

Figure 8.17: Learning clusters—building housing multiple classrooms

The school building surveyed was one among several that formed learning clusters arranged along the perimeter in an L-shape, leaving the resulting site area for play and assembly. Each learning cluster with two to three classrooms in a building had an entry flanked with something like a front porch to a home (see Figures 8.15–8.17). Although ordinary in appearance, a closer inspection revealed students' handmade

works, such as tiles, mini murals and painted patterns on paving (see Figure 8.18). These objects, which were embedded into the built site and school environment, were suggestive of the aim to create a sense of ownership and belonging at the school.

Figure 8.18: Handmade garden feature by student

The main entry to the school site is too simplistic to stand apart as a main gate to a school (see Figure 8.19) and is perhaps in accordance with the Montessori pedagogy of visually subtle learning environments or an attempt to replicate the familiar or 'secure' environs of home (Korpela 2002). The simplicity of the surroundings is carried forward into the interiors and landscape, and it would be worthwhile to undertake questionnaires and surveys to determine how the students rate this school campus experientially and aesthetically.

Figure 8.19: Main entry to School 1

8.2.2 Tool 1: questionnaire

In addition to the above factors, both typical students and those with LDs stated that they had no issues finding their way around the school site, indicating that the layout was accessible by students of both groups. From the preferred attributes of the school

building itself, only two out of the six students[64] surveyed mentioned that they liked the colours of the school, including one student with an LD (undiagnosed ASD), who considered the building and classroom comfortably spacious. All students stated that there was no specific part of the existing building that they liked or disliked, while two students added that they liked other parts of the school campus, such as the library and computer room, because they enjoyed reading or working on the computer. Again, this neutral attitude to the current school space may suggest that the space is lacking in its quality of engagement and is not experientially rich in environmental affordances from a spatial design perspective. Conversely, all students surveyed indicated a liking for multiple places outside the classroom, ranging from the frog pond to objects in their play areas. They also commented on the practical aspects that they felt could be improved, such as the semi-open areas for meal times receiving better protection from the weather.

During the period in which the survey was conducted, the outdoor patio roof span was insufficient to protect seats and dining tables from getting wet in the rain. The teachers also commented on this aspect and noted that the classroom sizes could be 'more sensible' than was currently the case; they were 'neither too small nor too big'. There were no significant deviations in the spatial preferences of either group of children. The children and their teachers believed there was room for improvement in the existing facilities of the building.

8.2.3 Tool 2: image survey report

School buildings

Out of the four school buildings shown to the students, the buildings that elicited the highest number of positive ratings were Image B4, followed by Image B1, with five positive ratings (see Figure 8.20). An important observation was that the students formed their opinions and drew inferences using not only the images in front of them, but also by evaluating them in relation to the previous images in the survey and subsequently comparing them to the limitations of the existing school facilities. For instance, the surveyed students noted that, similar to their occupied school,

[64] Six out of 14 students were able to participate in questionnaire survey. The remainder were unable to participate due to study schedules and absence due to illness.

Image B1 lacked a shelter or an undercover area to use when it rained; hence, it was not very 'likeable'. No significant differences in responses were seen between the LD group and typical students.

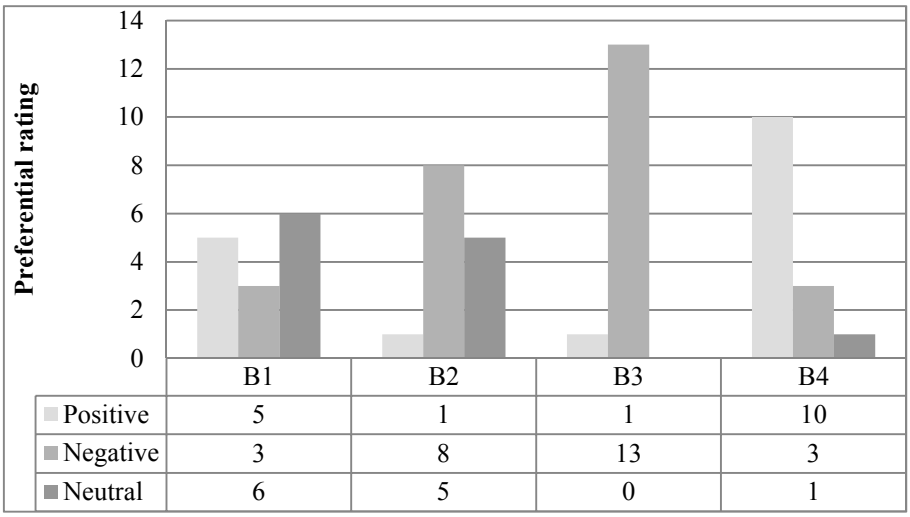


Figure 8.20: School building image ratings

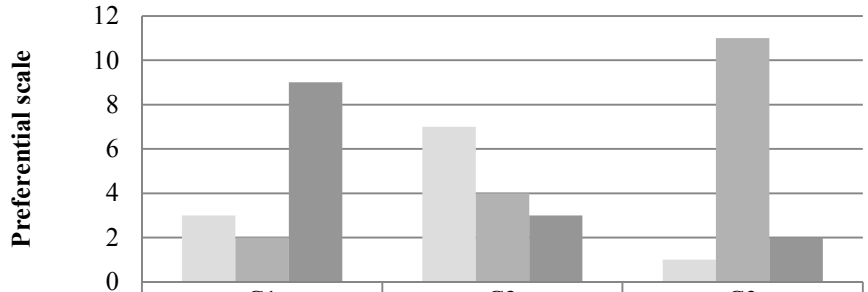
Appearance, aesthetics and size of the buildings were most influential in how students rated each of these images. For instance, multi-storey buildings (as in Images B1 and B4) were inferred as buildings that might be more spacious than the occupied school and the other images. The aesthetics of the building—for instance, the unique colour palette and sciographic projections in Image B1—elicited a positive response, whereas the lack of colours influenced ratings negatively for Image B2. However, when students were questioned as to why this building was not preferred, since it was similar to their own school, they responded that their existing school had 'some colours', was comparatively larger and had green play areas with no obtrusive fences, unlike Image B2.

Image B3 was rated highly on the negative preferential scale, mainly because the respondents could not relate the building in the image to how they thought a school building and its environs should appear. Their cultural and social backgrounds had influenced specific impressions about what was acceptable and unacceptable in a school building (Rapoport 1990). Although the previous two buildings were different from the occupied schools in terms of size and materials, they were acknowledged as possible school buildings and discussed accordingly.

For most of the images, the availability or lack of lawns and play equipment, as well as the size of the play areas, were key reasons given for negative ratings of the images. For example, lack of basic amenities such as green areas to play, play equipment and the barren and sandy nature of the landscape elicited negative ratings for Image B3. Similarly, comments were made relating to the 'green envelope' in Image B1, with one respondent commenting that the building looked 'too tight [and]… should open into more space'. The presence of lawn and play areas was one of the key reasons for positive ratings of Image B2.

Interior areas

Figure 8.21 demonstrates that of the three images of classroom interiors shown to the students, the highest positive rating was for Image C2 and the highest negative rating was for Image C3. The key factors influencing students' perceptions were colour palette, furniture and spatial arrangements, and a match with their understanding of what the classroom should provide in terms of experiences and engagement for learning to occur.



	C1	C2	C3
positive	3	7	1
negative	2	4	11
neutral	9	3	2

Figure 8.21: Classroom interior ratings

Image C1 received a mix of positive, negative and neutral comments. The negative ratings related to concerns regarding the students' capacity to complete their school work on zig-zag tables and in associated seating arrangements. Students made improvements to C1 by superimposing elements from their occupied classroom that were deemed important to their learning. This image was rated positively by students with LDs for the layout and subdued colour palette. Typical students rated the colour palette positively using adjectives such as 'OK' and 'nice'.

Image C2 was the most preferred for its colour palette. Students, including one of the students with LDs, used adjectives such as 'fun', 'bright' and 'nice' to describe their reasons for rating this image positively. However, the small number of negative ratings was due to some respondents finding the image 'too cluttered' and/or 'too colourful'; one of these students was an LD student with ASD.

Image C3 rated highly on the negative end of the preferential scale, with most respondents not being able to identify with the idea of learning occurring in a setting represented by the classroom in the image. The unfamiliar floor seating arrangements prompted concerns about being unable to sit on hard floors for the duration of a school day. The thick wooden beams were perceived as unsightly, as were the hard wooden floors. The window positioned at a higher level than their windows was perceived negatively, possibly because their windows allow views and permeability between indoor and outdoor spaces.

The classroom images did not reflect consistency in responses from the students of either group, reiterating the diversity of children's perceptual needs in a learning space. For instance, Image C3 was rated differently not only by children with LDs, but also by typical students. Additionally, any deviations from their ideas of what was normal in a classroom, such as colour, illumination, materiality and, most importantly, furniture and its arrangement, elicited negative ratings of the classroom as a learning space. All images were assessed by students based on what was familiar to their notions of a learning space, and yet they added comments on environmental excesses such as colour.

The overall responses to Image C2 suggest that while some students associated the idea of fun with colour, others felt that this classroom was 'too colourful' or 'too cluttered'. Similarly, differences were noted in the responses of the two LD students for Image C3, possibly because of variations in their types and spectra of LDs.

Miscellaneous school spaces

Of the four images from miscellaneous spaces in school buildings, Image M1 received the highest negative ratings and Image M2 received the highest positive ratings. The responses indicated that the ratings were influenced by spatial qualities of colour, affordances and size, as in previous images.

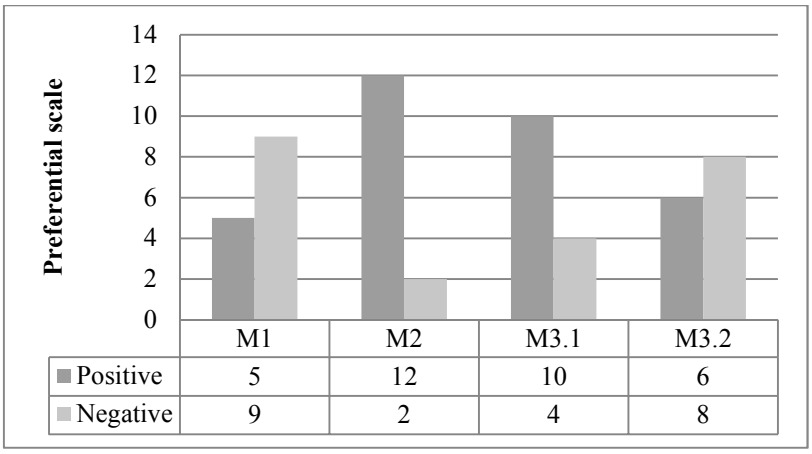


Figure 8.22: Miscellaneous school space ratings

Image M1 was the least preferred by both groups; responses were strongly reflective of their understandings of this space as not conforming to their prior notions and associations of a typical school space and the objects within such a space that inform its typicality. However, the presence of a 'bonfire' and circular seating raised some questions from the students, as well as speculation that such a space within a school would perhaps be suitable for non-academic subjects such as storytelling, socialising and eating food.

Image M2 was the most liked for the presence of a 'staircase'. This seemed to appeal to most students, including those with LDs (behavioural learning impediments and undiagnosed ASD). Other factors that influenced positive ratings were the potted plants and the pencil sculpture. These objects, along with the idea of climbing stairs to the classroom, were fascinating prospects for both groups.

Similar to the responses to the classroom images, the miscellaneous school space images were rejected when they did not conform to students' understanding and expectations of what typical school spaces should afford in terms of opportunities to learn. Excesses in the colour palette elicited negative ratings, as seen from responses to Images M3.1 and M3.2, while spaciousness and voluminosity were considered positive. Preferences differed among the students with LDs, with the ASD student disliking the space in Images M3.1 and M3.2 for its excessive use of white, but adding that it was nice except for its colour palette. This diversity could result from the ASD student's heightened sensory awareness of the physical environment.

8.2.4 Tool 3: wish poems and art survey

The wish poems predominantly suggested that there was dissatisfaction with the existing school building and classrooms in terms of size and the quality of specific facilities. Word cloud frequency analysis shows the dominance of three words—'bigger', 'better' and 'more'—that were used frequently in the contexts of school, classroom, playground, garden and library.

The site analysis of the fieldwork sketches and observations showed that the school met all 'standard'[65] criteria for space requirements. However, 'better library facilities' were mentioned as a desired feature of an ideal school. These were indeed lacking, as reflected in the answers to the teacher and student insights survey.

The wish poems showed that five out of 14 students felt that the school and/or the classroom could be larger. The playground was desired to be more spacious, with more and better play equipment than was currently at the school, including a flying fox, climbing frames and slides. A 'more colourful and brighter' classroom was also desired in addition to more study materials and locker facilities. The existing colour palette of the classroom comprised standard, subtle shades of light-coloured walls and blue vinyl flooring, with rugs to create a visual demarcation of areas for various activities (see site image and site analysis). However, this was not considered engaging or interesting enough to maintain a 'level of arousal' for some students. No specific comments were made regarding the aesthetics of the dream school building, other than changes to colour based on individuals' colour preferences. Finally, two students commented that their ideal school would be a multi-storeyed structure with a staircase.

[65] Based on this study alone, it cannot be claimed that building standards in terms of user numbers per space are insufficient. Such a deduction would require further studies on a greater number of schools to deduce discrepancies in any of the school design standards. This is beyond the scope of this study.

Figure 8.23: Art survey

The wish poem data from the two LD students did not reveal any significant differences in their concepts of the ideal school. One LD student wished for a green school with flowers (green being his favourite colour), and the second student expressed concerns regarding existing chairs, desiring that the ideal school have better chairs and a playground with a larger garden.

The drawings matched the statements in the wish poems and gave those with writing limitations the opportunity to express themselves through drawing. Additionally, equal numbers of students depicted either built environments only or built environments situated in green contexts (see Figure 8.23; right). For instance, after dividing the paper into four parts, one student drew his aspirations for the built and natural components of his dream school in each section (see Figure 8.23; left). In varying proportions, all except two students depicted naturalised aspects, including outdoor activity areas such as lawns and pools, as part of their drawings, implying that natural aspects informed and were a part of their understanding of school environments.

8.3 School 2 (Montessori)

School 2 was studied during class sessions over a period of 15 days in a classroom in which six students out of 14 opted to participate in the study. This was a newly constructed modular building with a view to green areas from a deck (see Figures 8.24 and 8.25).

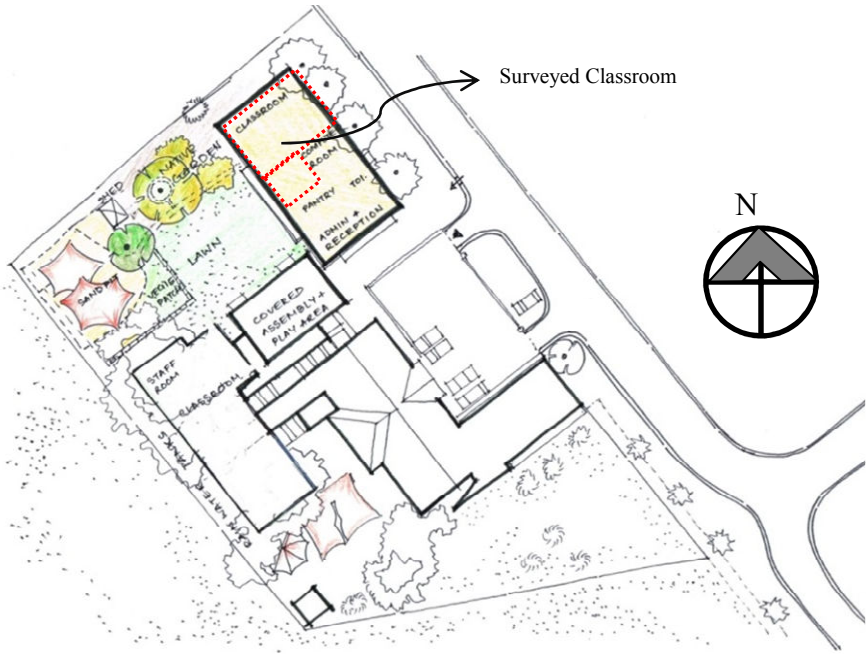
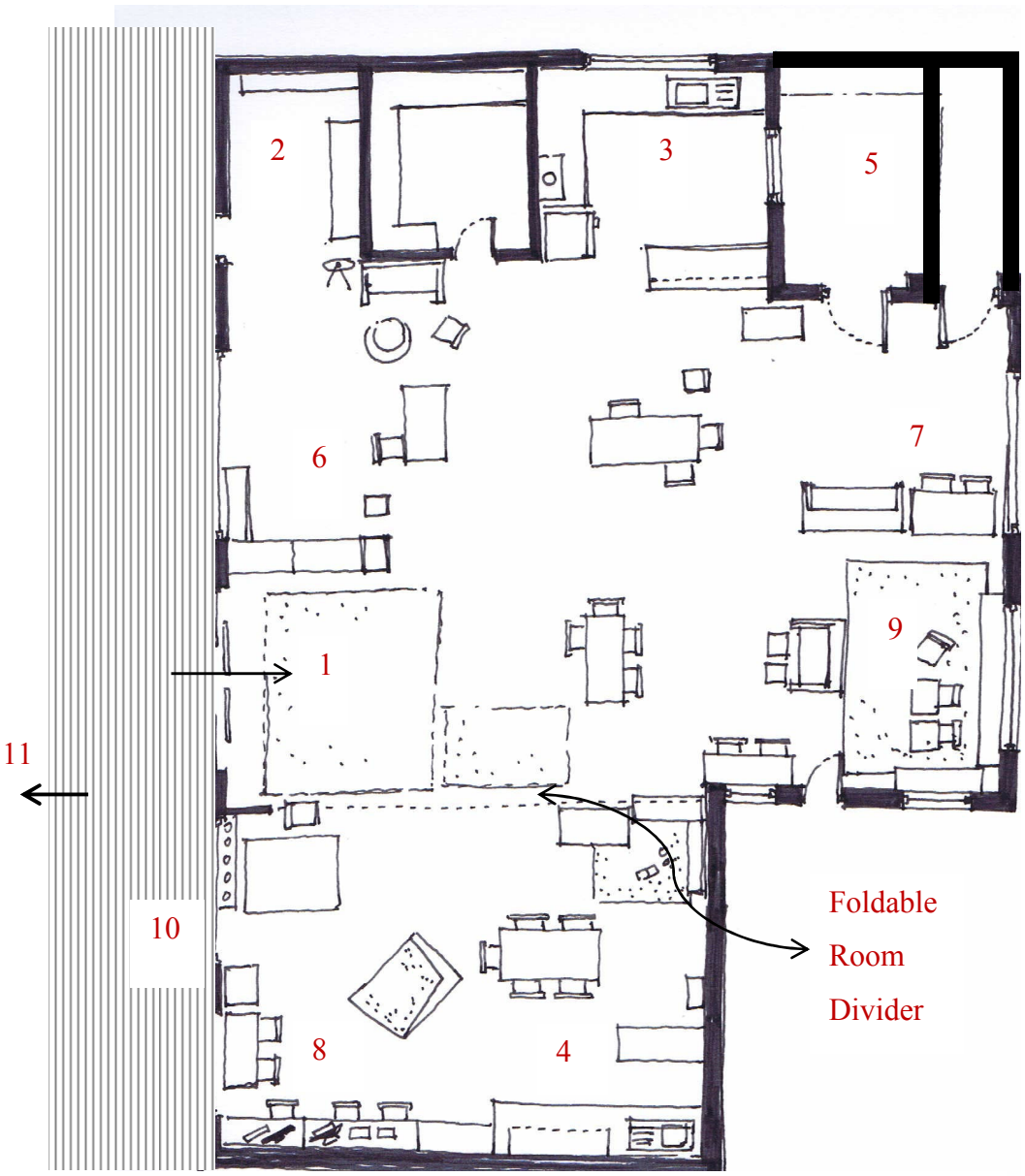


Figure 8.24: School 2 (Montessori)—schematic site plan



1. Entry and floor seating for Group Discussion
2. Storage and Book Shelves
3. Kitchen
4. Small Kitchenette
5. Toilet
6. Book Nook and Quiet Corner
7. Quiet Corner
8. Computer Nook
9. Reading Corner
10. Entry Deck/Foyer with Bag storage facilities
11. Towards outdoor spaces

Figure 8.25: School 2 (Montessori)—schematic floor plan

8.3.1 Passive observations

Similar to School 1, passive observations were conducted in classroom interiors and adjoining exterior spaces that were used as part of routine school activities by the participants of the study.

Interior spaces

This was an L-shaped classroom in a new school building with built-in modular components. The classroom had a variety of seating arrangements using 25 conventional desk-and-chair sets for 25 students, floor desks set with cushions and rugs, and solo-work corners and zones arranged with bookshelves and storage furniture (see Figure 8.26). Upon closer examination, the space appeared to have been created to support the pedagogical principles of self-guided, exploratory and experiential learning. These observations have been tallied against questionnaire responses to affirm students' and teachers' impressions of the space.

Figure 8.26: Informal seating arrangement

Classroom organisation and furniture

The chairs and desks were of the standard school furniture range also seen in the previous Montessori school. However, a key difference here was the availability of different types of seating furniture in addition to the typical desk-and-chair sets. Floor tables with cushions and rugs were provided, as shown in Figures 8.26 and 8.27. Some of these were spread out in 'cosy' corners or areas created with the help of storage and bookshelves and scaled down to suit this age group. Additional

trolleys of small rugs were also accessible. Children were seen to constantly change their locations for work depending on the subjects and tasks set for the session. The physical settings (curriculum-based zones and learning material/equipment) were organised by the teachers in the manner they deemed most suitable, and according to their comments on the questionnaires, the space allowed them to alter the settings as required. In this instance, the classroom space supported the teaching and learning objectives of the Montessori model.

Additionally, spaces were visibly segregated into a variety of workspaces using the furniture and furbishings. Figure 8.28 (left) shows a reading corner created by organising bookshelves into a C-shape and using rugs and cushions on the floor to further define it. Students were observed using this space independently for both on-task and off-task activities. Figure 8.27 (right) shows a conventional desk-and-chair setup placed in a corner for working solo or in a pair. Children frequently used this when they wanted to work independently. Observations of postures and engagement with the physical aspects of the classroom showed that children constantly moved from one part of the classroom to another, deciding freely which corner or niche of the physical environment was best suited to the task at hand. Similarly, the lightweight floor–desk setup (see Figure 8.26) was moved around by students to any space in the classroom in which they chose to work. This furniture model of floor-based seating and freedom of movement was not seen in Montessori School 1 and was in accordance with Montessori pedagogy.

Figure 8.27: Foldable partition walls for flexible and versatile learning spaces

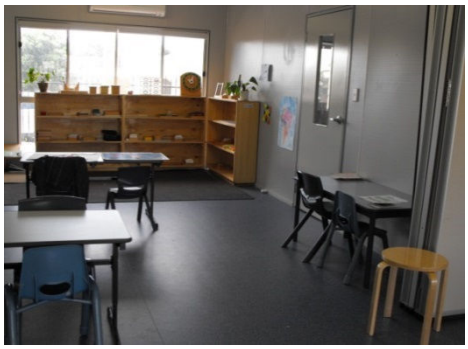
The classroom also had movable partition walls (see Figure 8.27), segregating the existing space into two smaller rooms, each with its own kitchen—albeit one smaller than the other—as needed. This was an interesting feature because it offered the educators the ability to partition the space into smaller units to meet the requirements of varying curricular activities. The spaciousness of the room allowed the children to interact freely with the environment in the manner they chose. This was clearly reflective of the Montessori pedagogy of allowing freedom of movement and engagement with the environment for self-guided learning (Lillard 2012; Walden 2009).

The physical settings of this classroom environment were observed to be highly supportive of group work, group teaching, one-on-one teaching and solo work. As part of their questionnaire responses, the teacher and teaching assistant stated that a larger space posed no disciplinary issues in managing the students, and that the 'space within a space' concept worked well with their teaching methods. As outlined in Chapter 3, this zoning of space is another feature of Montessori learning settings created to accommodate diversity of learning abilities among students (Lillard 2012; Montessori 1912, 1969) and is supported by the current spatial profile.

It was observed that Montessori pedagogical concepts were consistently followed in the teaching practices of this school, where educators acted as guides rather than controllers (Montessori 1912). Consequently, the children were observed moving constantly between indoors and outdoors during school hours without any reprimand from the teachers. However, there were frequent reminders or encouragements when a task was left unfinished or ignored, and the school rules were prominently displayed within the classroom and memorised by the students. This freedom of movement was possible because of a symbiotic nexus between pedagogy and design that encouraged exploration via continuity between indoor and outdoor spaces, as well as a generous but proportionate space that provided flexibility and efficiency in line with pedagogical requirements.

Learning spaces

Although the interiors were not designed by a professional with the objective of making a statement, the students perceived these as spacious, comfortable classrooms in which they were content to learn.



(a) (b)

Figures 8.28: (a) Reading corners with floor seating and (b) conventional desk–chair setup

Figure 8.29: Diversity in seating arrangements—informal floor sitting for solo tasks adjacent to group seating

This was reflected in comments made in the questionnaire survey about their existing classroom; each of the six students surveyed rated the classroom as highly preferred for its attributes of spaciousness and their favourite nooks. When asked to state aspects that they would like to add or change to the existing classroom, no comments were made about the physical environment, its wall colour or furniture. This contrasted with the responses to the image survey (see Section 8.3.2), where the

respondents stated that they would change aspects such as wall colour or illumination to improve certain spaces.

No significant differences between LD and non-LD students were observed in their engagement with the classroom environment from the behavioural perspective. Both groups accessed the environment with ease. For respondents who occasionally found it difficult to work in groups, the space to sit and work solo within the classroom seemed to allow them to complete tasks on time. The combination of pedagogy and a space that supported teaching and learning appeared to have produced an overall sense of well-being in the class, as supported by the responses to the questionnaires.

Colour palette

The colour palette of the classroom was very subtle, with specks of colours provided by the wooden texture of bookshelves and storage, in addition to students' study materials (see Figure 8.29). The colour of the walls and flooring were dull greys and blues, which did not seem to create a significant effect on the overall ambience of the environment. However, the colours provided a distinct backdrop for the study materials. The internal surfaces of this classroom, such as the walls, flooring and ceiling, worked best to visually highlight what was important in the learning setup—for example, by enabling students to locate study materials and identify spatial niches suitable for individual spatial needs and learning activities.

Light

This classroom was well illuminated, with energy-efficient lighting simulating natural daylight conditions. The literature considers such lighting beneficial for learning processes to improve attention, on-task behaviour and physiological processes (Martin 2006; Plympton, Conway and Epstein 2000; Vandewalle, Pierre and Derk-Jan 2009). Blinds on full-length windows also allowed for the control of glare. A glass façade on the longitudinal wall of the classroom opened onto a large covered deck that allowed natural light and protected the interior from the weather.

Heating, cooling and air quality

The classroom and the building housing it were ventilated both artificially and naturally. Thermal comfort was provided by split-system air conditioning, and sun-block blinds offered flexibility and choice to change the thermal settings in accordance with users' needs. A digital thermometer in the classroom was monitored by both students and the teacher, suggesting broad involvement in maintaining physical comfort levels in the classroom as required. This was further supported by questionnaire answers that focused on the existing built environment aspects of the occupied classroom.

Noise and acoustics

The noise level in the class rose intermittently and would likely be a distraction to those who are easily disturbed. However, this did not seem to divert any of the respondents from their tasks. The niches or zones appeared to provide opportunities to work around ambient auditory and physical distractions.

Figure 8.30: Deck leading from classroom to outside

Figure 8.31: View from the deck to other parts of school campus

Exterior spaces

There was easy access between the exterior and interior spaces, making it relatively easy for the children to move in and out of the classroom via the wooden deck (see Figures 8.30 and 8.31). The deck also functioned as the 'eat-out' or lunch area where the children had their snacks and lunches. It offered a view of the school settings (see Figures 8.31 and 8.34), including the veggie patch, lawn area, sandpit and other school buildings. Although it appeared open, it echoed the 'space within a space' concept seen in the interiors, exhibiting a simple landscape with many trees and shrubs that provided opportunities to enact make-believe games and play.

Figure 8.32: 'Quiet time space'

Figure 8.32 shows a place among the trees alongside the lawn area that two of the six surveyed students considered their 'quiet time' space. This was where they went when they were not feeling up to company, when they felt sad or when they wanted to be on their own. To the researcher, it appeared to be simply a dirt patch with tree stumps. However, the children mentioned that they sat on the stumps and sometimes chatted with their friends or spent time thinking. A similar response was seen in the questionnaires from Montessori School 1, where students rated specific areas of outdoor spaces as 'niches' for secret meetings and spaces to spend quiet time.

Figure 8.33: Covered area for all-season use

The covered area in Figure 8.33 was an essential setting for the children's outdoor activities. From the questionnaires and other surveys, it was clear than an important part of school activities was play and games, and the children acknowledged and appreciated this semi-covered outdoor space with roller shutters—flexible for use on both cold winter days and hot summer days. To the children, not being able to play and engage with the outdoor elements was a cause for concern and disappointment, as seen in surveys from School 1, which was also a Montessori school. The students in School 1 mentioned the need for a space where they could freely go about their school activities, such as eating lunch and snacks, without any concerns about the weather.

Although it was a prefabricated structure, the building offered simple yet varied opportunities to carry learning from the classrooms to the outdoors.

Figure 8.34: View from deck to play areas

The lawn area shown in Figure 8.34 appeared to be the favourite of the six students surveyed, with playtime or recess being their favourite time of the school day. In terms of pattern language (Alexander, Ishikawa and Silverstein 1977), the green space formed the conceptual core of the school and connected the clusters together. This was seen to work positively for the surveyed classroom, as there were very few visual barriers between the classroom clusters.

Figure 8.35: View from play area and veggie patch to classroom

The school building appeared plain and visually non-indicative of being a school for young children (see Figures 8.33 and 8.35). However, despite its generic appearance, it was seen to be enjoyed and explored by its young users, just as the Montessori pedagogy intended.

8.3.2 Tool 1: questionnaire

Three out of the six students—including both types of children—cited the spaciousness of the classroom and school site as the school environment's best feature. No students mentioned specific issues in navigating the building or the school site. Given a choice between the classroom and other spaces in the school, all students stated various parts of the school grounds as their 'most favourite spot[s]'. These ranged from the veggie patch to the garden to the lawn area. Each student mentioned an area outdoors that appealed to their 'place-making' disposition (Titman 1994) and what they liked to do best, such as playing their favourite sport, finding places to hide or, as one student stated, 'watch[ing] tomatoes go red'. Similarly, within the classroom, students had a variety of 'spots' that they enjoyed, such as the book corner or the computer nook, with each student stating that they liked these areas because they could conduct their favourite activity in that space, including

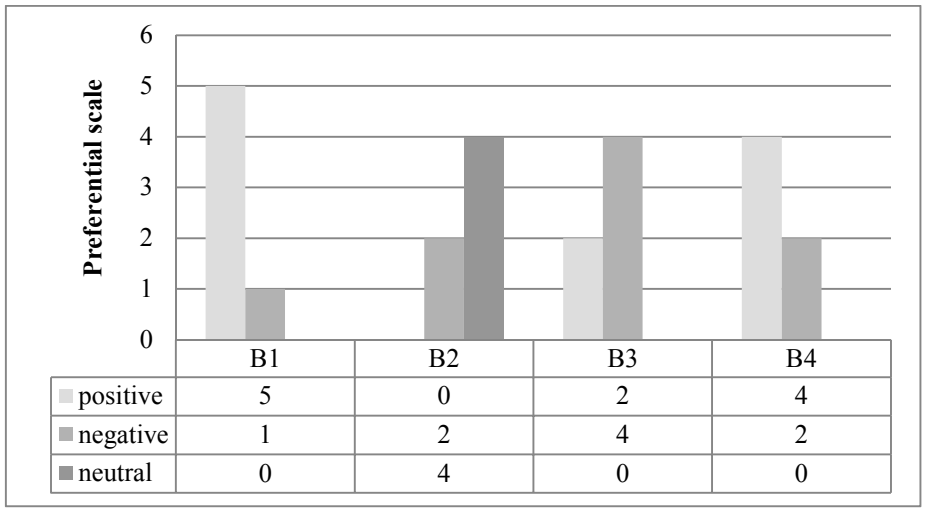
reading or studying independently. An LD student found that the ability to move freely in and out of the classroom was a positive aspect.

All respondents were satisfied with current comfort levels within the classroom with respect to heating and cooling, space availability, and seating and furniture arrangements. No significant comments were made relating to the built environment regarding any changes desired in the students' current classroom. However, it was noted that this building block was newly built and had not been experienced in summer; thus, it was impossible to confirm the continuity of its comfort throughout the year. The responses supported the passive observations that the students were generally satisfied with their current classroom and play areas.

8.3.3 Tool 2: image survey report

School buildings

Differences in users' perceptions of the scale and size of the school spaces were observed to be key reasons defining their responses. Out of the four buildings, the buildings with the highest number of positive marks/dots were Images B1 and B4, with seven positives for each due to aesthetics, materiality and being closest to respondents' culturally influenced perceptions of what a school building should look like. Image B3 was the least preferred because it lacked the facilities (illumination and spatial arrangement) and affordances (lawn and play equipment) that the children from School 2 were accustomed to in their occupied learning environment.



	B1	B2	B3	B4
positive	5	0	2	4
negative	1	2	4	2
neutral	0	4	0	0

Figure 8.36: School building image ratings

For all building images, at least one out of the six students commented on the nature (variety), facilities (for play and activities) and extent (size and accessibility) of green elements in the image (e.g., lawn, plants and trees) that formed part of their evaluations as to whether a building was likeable. These green elements influenced their space and place preferences. Comments on the appreciation of spaciousness and voluminosity (e.g., Image B1) and the lack thereof (Image B3) implied an understanding of the importance of these qualities in their school environment.

Classroom interiors

Of the three classroom interior images, Image C1 received the most positive ratings and Image C3 received the most negative ratings. The responses to classroom and miscellaneous images showed that the physical attributes of the built environment, such as scale or proportion and their limitations, were considered before stating their reasons for liking or disliking an image. Similar to School 1, respondents in School 2 indicated that seating arrangements influenced their ratings of images, as noted from Image C1 (rated positively) and Image C3 (rated as least preferred).

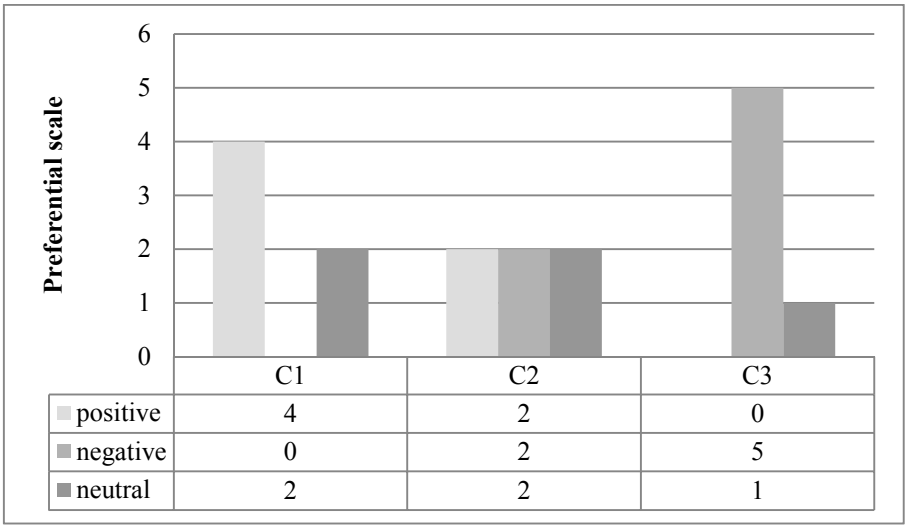
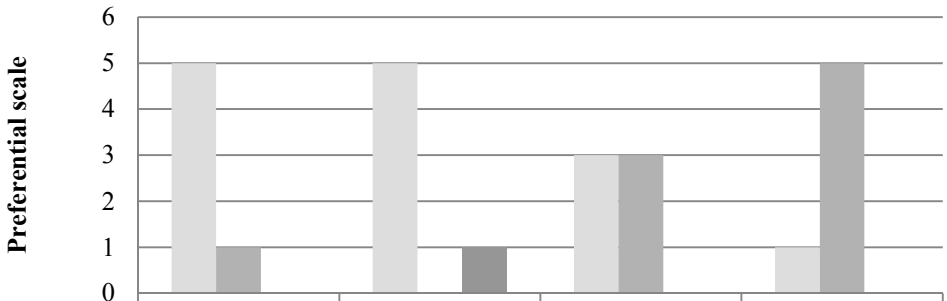


Figure 8.37: Classroom interior ratings

Miscellaneous school spaces

Environmental excesses such as colour and spatial dimensions (height, voluminosity, spaciousness or the inverse) were influential in defining students' ratings of these images. For instance, responses to Images M3.1 and 3.2 reflected strong aversion to the monochromatic colour palette, whereas Image C2 received some negative ratings

because it was perceived as an overtly cluttered and colourful space. These responses suggest a preference for moderation in environmental stimuli. The responses also indicated that students' judgement of the space was influenced by the whiteness of the space rather than a lack of colours. Eclectic objects in Image M2, including the indoor plants, giant pencil sculpture and posters, were noted by students and appreciated by all except one, who disliked the image for the same reasons.



	M1	M2	M3.1	M3.2
positive	5	5	3	1
negative	1	0	3	5
neutral	0	1	0	0

Figure 8.38: Miscellaneous school space ratings

There were no significant differences in answers between LD and non-LD students, other than reiterating what is known from literature reviews regarding the need for structure and moderation in environmental attributes for those with sensory deficits such as ADHD. Conversely, Image B4 was rated negatively by typical and LD students, indicating differences in perceptions regardless of LDs.

In brief, the key factors justifying students' ratings of images were the appearance of the building (size, voluminosity, materiality and aesthetics), seating arrangements, affordances (facilities to find familiar opportunities for familiar learning processes), environmental excesses (colour or lack thereof) and match with their associations (cultural, pedagogical) of school space. When mismatches occurred with these understandings, the images were rated unfavourably, as noted in the responses to Image B3.

8.3.4 Tool 3: wish poems and art survey

The wish poems and art survey from this school were completed by four out of the six students. The poems analysed against word frequency maps showed no

significant wishes for improving specific built environmental attributes, except in relation to colour, with half of the students commenting on the need for colour either for the classroom or the building. The colour palette of this school's exterior was similar to that of School 1. While the subdued colours may have been intended to limit 'over-arousal' in children who were easily distracted (Gaines and Curry 2011; Zentall 2005; Zentall and Zentall 1983) or to offer a base for exhibiting students' colourful work, these responses showed that the colour palette needs to be reassessed for its suitability for children's aesthetic, perceptual and sensorial needs.

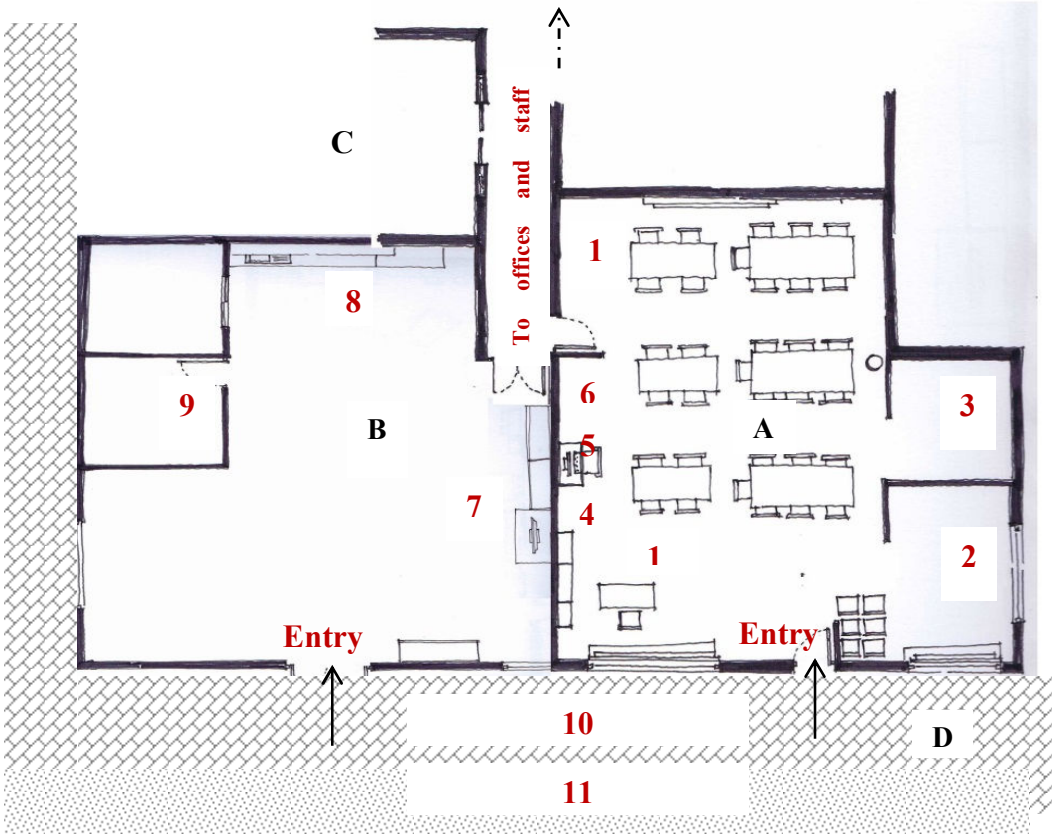
Only one out of the four students desired a larger school, and a student with LD wished for a quieter school. The field observations noted that noise was generated within the classroom from conversations between the students, and not between students and teachers. However, outdoor sources of noise were not noticeable. While only one out of the four students mentioned the need for a quieter learning space, it must be noted that two students opted out of the study, and the remainder of the class did not participate. Consequently, the possibility that noise generated within the classroom was a concern to other students cannot be ruled out.

All students made comments regarding new objects not present in their current school, offering a diverse range of suggestions for elements in the exteriors, including climbing frames, flying foxes, soccer pitches and swimming pools. Most students (three out of four) mentioned natural aspects, stating that they desired a chicken coop or wanted to be close to a beach or forest. All of these responses share the common theme of diverse and enriched experiences as part of the school environment for the students.

8.4 School 3

School 3 was a traditional school with a structured type of pedagogy. The study was conducted over a period of three weeks during school sessions, and seven students opted to participate in the case study. An art room and a multipurpose room were also part of studying the interior spaces for School 3, as these were part of the curriculum during the period of the case study. This was a relatively older school building (compared with Schools 1 and 2), and it had undergone many additions and alterations to address growing needs and changing school standards.

Figure 8.39: School 3—schematic site plan



A. Classroom
   1. Teacher's desk
   2. Group discussion and quiet corner space
   3. Store
   4. Indoor air-conditioning unit
   5. Computer nook for single person use
   6. Sink and wash area for students
B. Multipurpose room
   7. AV equipment and teacher's desk
   8. Kitchen sink and cleaning-up area
   9. Store
C. Art and activity room
D. Exterior settings
   10. Undercover paved area
   11. Green settings and connections with formal play areas

Figure 8.40: School 3—schematic floor plan

8.4.1 Passive observations

Interior spaces—classroom

The classroom was part of a building block of three classrooms and a staff room and comprised pantry facilities, toilet facilities, a library corridor, a multipurpose room, a small art room, the principal's office and an administration section. The classroom could be accessed at two points: the main entry through the administration area and a second, smaller entry opening onto the outdoor spaces for play and meals.

The L-shaped classroom had a supplementary space (see Figure 8.40, Item 2) allotted for quiet time, which offered additional learning support to students with learning problems and those needing quiet time to work on their own. Additionally, the space enabled the special needs teacher to work with special needs students while remaining part of routine classroom sessions.

Figure 8.41: View from the 'quiet time' corner of classroom

Figure 8.42: View of the classroom from teacher's table 2

Classroom organisation and furniture

The school furniture was from the standard range, as specified in the requirements for school settings (Standards Australia 1999). The seating arrangement was structured into work settings for groups of four and above and lacked possibilities for solo work compared to Montessori Schools 1 and 2. This may not have been a negative aspect, as it matched the pedagogical requirements of traditional school

settings and may have been a response to the small space catering to the needs of a disproportionately large number of students. Whether this arrangement worked for those with special needs had to be verified by observations and via the teacher questionnaires. The classroom had two teachers' desks situated at opposite ends of the classroom. Both desks were used by the teaching staff depending on the subjects taught during the day. One of the desks was shared by a special needs teacher and a teaching assistant on specific days of the school term. Dual facilities in the classroom for teachers were also observed in the Montessori schools surveyed. This aligns with students' needs from an educational perspective for mainstream schools to provide space to support the needs of children with LDs.

Figure 8.43: 'Quiet' corner of classroom

Visually, the room seemed to lack coherency in its utilities and clarity in its methods of communication. For instance, it was difficult to find the whiteboard on the wall, as it was almost lost among the eclectic assortment of surfaces and textures displayed on the walls. For a first-time user of this space, it would take some time to locate the whiteboard. Similarly, there was visual ambiguity because the door to the storeroom adjacent to the whiteboard was also lost among the displays of student work and learning settings (e.g., time sheets and class rules) and could not be differentiated as a storeroom door. It was the teachers' decision to put up the students' term work; thus, it appears to be standard educational practice to display term work, timetables and instruction charts on the walls, partly as a motivational exercise and partly to assist students to remember school rules and schedules. It was evident from the

excessive use of built environmental surfaces, such as display areas, that the physical settings were adapted to fit a building that was not up to date with changes in teaching pedagogies and the growing needs of users. Additionally, the circulation space between the desks and tables could have been wider to allow for better movement and flexibility. The students' movements appeared to be cautious as a result of these constraints in circulation.

Figure 8.44: Classroom spatial arrangement of furniture

Colour palette

The colour palette of the classroom was similar to those in Schools 1 and 2. The same type of floor covering was used, but in a carpeted finish and with white ceilings. The major issue was the inability to see any wall colour, as the walls were covered with students' work and noticeboards (see Figure 8.44). The walls were a subtle blue colour, which may have enhanced the physical and mental health of both groups of students, as suggested in the literature (Engelbrecht 2003; Grangaard 1995; Torrice and Logrippo 1989). However, they were not sufficiently visible to have a significant influence on students' sense of well-being and health. The bright patches of other colours were vibrant and perhaps used under the assumption that children like multi-coloured environments. However, from an adult perspective, it appeared excessive. Limited comments were made on any aspect of the classroom—especially

on its multi-coloured, saturated environment—to suggest that the children preferred such an excessively colourful environment.

Learning space

From a design perspective, this L-shaped classroom appeared to have several issues. The first issue was the distracting sounds of voices from an adjacent classroom, which made it difficult to communicate and focus on tasks in the surveyed classroom. The wooden wall partitions between the classrooms were not soundproof, thus allowing the transfer of voices and sounds from one classroom to another. The second issue was the feeling of claustrophobia conveyed by the many artworks and learning materials hanging from the ceiling. Although the ceiling was at a normal height of 2.4 metres, it still seemed too low. However, this observation had to be verified by the students' responses [66]to determine whether the height issue was relevant to them.

Students' works hanging from the ceiling was observed in both alternative schools surveyed, giving the impression that it is normal in educational practice to use hanging art/learning materials to facilitate learning via visual cues or in 'physical settings'. However, the most prominent aspect was the overall cluttered appearance of the classroom arising from an eclectic assortment of students' work, such as posters, worksheets and schedules, which appeared excessive because they obscured the walls from the floor to the ceiling. Although it made the room appear colourful, from the perspective of a designer and adult, it appeared chaotic and distracting. Literature reviews suggest the need for balance in physical environments and settings, whereby sensory overload or overstimulation should be avoided for children with LDs (Gaines and Curry 2011)—specifically those with ADHD or ASD with added issues of atypical (hyposensitive or hypersensitive) sensory responses to environmental attributes (Baranek 1998; Zentall 2005). The room provided a clear example of users struggling to adapt to a built environment that has not been updated to match their needs.

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[66] The findings from a comparison of responses and observations have been discussed in following chapters 9 and 10.

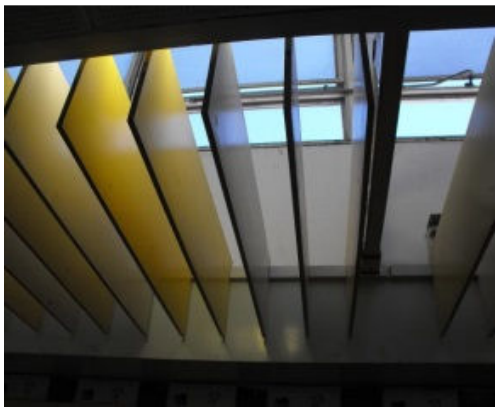


Figure 8.45: Detail of ceiling louvres—provision for natural daylight and ventilation

Figure 8.46: Main entry to classroom connected to other internal spaces in school

Light and ventilation

Some limitations were observed in terms of allowing natural light and ventilation into the room (see Figures 8.45 and 8.46), as skylights with ventilation louvres that were aimed at bringing in natural daylight were insufficient and failed to contribute to the classroom's existing natural ventilation issues. The windows, which could have helped to introduce natural light, were used as pin-up boards to display students' work and prevent theft and vandalism at the school by blocking views into the classroom. However, it must be noted that this was a user response to an ongoing

social problem of vandalism and theft. The need to prevent such incidents superseded the need for natural ventilation and illumination, in turn causing reliance on artificial heating and cooling systems.

Heating and cooling

When in use, the air conditioning system appeared to be very efficient in maintaining comfortable temperatures within the classroom. However, without it running even for a short while, the classroom soon became uncomfortable and warm, indicating a dependency on artificial heating and cooling systems. This school was studied during the months preceding the summer holidays; hence, it was possible to observe the changes in the physical environment produced by increases in the external temperature.

Multipurpose room

The multipurpose room (see Figure 8.47) adjacent to the surveyed classroom was a shared facility created for activities such as watching movies, story time, and arts and crafts. The teacher stated that having carpeted flooring instead of specific furniture enabled flexible use of this space for different subjects and sharing with other classes. During observations in this room, it was noted that in craft sessions and when watching movies, students engaged with this space as flexibly as the environment afforded.

The children had to sit on the carpeted floor to complete their tasks, and their postures ranged from lying on their stomach while watching a movie to sitting cross-legged while working on crafts. Some were observed sitting in circular groups, while others worked independently. It was interesting to note that, when given instructions about an activity or task to be completed, but provided with no furniture, the children interpreted their own environmental affordances as to how they would undertake the activity or task in this space. The absence of furniture in the room meant that they had to form groups or work alone. The teacher instructed whether the activity was group or solo work, but without these instructions or visual cues, they were seen to gather in groups or pairs to discuss the task.

Figure 8.47: Multipurpose room—shared room facility

The interiors of this building, although well maintained, had clearly seen many additions and alterations over time in response to change. The building seemed to have reached a saturation point architecturally, and this affected users, as was evident in issues such as noise transmission, inadequate storage and the teachers' difficulty in adapting to the physical environment.

Although the building had physical permeability with outdoor spaces, visual barriers erected by users as a response to the social issue of vandalism and theft had given rise to new issues such as problems with ventilation, which in turn changed the way the building was experienced. While blocking the windows, the users unintentionally blocked the view of the outdoors, as well as the natural ventilation and light, thus creating a strong dependency on artificial heating and cooling systems. Any building that is being constantly modified may fail in its functions if the modifications are not carried out to match the multiple factors and systems linked to the building's users, site location, topography and socioeconomic positioning.

Art room

Since the students' responses included spaces outside the classroom, the art room (see Figure 8.48) was also assessed for its spatial qualities. It was found to be a well-illuminated room with high ceilings and a comfortable thermal range maintained by a central air conditioning system. The room had adequate facilities in which to store

materials and work, in addition to instruction boards and a storeroom. This room was spacious and had no visual clutter, despite the eclectic collection of artwork left behind on shelves and boards. The art teacher present during the observations mentioned that this room had previously been 'livelier', as the students' works were displayed during the school term. However, the high ceilings showed that the wall surfaces could only be covered with colourful objects to a point; thus, it could not have the same 'cluttered' appearance of the classroom.

Figure 8.48: Art room (new building)

As a new building, the art room was spacious and well illuminated and ventilated compared to the classroom. Students' responses did not offer comparative insights into how they perceived their classroom in contrast to this more spacious art room. However, from a designer's perceptive, the qualities of voluminousness and the relevant spatial size of this room should have been present in the classroom to enable better spatial experiences.

Exterior spaces

Figures 8.49 and 8.50 show the paved and raised play area adjacent to the surveyed classroom. The natural settings were separated by a paved pathway from the classroom, and raised limestone blocks afforded seating to the students. Children were observed participating in different activities such as eating, playing and engaging in games and conversations with classmates in this area. Perhaps because of their natural tendency to explore and experience physical environments (Day 2007), even where supported by a classroom setting allowing tactile engagement (such as in the Montessori schools surveyed), the students appeared to enjoy being outdoors during their short lunch breaks or playtime.

Figure 8.49: Play areas in proximity to classrooms

Figure 8.50: Outdoor paved area outside classroom

The two play areas most used by students in the classroom surveyed are shown in Figures 8.51 and 8.52. The school had a variety of play areas—some covered, some paved—and equipment catering to the children's interactive needs. The permeability between the classroom and outdoors was flexible and easily accessed by the students. During the image survey, the students appeared more eager to answer and participate compared to the first questionnaire conducted. To conclude the surveys, they were asked to state their favourite place in the school and the reason for their choice. Only one student out of seven, who had an LD, preferred the classroom best. Four out of seven favoured the outdoor areas to the classrooms, while two students liked the art room best.

Figure 8.51: A place to chat and play

Figure 8.52: Basketball court and view of veggie garden

8.4.2 Tool 1: questionnaire

The students' responses in this group showed a clear preference for outdoor spaces. Of the three categories of school environment—building, classroom and outdoor spaces—the students commented most on the outdoor spaces. The school oval was the most popular of all outdoor spaces. However, each student also mentioned other areas, such as the frog pond, sandpit and spaces under the tree canopies. One student, who said that the play areas lacked variety, but also, pointed out that the paved areas under the tree canopies were preferred for their versatility as a space to play, sit and eat meals. This undercover area outside the classroom was a well-liked space by at least four out of the seven students, who justified their opinion by stating that the space allowed them to run, meet friends, play games and hide.

The school building received fewer comments, but these were mostly positive because of the building's bright blue colour, size and the terracotta murals made by students. Comments were also made about preferring the old art building over the current classroom because it 'allowed [them] to make a mess at art'. The classroom

received very few comments, with only three out of the seven students stating that the positive aspect of the classroom was its proximity to the green settings, and that it was a place that allowed them to work. These responses reiterate that children prefer environments that allow them to be secure and to fulfil their propensities for play and exploration (Day 2007)—specifically when the building has a physical connection to green settings and has colours on its façade, albeit in moderation. These outdoor aspects were evident as factors that motivated the children to be in their learning environment and enjoy it.

However, the fact that the classroom failed to form part of their insights or comments on preferred places may indicate a subconscious dissatisfaction or disinterest in their classroom settings. The children also specified a practical wish list for the school, including the installation of shower cubicles adjacent to formal play areas, the replacement of older elements such as flag poles and the addition of a larger, more visible school sign at the entry to the campus.

The children's behavioural associations with the built environment, such as the need for quiet time, a place to be with friends or a space for feeling sad or happy, were related to areas outside the school building (e.g., the playground, oval and undercover paved area). Interior spaces preferred for spending quiet time were designated as the art room and the library. Only one out of the seven students mentioned the niche area in the classroom for special needs students as a place to spend quiet time. There were no significant differences between typical children and those with LDs regarding place preferences and perceptual tendencies.

Most students had no issues navigating their school, and no significant issues were commented on by students regarding distractions caused by noise, which may have meant that they had adapted by tuning out auditory stimuli (Haines et al. 2003). This adaptive mechanism can be a cause for concern, as suggested in the literature, as children often cannot discriminate between relevant (e.g., teacher's instructions) and non-relevant (e.g., conversations in the neighbouring classroom) noise when exposed to chronic auditory distraction, instead tuning out both sources of noise. However, as assessment tests were not part of this survey, the researcher could not determine whether the noise levels impeded learning.

The most preferred and appreciated spaces were the outdoor sports areas, which included covered and open play areas as well as lawns and landscaped settings. Play areas were preferred over indoor areas at this school.

8.4.3 Tool 2: image survey report

School buildings

Out of the four buildings, the buildings with the highest number of positive marks/dots were buildings one and four, with 11 positives each, and Image B3 received the highest number of negative ratings (see Figure 8.53). Appearance (aesthetics, materiality and size), affordances of built and landscape areas and colours were key factors justifying the responses towards the school buildings. Similar to Schools 1 and 2, responses in some instances were based on the condition of the occupied school building. For example, Image B1 was rated positively because the school was larger than their school. Image B4 was also rated positively for qualities such as cleanliness, shine, colours and the potentiality of having many classrooms. In contrast, the students' school was an old, single-storey structure. Image B2 was closest in form, aesthetics and materiality to the students' school building, yet it received an almost equal number of likes and dislikes. The key reasons stated were that Image B2 appeared uninteresting, lacked colours and was not engaging enough. It raised questions of why Image B2, which was closest to their definition of a school environment, was rated as being unengaging and satisfying their aesthetic expectations.

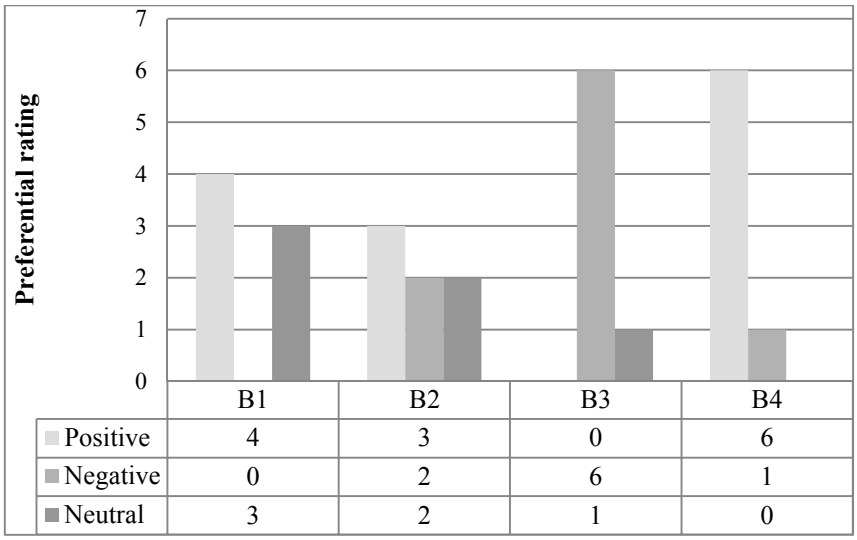


Figure 8.53: School building image ratings

Similar to Schools 1 and 2, Image B3 received the highest negative ratings because it did not match students' understanding of school environments and their affordances. The main reason stated was that it looked too old and dark and, as one student put it, 'not really like a school'. Suggestions were made by an LD student to add green elements to make it more engaging. Image B3's negative rating was influenced by its unfamiliar site, dry landscape, exposed brickwork, lack of colour on the walls and lack of doors and play equipment.

Classroom interiors

Three key factors defined the responses in School 3: seating arrangements, furniture or lack thereof and spatial organisation. As Figure 8.54 illustrates, Image C1 received the highest number of positive ratings despite its unconventional spatial arrangement and similarities in colours and materiality to the students' occupied classroom. The negative ratings were also related to seating arrangements due to a lack of independent and group seating arrangements.

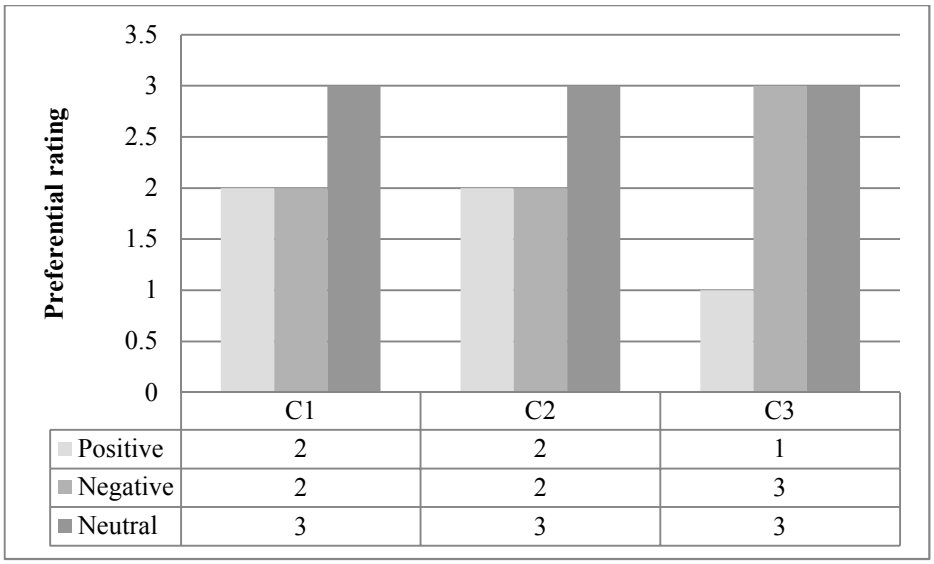


Figure 8.54: Classroom image ratings

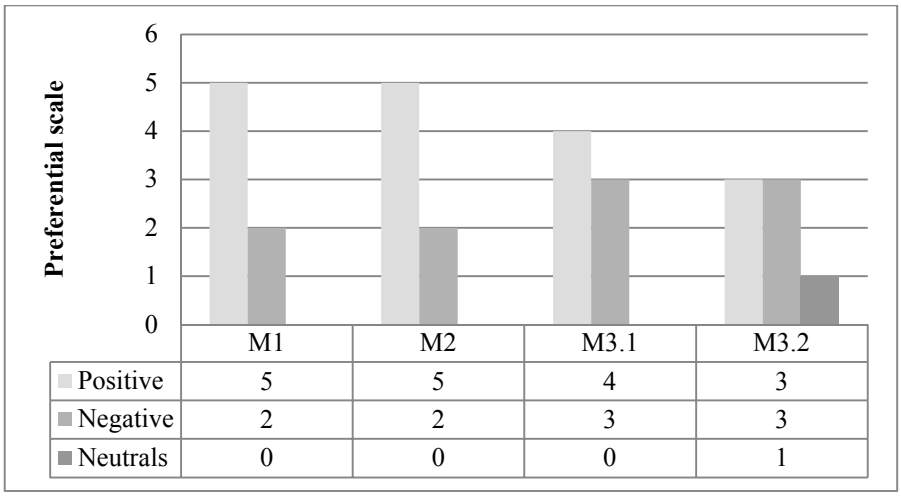
The classroom's settings, although cluttered from the researcher's perspective, seemed to have created a sense of place for the students, who wanted to transfer this aspect to Image C1 so they could then potentially like it better. One of these students had an LD. Image C2 received mixed responses, with opinions differing about what is considered too colourful or too cluttered. Thus, students in this traditional classroom, although occupying a comparatively smaller space with spatial colours influenced by students' artwork, rated a visually similar classroom as cluttered, and five out of seven students considered it excessively colourful.

Image C3 received the highest number of negative responses—mainly because the school did not appear to match what the students understood a learning space to be. They expressed concerns about being uncomfortable in such a classroom with no chairs to sit on. At the same time, spatial engagement in their existing, multipurpose room at school was seen to be comfortable and interactive, and they eagerly participated in activities such as watching movies and creating craft. The activities defined their spatial usage and expectations supporting their learning tasks. Although Image C3 was displayed as a classroom, not all students could relate to it as a classroom space. The familiar settings in their current classroom, with its eclectic collection of study materials and student work, were what they seemed to associate with a colourful and interesting learning space. This was mirrored in the suggestion made by one student to 'make it [the classroom] nicer'. However, another student added that his or her classroom could be as large as the pictured classroom, so its

equipment could be accommodated—possibly with room to spare—which clearly indicated some concerns about the availability of space in the student's classroom.

Miscellaneous school spaces

Colour and elements in spaces (e.g., indoor plants, sculptures) played a key role in defining students' responses to miscellaneous school spaces. Of the three miscellaneous images of school spaces, Images M1 and M2 received five positive responses each. Image M1 evoked mainly positive ratings, despite students being unable to relate it to a space within their school. Here, they were asked what they thought they might do in such a space if it were part of their school campus. Most students felt that such a space was ideal for group activities such as art, camping, telling stories, singing songs and playing. This was based on their observations of a circular-seated central fire pit and a view of nature. The subjects selected by students for learning in this space were non-mainstream ones such as art and storytelling rather than subjects requiring focus and 'solo-work' spaces. These are subjects that enhance engagement and communication. The only student who did not like this space felt this way because of a fear of fire. The students were clearly able to read a space and understand the opportunities they might provide in the learning context.



	M1	M2	M3.1	M3.2
Positive	5	5	4	3
Negative	2	2	3	3
Neutrals	0	0	0	1

Figure 8.55: Miscellaneous school space rating

Image M2 was rated mostly positively because of the staircase and the pencil sculpture. While many students liked this image because of its physical elements, almost all of these elements were not preferred by a small number of students,

including an LD student, thereby reflecting differences in the perceptions of similar elements within the same age group.

Images M3.1 and M3.2 received three negative ratings each and evoked mixed responses. The students in this group occupied a classroom with too many objects, materials and colours in its interiors. Neither the school nor the classroom surveyed had a similar space in terms of voluminousness or lack of visual clutter to the one displayed in the images. However, the main physical quality that influenced the positive and negative ratings was the colour palette of 'black, grey and white', which was considered futuristic by four students, while three others found it unappealing. Another aspect that influenced the positive ratings was the ramp/staircase that appeared to offer the potential to 'climb and run'. Image M3.2 evoked similar responses, but a greater number of students disliked the completely white interiors, even for the corridor, which is a transitionary space that is unoccupied for long periods.

8.4.4 Tool 3: wish poems and art survey

At least three out of the six students depicted the buildings as multi-storeyed structures, with an equal number of students drawing staircases, elevators or escalators as part of their school buildings. Five out of the six students depicted naturalised features as part of their dream school settings, including elements such as grass, lawns, trees and butterflies. The LD student's drawing did not depict any specific preference for a built environment or naturalised aspects in the school. Five out of the six students also drew whimsical elements such as pets and fireworks as part of their dream school. In general, the concept of a dream school reflected a preference for the following elements:

- a 'multi-storeyed' structure
- naturalised elements as part of the school environment
- opportunities in the school environment to be active and mobile—specifically by moving 'upwards' on staircases and in elevators.

Additionally, the drawings reflected a preference for naturalised aspects such as lawns and trees to be part of the school. There also seemed to be a requirement for an environment where the classroom and the playground merged together. This is

evident not only in the results of the word cloud, where the most prominent words were ‘classroom’ and ‘playground’, but also in phrases such as ‘jungle school and classroom’ and a ‘pool in my classroom’.

Both non-LD girls wished for elevators and a larger school, suggesting inclinations for movement and the need for relevant-sized spaces in contrast to what was currently available. Four out of the six students wished directly or indirectly for a sense of openness in the size and volume of their school, using descriptions including a ‘castle-like’ school. Three out of the six students also wanted a pool or an ocean in their classroom. In their art, all of the girls depicted a built environment with a natural setting or a natural setting on its own; in contrast, the boys depicted built environments. The LD student desired a more adventurous school with ‘flying classrooms’ and ‘buildings connected to roller coasters’. There were no specific comments made about aesthetics in terms of colour. These drawings and poems supported the questionnaire responses and image survey results with respect to the limitations and strengths in the occupied school.

8.5 Summary

This chapter presented the data collected from three schools in Perth and described them based on the foundations set by the literature in previous chapters. In doing so, the case studies provided rich insights into children’s attitudes and their expectations of their school environments, which contributes to furthering an understanding of the aspects that require consideration when creating child-centred school designs. Chapter 9 presents the findings obtained through a comparative analysis of the data collected from the three schools, and as weighed against the theoretical foundations of previous chapters using the CCA method, as outlined in Chapter 2.

Chapter 9: Findings from the Case Studies and Evaluation of Children's Responses

9.1 Introduction

Chapter 8 presented rich qualitative data collected from children in three Perth primary schools. This chapter analyses the data collected and presents the findings. As stated previously, these case studies assisted in answering the thesis questions about ways of designing mainstream schools that respond to the spatial needs of young users and thus are child-centred. They offer detailed and varied insights into children's understandings of schools as places that are colourful, engaging and, most importantly, close to nature. This echoes the sentiments of many progressive educators such as Tagore (1928), Steiner (1995) and Montessori (1964), who opposed the factory model of schooling and promoted learning environments that support children's inclinations to learn via exploration and engagement. The responses also suggest that if children's imaginative views are incorporated into the design process of schools, this would help to reduce ambiguities about the ability to design buildings that resonate with children's spatial needs.

As discussed in Chapter 2, the case studies were conducted with a focus on understanding the relationships between space and behaviour using the person–environment fit theory (Parsons 1909) and Gibson's (1986) theory of affordances. These were further informed by the theoretical framework[67] of the study and included observations about both the natural and built elements of school environments. The overall aims of the case studies, as discussed in Chapter 2, are as follows:

- To observe built environmental limitations and opportunities in the school environment and identify how variations in spatial opportunities influence behaviour and interactions with the environment.

[67] The theoretical framework was outlined in Chapter 2 and is grounded in literature about spatial design, education, special needs education and environmental psychology.

- To analyse users' responses—in groups both with and without LDs—to their school environments and examine the similarities and differences between the two groups.
- To examine users' responses to questions about 'what exists' in school environments and further an understanding of what can be done differently or better to respond to these choices.

9.2 Individual Analysis of Data Collected

The data analysis within each school[68] reflected diversity in understanding and perceptions of school environments in groups with and without LDs. The following sections outline the data that were unique to each school and discuss the implications of these data.

9.2.1 School 1

School 1 had a prefabricated building and a 'transition space' that enabled those with LDs to acclimatise to the learning environment, as discussed below. The responses and attitudes from the passive observations and questionnaires indicated that the users were conscious of deficits in the learning environment and the need to rectify them to improve their perceptions of their learning space and its experiential value. For instance, the interior palette of materials and colours was a subtle palette of blue vinyl flooring with light pastel pink walls and timber and plastic furniture. However, the responses also demonstrated that students desired a change to livelier, but perhaps not loud, colour schemes.

The literature suggests that the availability of a spatial contingency assists in determining what works best by applying what is referred to in education as 'structural' or 'ecological' interventions to address the needs of those with LDs (Carbone 2001; Mostafa 2008). However, a combination of differences in the implementation of pedagogies and spatial constraints in the classroom resulted in the space not being used for its original purpose, as seen in the avoidance of the reading area and the workstation next to teacher not fulfilling its function as a dedicated workspace for a student with an LD. This suggests that educators, special needs

[68] Schools 1 and 2 are Montessori schools and School 3 is a traditional school.

consultants and designers need to collaborate to create solutions where successful dialogue can occur to respond to the needs of those with LDs.

The exteriors of the school had several features that supported both groups' place-making dispositions (Titman 1994), such as places to hide and enact make-believe games. However, these appeared inconsequential to adult perceptions of the experiential value of space. Nonetheless, these areas were created to suit the scale of children, and in some places—for instance, the mulched area with the bush garden (adjacent to the sandpit play area in Figure 8.11)—there were adaptations to environmental limitations where children engaged with these spaces using their imagination. Thus, adult perceptions of experiential rich and engaging environments may differ significantly from children's perceptions, and these require further examination to create spaces that resonate with children's understanding of space.

The image survey responses from School 1 prompted similar responses and implications across images of all schools, except for responses to Image B2, which received negative ratings despite being similar in appearance to the students' occupied school. The reasoning was that their occupied school was larger, had 'some colours' and had green play areas with no obtrusive fences, unlike Image B2. Thus, while prefabricated standard school buildings may not be an issue, their affordances, qualities of colour and spatial experiences influence children's motivations to use such places as learning environments.

9.2.2 School 2

The responses from School 2 indicated a high level of satisfaction among children, as the school appealed to their varying sensibilities of space and provided diverse opportunities for engagement. The interiors supported freedom of movement and offered a variety of spatial affordances in accordance with Montessori pedagogies. Spatial zones were defined by a variety of seating and furniture arrangements and responded to the diverse needs of both typical and LD students. These aspects were not observed in School 1, which was also a Montessori school; thus, the interpretation and implementation of Montessori principles may result in different requests from educators, facility planners and designers. However, designs of an

informal style of seating and furniture can be further explored as alternatives in mainstream classrooms to respond to users' diverse spatial needs.

9.2.3 School 3

School 3 differed from Schools 1 and 2 in its pedagogy and spatial arrangement. The passive observations, questionnaires and surveys in this school combined to indicate that the size of the spaces in the existing school were insufficient to support the school's philosophies of inclusiveness and the children's propensities for movement and engagement. Spatial limitations were evident from the movement patterns of respondents within the classroom, which appeared constrained, as well as the excessive use of built environment surfaces for displays. Incompatibilities with the changing needs of pedagogies and the growing needs of users were observed in the difficulty in organising space for a variety of learning needs and activities. These factors of visual incoherence, saturation and inflexibility of space were the most prominent issues, in contrast to the theory of affordances (Gibson 1986), and influenced how students of both groups engaged with their environment.

The wish poems and art surveys showed a demand among children for an environment that is large, interactive and begging to be explored. This was evident in phrases such as a 'castle-like classroom', a 'bigger school' and a 'ladder in [the] classroom'. One of the key points made by respondents—an 'opportunity for being mobile or active'—indicated a specific behavioural inclination when experiencing the school as a 'place'. In the built environment context, this may also be translated into a pattern of school design that provides opportunities to engage with school environments in a mobile-sensory manner to be supportive of children's natural behavioural tendencies.

9.3 Comparative Analysis of Data Collected

As outlined in Chapter 2, the data collected from the field observations and surveys were analysed using CCA. An interpretation of the observations grounded in the theoretical components of the study is discussed below, with a focus on understanding children's responses to their environment, the aspects that influenced

their responses and the implications of these observations for developing child-centred and inclusive school designs.

9.4 Field Observations

9.4.1 Interiors (classroom organisation and furniture)

One of the fundamental points for examination was to understand how the spatial design facilitated or impeded person–environment matches between learners and their school environment. A key observation from the comparison of responses to classroom spaces was the viability of the 'space within a space' concept in responding to user diversity, as seen in one Montessori school and one traditionally structured school in the case studies. This concept (see Figure 9.2) entails the provision of spatial niches and transitional spaces adjacent to or within a larger learning space that fulfil special needs requirements for both educators (in the application of ecological interventions) and students (in the provision of spaces to work independently, to take medications and for psychological transition). These spaces supplement all learning spaces regardless of pedagogical models. The provision of these spaces enables teaching assistants to work with students with LDs during class schedules and follow continued instruction alongside peers, thereby allowing the teacher to effectively manage classroom activities. Montessori School 1 lacked such a space, and the teacher commented that the smaller classroom size made it difficult to make any changes to accommodate special needs students—especially while seeking to teach typical students effectively. However, a positive aspect observed in this school was the provision of a multi-function entry space that acted as a 'drop-off' point and bag storage while offering a psychological 'transition' space for students with LDs and enabling them to acclimatise to the classroom environment prior to undertaking learning tasks (McAllister and Maguire 2012).

Person–environment mismatches occur when a school's design fails to meet the pedagogical and spatial needs of children, which in turn influences educators' ability to offer interventions to students with special needs (as seen in School 1). Another issue noted was the need for educators to use interior wall and ceiling space to display content relevant to facilitate learning (e.g., learning resources, schedules and student work). However, school interiors were not seen to afford the relevant spatial

height or provision to accommodate this need, thereby resulting in a cluttered appearance. This raises questions about the validity of school building standard specifications with respect to the height of school interiors and the need for higher ceilings for use as part of the learning setting to display students' work, learning content and class rules. Consequently, architects and school designers need to collaborate with educators and special needs consultants to ensure the viability of providing such 'spaces within spaces', and thereby guaranteeing the inclusiveness of learning spaces.

While the findings of the case studies reiterate the need for flexible spaces that teachers can adapt to the heterogeneous needs of the classroom—specifically to assist children with LDs—caution needs to be exercised when creating these spaces. As Krovetz (1977, 263) explained, an excessively flexible space may fail in its function; for example, a space designed to function as both an auditorium and a gymnasium would not be successful as either. Further, as seen in the development of twentieth-century trends of flexible, open-plan spaces, establishing a person–environment fit (Parsons 1909) is necessary for successful learning outcomes. A person–environment match necessitates that designers synchronise spatial design, pedagogical efficiency needs and children's psychological and behavioural requirements. Such harmony could motivate students to perform better and promote a sense of well-being (Holland 1997) and good behaviour (Altmaeir and Hansen 2011). As suggested by Ahrentzen et al. (1982, 230), one possible solution might be to design a diverse range of spaces to match the heterogeneous needs of the primary users in:

> Classrooms that accommodate structured teaching styles, spaces that allow for isolated, individual study, and areas conducive to peer teaching and teacher 'consulting' styles.

Montessori School 2 had such a classroom that catered to the diverse natures of users' learning needs. These observations highlighted the need to create supplementary spaces in classrooms to mesh the needs of those with and without LDs in mainstream schools. The literature also suggests that such spaces could allow students who face stress and anxiety (for reasons including, but not limited to, LDs)

to find a place to ‘think’, ‘be alone’ and ‘fulfil a need for some quiet time’ (Titman 1994).

Field observations in School 1 noted that, except for one student with ASD, students were not encouraged to leave their seats or chat among themselves. This was a significant deviation from classical Montessori principles as noted in the literature. While discussions of differences in implementation are outside the scope of this study, it is important to note that in this case, the school space and pedagogy each had limitations, which in turn influenced the way children behaved in the class. They were less mobile compared to School 2 and had a ‘structured’ routine (also observed in School 3) similar to that of traditionally structured schools. In all three schools, pedagogical implementation (differences in how each educational ethos was articulated by educators) and consequent differences in seating arrangements and classroom furniture influenced students’ behaviour and interactions with their spaces. This aspect highlighted a crucial link between education and space that requires consideration in the design process because of its effect on children’s behaviour and its ability to access opportunities in the environment that are relevant to their learning processes.

9.4.2 Exteriors

The field studies also showed that children explored and engaged with all available outdoor spaces and green settings through activities other than those for which these spaces might have been intended or designed. Studies in the school environmental context outside of the classroom have noted the importance of outdoor spaces for mental and physical health (Ozdemir and Yilmaz 2008), enhancing social connections with communities and enriching students’ sense of well-being (Department for Education and Skills 2002, 95). Similarly, a better quality and quantity of outdoor spaces have been shown to positively influence students’ learning experiences (Bowker and Tearle 2007; Dyment et al. 2009). These outdoor places appeared to have emotional associations attached to them, such as feelings of privacy or the provision of a space for ‘quiet time’. This is supported by other place–preference studies (Hart 1979; Moore 1990), with the consensus being that children feel the need to be alone, perhaps to escape from social pressures; hence, such ‘hiding places’ are important and hold emotional significance for children (Cosco

and Moore 1999; Hart 1979; Moore and Young 1978). The literature and case studies agree that the design of school spaces must include spaces where students—with ADD/ADHD and ASD co-occurring with LDs—can have quiet time to cope with issues. It is essential that care and attention be given to the creation of such spaces for retreat and calm.

Figure 9.1: Drawings of students' 'favourite place at school'

Figure 9.2: 'Spaces to be': multiple spatial affordances at School 2; fieldwork sketches

9.5 Questionnaire

Responses to the questionnaires and surveys (see Table 9.1) resonate with Titman's (1994) observations that children have a clear concept of what they want in their 'ideal' school grounds, and they seek specific places to think, feel or engage with their environment to gain a sense of belonging, be themselves or engage in activities as an extension of their personalities (e.g., games, socialisation and play). Whereas the above observations pertain to school playgrounds, the study also found similar attempts among students to find a space for 'doing, thinking, feeling and being' within their school interiors. The need for such a space was observed in students' responses at both the Montessori and structured schools. However, School 2 provided a 'space within a space' (see Figures 8.25, 8.27 and 8.28) to offer varied opportunities for 'doing, thinking, feeling and being', whereas Schools 1 and 3 appeared to fulfil this need only through their outdoor spaces. Consequently, the children's ratings of School 2 spaces (interiors and exteriors) were positive, and suggestions about the schools depicted in the image surveys included transposing their own school's attributes onto the new environments to improve them. Conversely, students from Schools 1 and 3 indicated a preference for their outdoor spaces based on the fulfilment of their emotional and behavioural needs.

Figure 9.3: School 2—a 'quiet corner' for independent work popular among students seeking a place to work or be alone during class time

Table 9.1: Sample of responses from image survey (School 1): students' insights into Image C3

Comments by students	LD/Non-LD
'I dislike this classroom because everybody is sitting on the floor'. *When probed what change could be made to improve it:* '[I] might like [it if there were] some desks or soft carpets [on which] to sit'.	Non-LD
'Doesn't look interesting. Hang more colour'. 'No desks or furniture'. 'You need furniture for some things'.	LD
'[I] wouldn't like to sit on the floor all the time'. 'Leave it to keep [the] roof strong'. 'Move it a bit higher'. 'Stripey colours. Should be like [our] current school. Should be oiled and made shiny. Bring this down [the upper window]. Move [the lower windows]'.	Non-LD
'I think this classroom is awful'. 'Too dull… no desks or chairs to sit…' *When probed what change could be made to improve it:* 'Add lots of colours, desks and chairs and whiteboard [which is] easier to see compared to blackboard… okay with lights'.	Non-LD
'Looks kinda dark'. *Probe: even with some study equipment?* 'I said it's OK because I like doing art [*It looks OK for art but not for working*]'. 'Not enough light for working'.	Non-LD
'They don't have desks; [I] think it's necessary to have desks… something to work on'. 'Love it. Bring [the] roof down'. 'Shift [the] windows down'. 'Just a bit of colour; not too much; [the] cream in [our] current classroom is perfect'.	Non-LD
'[A] very big space but no chairs'. *Probe: If you added chairs?* 'It would be better but not nice'.	Non-LD
'[I] like it because it's nice and big. High windows like skylights. [I] like [the] shiny surface [*pointing to ceiling in front of skylight windows*]. [I] don't mind them [windows] like this [*pointing to existing windows*] but I like them up there. I would choose skylights [rather than] existing windows'.	LD (Asperger's)

One of the aims of the case studies was to further an understanding of what could be done differently or better to respond to children's notions and choices about school environments. Another related aim was to explore whether such a young group of children could contribute coherent-enough views to assist designers in the conception of school designs. The literature suggested that children rarely have an opportunity to contribute to the design of their school (Ghaziani 2008; Rudduck and Flutter 2004). It emerged that the respondents in this age group had strong and coherent views regarding their school environment, and they expressed specific preferences about the quality of their learning spaces.

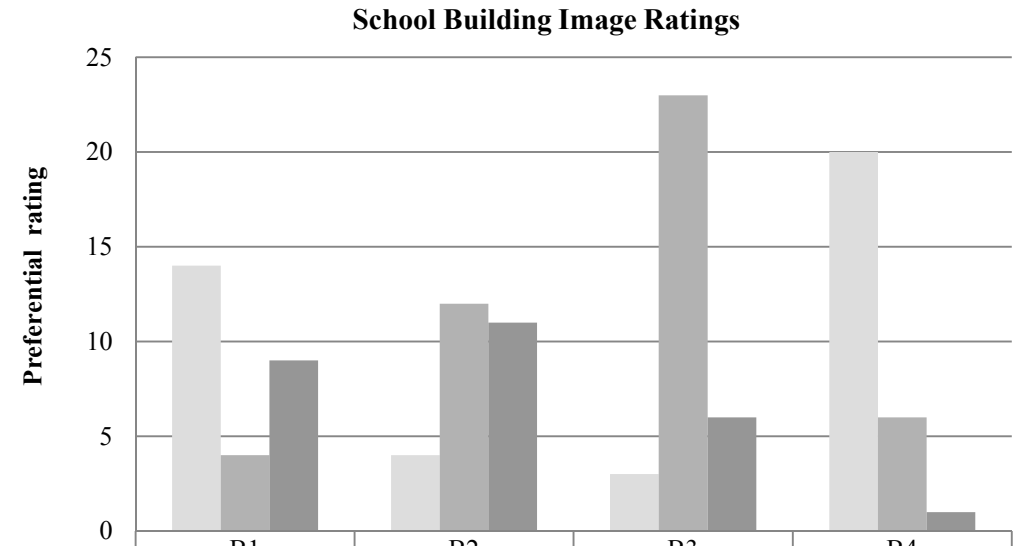
The children justified their preferences by drawing parallels and comparisons between their own schools and those shown in the images. For instance, the image survey in School 2 noted a maturity in students' ability to perceive and rate school environments aesthetically based on their previous experiences of learning environments—an ability that is not usually considered in students of this age. The classroom and miscellaneous image responses showed continuity in the children's advanced understanding of the physical attributes of the built environment—such as scale or proportion and their limitations—that is generally associated with mature understandings of architecture displayed by adults or design professionals. This supports similar findings from other studies concerning the relevance and importance of obtaining children's insights into, and attitudes towards, their built environments (Bland and Sharma-Brymer 2012; Şahin and Türkün 2012). These insights are significant for developing an inclusive architectural model for children with LDs, such as those with ASD (McAllister and Maguire 2012). The respondents' abilities to deduce, infer and offer insights into perceived 'excesses' and notions of aesthetics and balance reiterates the need to involve them as part of the design conception process. Consequently, children could contribute to eliminating ambiguities shrouding the conception of learning environments to produce designs that are supportive of the spatial needs of those with LDs in mainstream schools.

These findings validate ongoing investigations and views from multiple disciplines suggesting that children's post- and/or pre-occupancy input should be incorporated into design briefs and development (Adams and Ingham 1998; Adams et al. 2010; Johnson 2007; Lippman 2010a,b; Şahin and Türkün 2012; Walden 2009) for the

creation of successful learning environments and design prototypes that support students' behavioural inclinations.

9.6 Image Surveys

The image surveys[69] provided three components for assessment: the school building, classrooms and miscellaneous or transition spaces selected from a desktop study of international schools.



	B1	B2	B3	B4
Positive	14	4	3	20
Negative	4	12	23	6
Neutral	9	11	6	1

Figure 9.4: Building image ratings summary for participating schools

Figure 9.5: Images B1–B4 cannot be reproduced here due to copyright restrictions. These images can be accessed from urls provided in Appendix B

Figure 9.5: Images B1–B4 (for larger images and sources, see Appendix B)

[69] As outlined in Chapter 2, the image surveys aimed to obtain a better understanding of the responses from the questionnaires and further explore the key issues surrounding place preferences and interpretations of environmental affordances in the context of schools' spatial design.

9.6.1 Images of school buildings

Out of the four images of school buildings (see Figure 9.5 and Appendix B), Images B1 and B4 received the most positive ratings consistently across all schools, followed by Images B2 and B3. Respondents from the traditional school (School 3) offered mixed but mostly positive ratings for Image B2, but there were mixed responses from Montessori Schools 1 and 2, as discussed below.

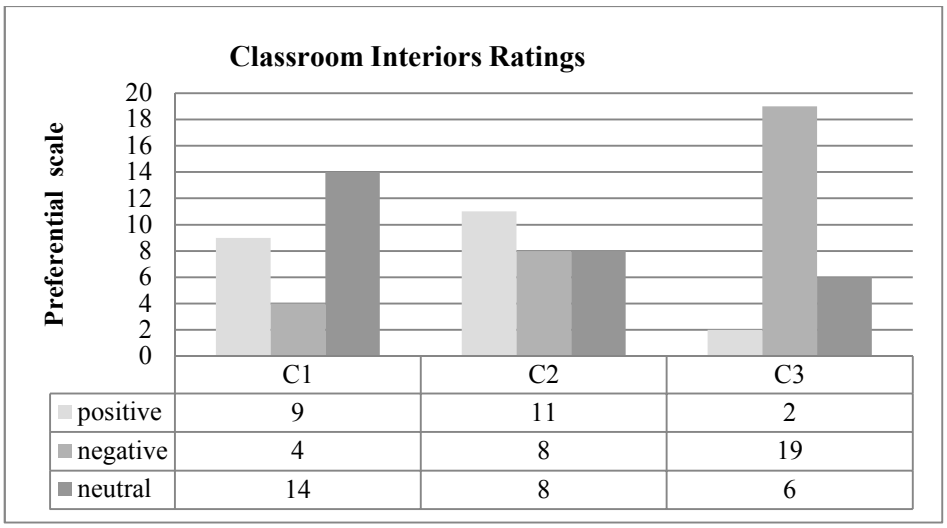
Image B1 was rated mostly with 'likes' based on its qualities of appearance, such as its colour palette, colourful nature, sciography projections (the architectural interplay of projected shadows and perspectives), materiality, multi-storey nature (interpreted as spaciousness), size and window profiles. Students also considered these aspects and the presence of elements such as lawns and ovals when comparing them to their own schools.

Image B4 (see Appendix B, Image B4) was rated as the most preferred, primarily because of its new appearance and multi-storey nature. Students from School 1 commented that large windows could mean quality illumination, and that the angled roof profile appeared to be a unique and likeable feature. Similarly, students from School 2 indicated that the same attributes of aesthetics and size were valuable, and that they would appreciate them more if their own school's existing qualities of openness, seating arrangements and connections to outdoor spaces were transposed onto it. Students from School 3 also noted qualities of 'shine' and apparent cleanliness, along with the colour palette of the school building in Image B4.

Image B3 differed most significantly from the typical architecture of Australian schools and was consistently the 'least preferred' by all three schools, regardless of their educational pedagogies. The respondents considered both the school building and site as an integrated whole when evaluating Image B3. The children questioned its relevance as a school because it failed to match what they believed a typical school building should offer. Some of the attributes mentioned were an apparent lack of illumination and unfamiliar site topography with no green settings (lawns, shrubs or trees) or opportunities for play (sports, games with friends or socialisation activities).

Nonetheless, Image B2, which was the closest to a typical Australian school building and to the students' own school buildings, received mixed responses, including a relatively high number of negative ratings. The key reasons cited were the apparent lack of colours and its comparatively plain appearance (with respect to the students' own schools), indicating that familiarity and relevance to users' built environmental associations are important, but can be superseded by perceptual sensibilities concerning aesthetics and affordances.

9.6.2 Images of classrooms



	C1	C2	C3
positive	9	11	2
negative	4	8	19
neutral	14	8	6

Figure 9.6: Classroom image ratings summary from participating schools

Figure 9.7: Images C1–C4 cannot be reproduced here due to copyright restrictions. These images can be accessed from urls provided in Appendix B

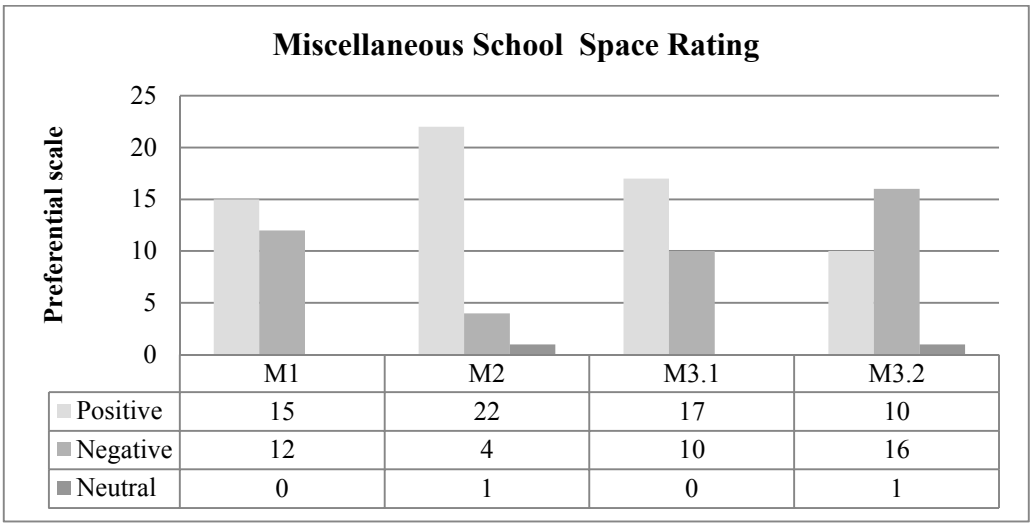
Figure 9.7: Images C1–C3 (for larger images and sources, see Appendix B)

Image C1, with the zig-zag seating, and Image C2, with the colourful setting, received the most positive ratings. Image C3 was the least preferred of the three images. Comments from all three schools focused on the seating arrangements or, in the case of Image C3, the lack of seating, which influenced its negative rating. The warm textures of wood and the spaciousness of Image C3 were ignored as a result of its lack of chairs, primarily because it did not match students' cultural and perceptual understandings of the qualities and opportunities that such seating provides. This was

consistent in the responses from both groups of students, indicating that furniture and its arrangement are important aspects of children's experiences at school. Literature suggests that seating arrangements (sociopetal and sociofugal) influence how children work and socialise at school (Osmond 1966). In Montessori classrooms, the arrangements vary to cater to diverse needs (Hojnoski et al. 2008). In traditional DI models, the extent to which these diverse needs are met depends on educators' interpretations and implementations; however, respondents from School 3 also indicated that furniture and spatial arrangements are crucial when forming preferences for these images. Image C1 was likewise assessed on its furniture arrangements, with respondents from School 3 commenting that students' work and displays from their own classroom could be transposed to improve the classroom in the image. School 3's classroom was overly cluttered and had spatial constraints; nevertheless, the responses showed that such displays add to students' sense of place and ownership. An equal number of respondents from School 3 also indicated that Image C2 appeared cluttered compared to their own classroom. A few students from School 2 also rated this image negatively for it being too colourful, including two students with LDs, potentially as a result of their needs for structure and moderation (Carbone 2001; McAllister 2010). These responses suggest that perceptions of environmental excesses or limitations related to sensory overload[70] (see Evans 1984) differ among students in general, including those with LDs. A direct translation into design strategies may therefore be a complex task.

[70] As discussed in Chapter 3, sensory overload occurs when there is mismatch between available information and the ability of an individual to process this information, subsequently causing stress. This implies that excesses in information from the environment (e.g., stimuli or cues) can be detrimental for children of both groups, but more so for children with LDs and hypersensitivities to environmental stimuli.

9.6.3 Images of miscellaneous spaces



	M1	M2	M3.1	M3.2
Positive	15	22	17	10
Negative	12	4	10	16
Neutral	0	1	0	1

Figure 9.8: Miscellaneous image ratings summary from participating schools

Figure 9.9: Images M1–M3.2 cannot be reproduced here due to copyright restrictions. These images can be accessed from urls provided in Appendix B

Figure 9.9: Images M1–M3.2 (for larger images and sources, see Appendix B)

Image M2, of a multi-storey school atrium, was rated as the most preferred (see Figure 9.8), and Image M3.2, of a long, stark white corridor, was the least preferred of the four images across all three schools. Image M2 was admired by many respondents (21 out of 28) for the objects in the space, such as the large-scale pencil sculpture and the potted plants. The permeability of the outdoor–indoor spaces created by a glass façade and the idea of climbing stairs also appealed to those who rated this image positively. Image M1, of a space with circular seating around a campfire, evoked mostly positive responses from Schools 2 and 3, but not from School 1. The mixed responses were a result of respondents being unable to understand its relevance to the learning activities at School 1. Those who rated this image positively, including those from School 3, felt that it would be a space for socialising and activities such as storytelling, which they engaged in using the multipurpose room dedicated for group work. Although Images M3.1 and M3.2 were images of the same school building, the use of black colour and concrete textures influenced the ratings of these images, with Image M3.1 rated more highly

consistently across the three schools. The children's aesthetic sensibilities clearly preferred a moderate use of colour, and stark whites such as those in Image M3.2 or the colourful settings of Image C2 were not considered a positive attribute by the greater part of the sample for this study.

Additionally, the responses across all three schools consistently showed that the children evaluated the images by comparing them to their existing school architecture, at the same time offering insights into what they considered essential for a learning space. Three key aspects were prominent in their preferences. The first was the overall appearance of the building, including its attributes of space, size, newness and number of storeys (see Appendix B, Image B4). The second was the quality and type of furniture and its arrangement, and the third was the relevant match between respondents' associations (cultural, social and perceptual) and their preconceived ideas about the appearance of a school environment and its affordances (facilities, quality of its built environment and aesthetics). This last aspect of environmental association was most evident when the images differed significantly from familiar ideas of learning spaces in terms of seating, play facilities, green envelopes and crucial aspects of appropriate illumination. When these elements differed significantly, they provoked negative ratings for the respective image. The children also evaluated the images in terms of the opportunities they presented or lacked, and how these measured against their existing school settings, adding comments about what they felt they would add to 'make it nicer'. This comparison based on existing settings indicated their limited exposure to building settings; however, it is necessary to consult them to understand aspects around environmental associations and what they deem to be supportive spaces to engage and experience as part of their learning processes.

The students' responses also suggested that school designers need to evaluate the notion of balanced learning environments when designing school buildings. The responses from the image surveys in this study contained adjectives such as 'too much' or 'too colourful'. The survey provided a selection of buildings that were similar to the school buildings currently occupied by the participants, as well as buildings that contrasted with what the respondents were familiar with in terms of size, colour, places, spaces and aesthetics. While no average similarities were found

in these qualitative perceptions, questions regarding which aspects of the built environment would be perceived as 'too much' and lead to discomfort or overstimulation remain to be explored. For example, in relation to a classroom that overtly uses green in its interiors, a student with diagnosed ASD was quick to point out that, although his favourite colour was 'exit-sign green', he would not like 'so much' green in his classroom. Again, this raises the subject of the attributes of built environments that would be considered excessive by children—specifically those with heightened sensory awareness. As explained by Lackney (2004):

> brain research also suggests that the brain learns best when confronted with a balance between stress and comfort: high challenge and low threat. Stress motivates a survival imperative in the brain. Too much and anxiety shuts down opportunities for learning. Too little and the brain becomes too relaxed and comfortable to become actively engaged. The phrase used to describe the brain state for optimal learning is that of relaxed alertness.

Thus, school environments that span buildings, their interior spaces and the green settings enveloping school buildings must embody qualities of balance and may be enriched by children's perspectives on learning spaces. School designs must ensure that the ambient variables of the environment are developed as part of an 'iterative' process and are not focused only on superficial aesthetics. The image surveys also indicated that what appeared to be warm and inviting in interior design in fact elicited negative ratings, as this aesthetic quality was superseded by concerns arising from the practical aspects of seating arrangements, windows allowing for permeability between indoor and outdoor spaces, and levels of voluminousness that did not match students' sense of spatial scale and size.

However, to achieve a balance in the type of experiences and engagements afforded by school environments, we would need to undertake an interdisciplinary path and approach design by encouraging a dialogue between designers, educators and the key future users of the spaces being designed. A balanced built environment can be enriching and nurturing in its ambient qualities, supporting the brain's ability to learn and potentially alleviating the impediments associated with LDs. In the context of education, Jensen (2005) suggested that an uncomplicated yet pragmatic initial approach would be to remove the negatives from the learning environment before

seeking to fill it with positives. The same concept can easily be applied to a school's design approach, where designers could begin by identifying excesses in a school's spatial design that are perceived as negatives to create an experientially balanced and holistic learning space.

9.7 Wish Poems and Art Survey

The wish poems and art surveys supported the responses from the field observations and image surveys, thereby contributing to the triangulation of the data. These two surveys aimed to discover the children's visual insights into elements that were missing from and/or that were the best features of their school to fill the gaps that emerged from the verbal surveys and field observations. The responses in this section again highlight the behavioural preferences among students to be able to move unconstrained from interiors to exteriors in their school spaces. This was unrelated to their satisfaction or dissatisfaction with the interior areas of the schools, and can perhaps be explained by the literature, which highlights the value of exterior elements of school spaces in affording opportunities to children with LDs to seek restoration and escape the routine challenges of learning processes (Carbone 2001; Greville 2009; Mostafa 2008). The exterior elements of school spaces also serve as valuable contributors to the social dimensions of the learning experiences of both groups of children (Brett, Moore and Provenzo 1993; Cosco and Moore 2009; Deniz and Akman 2012; Evans 1995). Thus, they might have informed several responses in which participants highlighted their spatial requirements to move seamlessly from the interiors to the exteriors of school spaces.

9.8 Key Findings from the Case Studies

This section discusses how the case studies, which are grounded in the theoretical framework provided by the literature, further an understanding of the links between school design and learning abilities among children with and without LDs. The key findings regarding the aims and objectives of the case studies are outlined below.

9.8.1 Opportunities and limitations in the school environment

The question of how opportunities and limitations in the school environment affect children's behaviour and spatial engagement was explored from the perspectives of

the environmental affordances and person–environment fit theories. The availability of appropriate spatial affordances in terms of size and accessibility was noted to affect children's ability to interact with their learning environments and teachers' ability to organise settings to accommodate the needs of children with and without LDs. For children with LDs co-occurring with other disorders, the availability of a space that allows movement and opportunities for escape and respite can enable them to maximise their learning potential.

Spatial limitations of size, as seen in School 1, not only influenced students' interactions with space, but also how they interacted with settings organised by educators in the interiors. Some spaces, such as reading corners, remained underused because of their location and proximity to doorways and kitchen areas that interfered with reading activities. Teachers also commented that a lack of supplementary space in School 1 was an impediment to responding to the needs of children with LDs because it prevented them from applying intervention and support to respond to their needs. The literature indicates that, for children with LDs co-occurring with other disorders such as ASD, the ability to be mobile while class in session is necessary. Studies indicate that spaces acting as constraints can prevent children with LDs from interacting with their learning environments in a way that is not distracting to their teachers and peers.

Conversely, when the spatial settings seen in Schools 2 and 3 (spaces within spaces) matched the pedagogical needs of flexibility and inclusion, children of both groups were engaged more actively in their learning environments. This enabled the creation of diverse spatial settings to respond to the diverse learning abilities of children of both groups. Similarly, poorly considered upgrades to school buildings as a response to social issues of vandalism and technological advancements highlighted the need for designers to conceptualise designs using a feedback process.

Observations and participants' responses indicated that spatial constraints in interiors and a lack of appropriate exterior spaces (that did not expose students to inclement weather) also influenced the social dimensions of learning. The literature suggests that an inability to communicate with peers in classrooms and during recess affects the social dimensions of children's learning, leading to stress in children and behavioural issues among those with ADHD and ADD (Baum and Valins 1977;

Brett, Moore and Provenzo 1993; Conners 1983; Epstein 1981; Evans 1995; Ormrod 2000). The case studies highlighted the importance for spatial design to support the socio-environmental dimensions of learning for both groups of children.

These findings demonstrate that the spatial qualities of size and function are linked to successful learner–environment transactions and teachers' abilities to offer special needs support and interventions. The greatest challenge for school designers is to create spaces to respond to the diversity of spatial needs among children, and specifically for children with LDs.

9.8.2 Children's perceptions of school environments

Korpela (2002, 363) defined place–preference theory as an examination of 'children's notions about their favourite (important, liked or valued) or the most unpleasant (disliked) places in their everyday surroundings'. The case studies indicated the following key aspects in relation to children's school environment preferences and associated behavioural tendencies (see Figure 9.1):

- a preference for being in outdoor settings such as the veggie patch, sandpit or playground and landscaped areas that were not intended to act as 'play or activity areas'
- an inclination for exploration, play and movement
- the importance of places associated with feelings of privacy (being alone and the need for quiet time) and escape (being sad, insecure or unconfident)
- a strong desire to engage with both the physical and natural environments of the school.

The literature suggests that natural settings are important for children's sense of well-being (Johnson 2007; Kaplan 1995; Kuo and Taylor 2004; Taylor, Kuo and Sullivan 2001) and often influence their place preferences (Lucas and Dyment 2010; Sargisson and McLean 2012). The findings indicated that children from both DI and alternative models perceived their school environments and their learning as an integrated whole, and that learning occurred in both school models. Students sought affordances from both the built and natural elements of the school environments to receive opportunities to learn via experimentation, experience and interaction,

regardless of the pedagogical models under which they studied. Thus, from a spatial design perspective, the environment must actualise affordances to facilitate learning via engagement with school environments.

The semantic difference between 'space' and 'place' had no room in this group's interpretations of what learning spaces meant to them. When analysed to identify the specific reasons for imparting significance to aspects of their school environment, their responses demonstrated that children look for spaces that allow them to contemplate, restore and enact their imaginative tendencies at play. A comparison of the responses also suggests that their spatial preferences, although influenced by their cultural and socioeconomic background, were not significantly influenced by differences in pedagogies.

However, the influence of pedagogical models changed the extent to which they learned and the nature of 'how they learned', as the 'designed' elements acted as catalysts. This also resonates with various studies that have addressed students' perceptions of school as holistic to include other pedagogical and social aspects such as gender differences, personal abilities and motivation to learn (Anson and Allan quoted in Barrett, Zhang and Barrett 2011, 110). What this translates to for schools' spatial design is an approach that is holistic and seeks to achieve a balance between the built and natural environments and between aesthetics and function to provide learning environments that are rich in experiential value and engaging for users.

Participants' responses to environmental variables in their occupied spaces and surveys indicate the following.

Table 9.2: Participants' responses to environmental variables

Variables	Views and links to dimensions of learning
Furniture	One of the most important aspects influencing participants' perceptions of their occupied school environments, as well as to the images in the surveys. The furniture and its arrangement offered cues to participants regarding whether they could find a match with their abilities to use the space. This influenced their motivation and preferences for settings with a diversity of furniture arrangements that equated to a diversity of learning experiences. The aesthetics and function of space defined by the furniture arrangements influenced their responses, as the arrangements contributed to their understanding of the environmental affordances that the space offered in terms of experiences (social and learning activities) and engagement (ability to be mobile and independently access resources) for learning to occur.
Exteriors—natural elements	Seamless transition between exteriors and interiors of school environments, quality and variety of experiences that the exteriors afforded, such as places 'to play', 'hide' and 'just to be…' linked to motivation to be in school.
Colour	Colour excesses (either monochromatic or overtly colourful) were identified as elements that affected participants' attitudes towards space.
Light	Observations indicated that a variety of natural and artificial light conditions were suitable for learning. No negative responses were made by participants about lighting conditions to guide the design process.
Thermal comfort	The ability to control temperature settings in School 1 enabled students to adjust personal comfort levels, and challenges with thermal comfort were observed in School 3.[71] It was not indicated whether this influenced their satisfaction levels in terms of their classrooms.
Noise	Noise interference was present in only one school, and teachers commented on difficulties communicating with students because of noise transference from neighbouring classrooms. There were no comments from participants on the challenges posed by noise.

One of the key considerations of achieving child-centredness in school design should be to create spaces that support their dimensions of learning (e.g., developmental, social and perceptual learning processes). Table 9.2 shows that environmental variables of furniture and colour act as cues for children to interpret environmental affordances and identify opportunities to establish person–environment matches.

[71] Students in School 3 were not allowed to be indoors in spring during recess because the air-conditioning systems, once turned off, increased temperatures in the classroom. Undercover play areas were provided for summertime use. Again, no responses were available from participants to identify how this influenced their attitudes towards their occupied spaces.

Responses towards furniture and spatial arrangement and exterior spaces also suggest that children emphasise aspects that support their behavioural tendencies and social dimensions of learning processes.

Children of both groups had strong preferences for 'moderation' in environmental colour schemes. However, colourful props, such as their own artwork, learning resources and charts, were favoured and not considered visual clutter; instead, they added to their sense of ownership and place at school and positively influenced their preferences. Exterior spaces play a vital role in developmental, behavioural and social dimensions of learning; these were highly valued and among the most preferred places in the school environment. If nature in the micro scale of a school environment can elicit such positive emotions, then introducing nature on a macro scale via spatial design could act as a major catalyst for the enhancement of learning by producing better physical and mental health in children of both groups. Consequently, school designers need to verify what these children's understandings of space are in relation to environmental factors that are highly valued and thus support their learning processes as against those that are considered as an environmental excess (for e.g., thermal discomfort, background noise) and that impede their ability to maximise their learning potential.

9.8.3 Similarities and differences in responses between children with and without learning disabilities

There was no consistency in differences observed in the responses of children with and without LDs. For example, the image surveys found differences between students in the LD group in School 1. However, there were similarities in ratings towards the same images in Schools 2 and 3. Differing perceptions of the same environmental stimuli among students with and without LDs were observed, raising questions about how to determine which colour palette would be perceived as an excess as opposed to one that is construed as balanced by both groups. Literature suggests that an LD student with ASD might perceive the built environment differently from those without an LD or who are at the lower end of the LD spectrum due to large variations in either sensory processing or sensory stimulation (Mangeot et al. 2001). However, it must be noted that the sample size of children with LDs in this study was small. Thus, further studies on a statistically larger sample size should

explore specific perceptual differences for students with heightened sensory awareness to determine the influences of ambient excesses of colour, noise and temperature, which are known to have both physical and mental effects on occupants.

9.9 Summary

Children of both groups gravitated towards environmental attributes that allowed them to negotiate the issues they encountered while learning, including coping with the variables of environmental distractions and spatial limitations. The case studies showed that school environments' affordances to engage and experience spaces in ways that support children's physical and social dimensions of learning strongly influence the way they interpret environmental affordances. These interpretations subsequently influence children's spatial preferences which, according to the literature, have been linked to their physical and mental well-being. Current school design practitioners therefore need to consider how design elements can afford engagement and experiences to facilitate the physical and social dimensions of learning to make designs child-centred in nature. Chapter 10 discusses the implications of the literature, the case studies for mainstream school design and pathways for future research.

Chapter 10: Implications for Mainstream School Designs

10.1 Introduction

The aim of the thesis was to examine the effect of spatial design on children with LDs studying in mainstream school environments from environmental psychology perspectives. Section 10.2 provides a synthesis of the findings by discussing the extent to which they concur with the literature and their significance for the creation of inclusive school architectural solutions. It highlights the current issues that limit the creation of inclusive school environments and makes recommendations towards meeting this aim by emphasising children's diverse needs from their learning environments. Section 10.3 concludes the thesis by highlighting aspects that need to underscore design decisions to make mainstream school environments more responsive to the needs of children with LDs.

10.2 Discussion: Linking Case Studies to Theoretical Components

A critical analysis of the literature examining physical environments and their influence on users found that numerous authors have argued that the nature of physical environments is linked to users' performance levels and their physical and mental well-being, including in learning spaces (Shabha 2006; Spencer and Blades 2009; Tanner 2000; Weinstein 1979). The consensus is that the better the quality of the physical environment, the better the performance. However, the focus of school design perspectives has largely been on the creation of safe and colourful buildings, without acknowledging the perceptual and psychological requirements of their young users. The inverse of this space–behaviour theory—that physical environments can also impede human performance—has largely been overlooked by designers when it comes to designing enclosures for children. Prevalent disciplinary attitudes of economisation and adherence to safety and standards often take precedence over gaining the qualitative insights of users. The analysis of the literature spanning the disciplines of architecture, education, behaviour and environmental psychology not only lends support to the space–behaviour hypothesis, but also argues that when design approaches fail to acknowledge the learner–environment transactions that are

relevant to children's learning processes, the resultant spaces can prevent children of both groups from maximising their learning potential.

This study critically analysed the literature on school buildings and explored the possibility of designing an inclusive school design solution. The review of education-based literature indicated that LDs cover a vast spectrum of learning impediments, each of which has limitations. Attention issues are known to occur as a result of factors other than ADD and ADHD, including student–space ratios (Kantrowitz and Evans 2004) and student–teacher ratios (Strayhorn Jr. and Bickel 2002). Management of student attention is therefore essential for LD groups and for those without LDs. Consequently, the current study focused on the learning environment and its influence on the symptoms of inattention and impulsivity, which were found to be common in several LDs, including ADD, ADHD and ASD.

10.2.1 Common spatial needs among children with and without learning disabilities

The key similarities in spatial needs among both groups of children appear to be a preference for seamless meshing of the built and natural elements of school environments. The literature suggests that children prefer environments that are restorative and allow them to escape social pressures (Hart 1979; Korpela 2002; Moore 1990; Mostafa 2008). Thus, schools' physical environments become a mediator of the process. Related studies have also found links between children's preferential relationships with their environment and attentional capacities in children with ADHD (Johnson 2007; Kuo and Faber Taylor 2004; Taylor, Kuo and Sullivan 2001). It is therefore essential for designers to identify children's environmental preferences to understand the design factors necessary to create child-centred and inclusive school designs.

The design of school environments—both built and natural—can have a significant effect on students' achievement levels, socialisation, behaviour and performance (Bowker and Tearle 2007; Department for Education and Skills 2002; Dyment et al. 2009; Ozdemir and Yilmaz 2008; Tanner 2000; Tanner and Langford 2003; Weinstein 1977; Weinstein and Thomas 1987). The findings from the case studies supported these theories and demonstrated that children's vivid imaginations in

response to their school environments suggest the need for colourful and interactive spaces that are also permeable with green settings. The physical, social and individual environmental aspects combine to influence children's ability to concentrate for longer periods (Evans 2006), thereby highlighting the need to consider the links between these aspects part of the design process. Based on the literature and case studies of this research, it is evident that the significance of green settings is worthy of serious consideration so that school designs are beneficial in alleviating symptoms of stress and anxiety and improve attention among children with and without LDs. This implies that the focus in designing schools should be on making them inclusive by extending the concepts of behaviour-based customisation beyond the building into the exterior environs to enable seamless connectivity between the building and the site. This overarching design perspective would consequently act as a facilitator to enable both groups of children to engage with learning spaces as needed to achieve optimum learning objectives.

10.2.2 Special considerations for children with learning disabilities

There is a growing body of research linking schools' spatial design and students' achievement levels. However, the corresponding response from a design perspective remains shrouded in ambiguity and motivated by concerns of economisation. All three schools studied presented the need for special design features to meet the needs of children with LDs, but only Schools 2 and 3 had dedicated spaces available. Literature relating to sensory experiences specifies how ambient attributes such as acoustics can create significant distractions for students with ASD or inattention issues (Mostafa 2008). However, School 3 had significant sound transmission issues that posed difficulties to both the students and teachers. These aspects could adversely affect the learning processes of both groups of students, but more so for those with heightened sensory awareness, as commented by the teacher. While assessment tests and behavioural mapping were not part of the current study to determine the extent of such influences on behaviour and learning, other statistically relevant studies on individual elements of built space, such as noise (chronic and unwanted ambient) and its relation to academic achievement, attention, health and behaviour (Bradlow, Kraus and Hayes 2003; Evans, Hygge and Bullinger 1995; Haines, Stansfeld, Job et al. 2001) support these findings, as discussed in Section 4.7.

Nonetheless, the 'space within a space' concept in alternative School 2 has potential as a design prototype to respond to user diversity though perceptual, behavioural and sensorial variations, while also acting as a spatial contingency for academic interventions. If this concept is treated as a conscious part of designing inclusive school design strategies where relevant spatial opportunities for learning are offered to children with LDs, it can perhaps form part of educators' efforts in terms of ecological interventions and non-medication strategies, as suggested by Carbone (2001) and Denney (2001). The creation of niche spaces inspired by alternative pedagogical models suggests opportunities for research into the development of spatial models with varied permutations and combinations of architectural attributes to respond to the heterogeneous needs of students.

Numerous diversities are observed in the group with LDs depending on the presence or absence of co-occurring disorders, which complicates the process of being able to translate their special needs into a design response in mainstream school environments. Extra sensitivity to environmental stimuli in some students due to heightened sensory awareness can influence attention processes (Reese et al. 2005; Zentall 2005) and differences in visual processing abilities (Freed and Parsons 1997). The presence of motor skills deficits, which influence spatial perceptions (Baumers and Heylighen 2010), make it difficult for these students to negotiate space. These differences require a design response that will enable them to be part of mainstream school settings while being able to access and negotiate their school environment alongside their typical peers.

Theoretical models from occupational therapy, such as the SIT (Ayres 1989), were articulated largely in the exteriors of all three schools, with the provision of climbing equipment and play areas suggested as developmental opportunities to students with sensory deficits. Similar affordances from design perspectives were not observed in the interiors of the schools for children with LDs. As Chapter 3 outlined, various design strategies are being implemented in special needs schools to respond to these needs, such as sensorial needs and affording sensory gardens (figure 10.1) or visual deficits and using flooring designs to enable wayfinding (figure 10.2). It is argued that while debates on the definition of LDs and objective identification criteria in education (Büttner and Hasselhorn 2011; Lyon et al. 2001) are resolved, models

grounded in special needs contexts for children with LDs are also used to inform the spatial design of mainstream school environments, making them more inclusive in nature. In doing so, designers can overcome some of the ambiguity that arises due to the emerging nature of data on LDs and the diversity of responses to environmental stimuli within this group.

Figure 10.1: Sensory Garden- Horsham Special Development School, Victoria, Australia is unable to be reproduced here due to copyright restrictions. Figure 10.1 can instead be accessed via (http://a4le.org.au/awards/2010-awards/2010-regional-award-winners-and-commendations/south-gippsland-specialist-school-childrens%E2%80%99-kitchen-garden,-leongatha,-victoria.).

Figure 10.1: Sensory Garden- Horsham Special Development School, Victoria, Australia, Association for Learning Environments (A4LE) 2012

Figure 10.2: Flooring patterns and textures - Hartvigsen K–12 School, Utah, US, is unable to be reproduced here due to copyright restrictions. Figure 10.2 can instead be accessed via (http://media.a4le.org/southwest/utah/Hartvigsen.pdf).

Figure 10.2: Flooring patterns and textures - Hartvigsen K–12 School, Utah, US, Association for Learning Environments (A4LE) 2013

The case studies did not reflect differences in understandings of space in schools between those with and without LDs. Nonetheless, as discussed in Chapter 5, there

are differences in response to environmental stimuli between typical children and those with LDs and among those with LDs in terms of responding to environmental influences of colour and noise. Literature on other environmental aspects of thermal comfort and light is either developing or too limited to draw conclusions regarding the differences and corresponding design response to these environmental stimuli. These diversities among students in mainstream schools and the lack of data on multiple environmental attributes suggest that a direct translation of the literature into design solutions cannot occur without collaboration with special needs consultants. Even then, it would need to follow an iterative process involving intra- and interdisciplinary collaborations, with the prototypes constantly refined based on emerging data from LDs studies.

10.2.3 Emphasis on child-centredness to achieve inclusion aims

Chapter 4 illustrated that emphasising the needs of the primary users, which in this study are students with and without LDs and teachers, will lead to meeting the objectives of both child-centred and inclusive school designs. The case studies of these three schools showed that children's perceptions of space differ from those of adults—specifically in the context of environmental opportunities that are relevant to children's perceptual and aesthetic sensibilities. These studies first demonstrated that a child-centred approach to design conceptualisation is also needed to gain insights into the school's environmental preferences in children with LDs. Second, the environmental affordances of spatial size, organisation and accessibility affected children's ability to interact with their learning environments and teachers' ability to organise settings to accommodate the needs of children with and without LDs. Learning occurs from various perspectives as a result of new experiences and engagement with learning environments (Glasersfeld 1996, 2005; Goldberg 2002; Hannaford 1995; Lippman 2010a; Piaget 1970; Zull 2002); thus, designers need to recognise the importance of understanding the spatial needs of learners and teachers in relation to learning processes to meet the aims of inclusion in school designs.

10.2.4 Supplementary spaces for responding to diversity among children with learning disabilities

A comparison of all school spaces in the case studies, while recalling instructional methods and pedagogical differences, noted that all children within the 6–8-year age group, including those with LDs, benefited from the provision of supplemental spaces such as secluded work areas to work independently or receive special needs teaching assistance. While such spaces act as contingency spaces (Lippman 2010a), they were also observed being used by typical students where and when available. The literature concurs that such spaces can act as transition spaces when educators require changes to educational paradigms (Carbone 2001), and they can offer 'escape spaces' (Mostafa 2008) or opportunities to escape unwanted sensory stimuli for severely hyperactive and ASD students. More importantly, they offer children with acute cases of LDs an opportunity to integrate with their typical peers without being conspicuous as a result of their differing abilities (Flynn and Rapoport 1976). The case study observations found similar indications in relation to children at Montessori School 2, who most often used available niches and spaces during classes that were in session. Where such spaces were limited—such as in Schools 1 and 3—children's comments and drawings of their ideal school environments frequently depicted elements from outside the building, including frog ponds, veggie gardens and play areas. The motivation for using these spaces was influenced by perceived sources of environmental stress (noise distractions or lack of optional spaces for restoration or self-regulation) or absent opportunities (lack of spaces to engage with nature and to spend quiet time, and inadequate formal areas for play activities). Similarly, when the school environment lacked the relevant qualities of offering agreeable challenges, experiences and opportunities in accordance with the person–environment fit theory (Parsons 1909), the students sought alternative spaces. These were both interior (art rooms and multi-use rooms) and exterior (play areas and gardens), thereby allowing them to engage their natural inclinations to be mobile, play and explore environmental stimuli (Cosco 2007; Day and Midbjer 2007; Titman 1994). Issues posed by unwanted environmental attributes (such as spatial limitations of size and mismatch with learning activities, as seen in School 1) adversely influenced students' attitudes towards interiors, with more students indicating a positive preference and motivation to use exterior spaces. Thus, students responded

to issues in their built environments by transferring their motivation and preferences to outdoor spaces as a coping mechanism. This response is similar to the practice of tuning out unwanted auditory stimuli (Broadbent 1971, 1978; Kahneman 1973) based on the environmental stress theory model (Haines et al. 2003).

As primary learning activities occur in classrooms, requiring children to look elsewhere to find person–environment congruencies can be detrimental to the overall learning objectives. Moreover, some of these inclinations, such as to be mobile and explore environmental stimuli in a tactile manner, are typical to each age group and must be considered when formulating strategies for designing school environments. The implication is that designers need to design learning environments with supplementary spaces in response to learning processes and associated spatial needs (such as sensorial and behavioural); such alternative spaces would afford children the relevant learner–environment transactions to facilitate learning.

10.2.5 Challenges in meeting inclusion aims in spatial design

While twenty-first-century school designs have seen many new approaches, including child-centred designs (Lippmann 2010a; Walden 2009), the architecture of schools remains largely unaligned with programmes of inclusion in educational practice, as stipulated in the policies of UNICEF and UNESCO (1994, 2005). Education policies in Australia operate according to ideologies of inclusion (Forlin 1998, 2001) through the provision of special needs teaching assistants and consultants. However, architectural standards lack such a policy to regulate school design standards. Thus, as shown in two of the three West Australian schools studied, school buildings lacked consideration of spatial affordances aimed at assisting educators and matching users' sensibilities. Architectural incompatibilities can impede teaching and learning processes in some cases, thereby posing additional challenges to those with LDs. It is vital that design conceptualisation processes acknowledge that there are additional dimensions to spatial influences related to health, behaviour and users' sense of well-being, as well as form, function and aesthetics. Design strategies that ensure congruency with these dimensions and that are relevant to learning processes would result in learning spaces that fulfil the basic function of offering an environment that is conducive to learning for children with and without LDs.

The analysis of the theoretical discourse in education, environmental psychology and behavioural sciences highlighted the difficulties associated with creating an inclusive school building. The presence of inherent disciplinary gaps between architecture, education and design is the primary issue in achieving an inclusive design solution. This is evident from existing knowledge regarding the importance of the space–behaviour nexus in architecture, and it can also be seen in research iterating the significance of built environmental stimuli on children with disorders such as ASD, hyperactivity and ADHD (Mostafa 2008; Tufvesson and Tufvesson 2009). The combination of case studies and literature in this thesis indicates that there are problems in intra- and interdisciplinary knowledge. Consequently, in two of the three schools studied, the resultant spaces were governed by pedagogy and functional efficiencies, yet were incompatible with teaching and learning needs. Addressing these issues requires new pathways, as proposed in Chapter 7, with the objective of designing school environments that are responsive to the behavioural needs of young children and supportive of their learning processes. Though research findings on LD group are limited, there is data available to start developing design strategies to respond to needs of the LD group in mainstream school settings. Table 10.1 offers selected examples of how inter disciplinary research findings from various disciplines can define design objectives enabling designers to create inclusive and responsive school spaces.

Table 10.1: Environment-behaviour design objectives to Design Strategies for Inclusive Learning Spaces – an example

Phenomenon/Research Name	Design objective	Potential Design Strategies
Design to support brain development		
Social challenges		
Negotiating varied complex social situations and relationships as part of brain development and evolution of the brain (Changeux 1985 cited in Zeisel 2006)	Learning spaces which affords opportunities for social and project situations for independent and group, enable the brain to learn	School spaces ranging from interiors (such as classrooms and hallways) to exterior spaces (such as pathways, gardens, undercover areas) can be designed to afford diverse range of opportunities for chance encounters, meetings and project situations
Design to support diversity in learner's needs		
Multiple Intelligence		
Individual brains process information (such as visual, social and emotional) differently (Goleman 1995: Gardner 1993 cited in Zeisel 2006)	Spatial design which affords opportunities to educators to articulate diverse learning styles to meet diversity in learning abilities	Classroom design can include varied spatial zones affording flexibility to learners and educators to choose between structured and open plan learning spaces For example: Contingency spaces (Jilk 2012, see Figure 10.3, Images A–D) Exterior environments can afford experientially diverse areas (for example: covered and open, hardscapes and softscapes) so educators have the choice to extend teaching and learning activities to outside the classroom and enabling learners to find a match with their specific needs such as of finding respite, restoration and self-regulation.
Design to support spatial needs of LD group		
SIT theory		
	Spatial design which supports academic intervention strategies (example- in seat behaviour, sustained attention among those with ADHD) and learning environments which responds to	Classrooms can be designed to accommodate furniture (example: Therapy balls), resources and equipment to address sensory integration challenges Classrooms can have zones for academic intervention activities and support for learners from LD group

	sensory integration challenges for those in LD group	Learning environments (exteriors and interiors) can afford balance of environmental textures, material and physical qualities (acoustic design, thermal comfort) which matches sensorial needs of those with sensorial processing deficits or disorders Example: ASPECTSS Design index (Mostafa 2014) – a design tool based on EBD approach which designs spaces to match sensory needs of autistic learners. Spatial design based on seven principles of acoustics, spatial sequencing, escape, compartmentalisation, transition spaces, sensory zoning and safety (see Figure 10.4 and 10.5)
Design focused on facilitating learning		
Practice theory and situated nature of knowledge acquisition (Lippman 2010a) Learning occurs as a result of learner-environment relationships where learners acquire knowledge through actively engaging with their physical settings	Learning environments which offers social context for knowledge acquisition through practical activities	Spatial design can offer multiple spaces encouraging flow of varied learning activities. Learning clusters with dedicated activity settings or zones allowing choice of teaching and learning through practical activities (for example art and music) connected to non-practical activities (for example book-based structured activities, library)

Source: as cited within Table 10.1

Figure 10.3: Images A–D 'Contingency spaces' (Jilk, 2012)

Figure 10.3A – Basic floor plan model 'Home Base' is unable to be reproduced here due to copyright restrictions. Figure 10.3A can instead be accessed via (Jilk, Bruce A. 2012. 'Place Making and Change in Learning Environments'. In *Children's Spaces*, edited by Mark Dudek, page 40. Oxford: Architectural Press).

A- Basic floor plan model 'Home Base'

Figure 10.3B – Alternative plan for collaborative learning is unable to be reproduced here due to copyright restrictions. Figure 10.3B can instead be accessed via (Jilk, Bruce A. 2012. 'Place Making and Change in Learning Environments'. In *Children's Spaces*, edited by Mark Dudek, page 41. Oxford: Architectural Press).

B- Alternative plan for collaborative learning

Figure 10.3C: Alternative plan for traditional learning activities is unable to be reproduced here due to copyright restrictions. Figure 10.3C can instead be accessed via (Jilk, Bruce A. 2012. 'Place Making and Change in Learning Environments'. In Children's Spaces, edited by Mark Dudek, page 41. Oxford: Architectural Press).

C- Alternative plan for traditional learning setting

Figure 10.3D – Alternative plan for creative learning activities is unable to be reproduced here due to copyright restrictions.Figure 10.3D can instead be accessed via (Jilk, Bruce A. 2012. 'Place Making and Change in Learning Environments'. In Children's Spaces, edited by Mark Dudek, page 42. Oxford: Architectural Press).

D- Alternative plan for creative learning activities

Figure 10.4: Sensory Design Matrix from (Mostafa, Magda. 2014. 'Architecture for Autism: Autism ASPECTSS'. Archnet-IJAR, International Journal of Architectural Research 8 (1): 143–158) is unable to be reproduced here due to copyright restrictions. Figure 10.4 can instead be accessed via (http://dx.doi.org/10.26687/archnet-ijar.v8i1.314).

Figure 10.4: Sensory Design Matrix (Mostafa 2014)

Figure 10.5: Sensory–needs based spatial zoning from (Mostafa, Magda. 2014. 'Architecture for Autism: Autism ASPECTSS'. Archnet-IJAR, International Journal of Architectural Research 8 (1): 143–158) is unable to be reproduced here due to copyright restrictions.Figure 10.5 can instead be accessed via (http://dx.doi.org/10.26687/archnet-ijar.v8i1.314).

Figure 10.5: Sensory–needs based spatial zoning (Mostafa 2014)

10.3 Conclusion

> …if we want children to grow up with a zest for living we need to give them living spaces that express that life is a grand experience. (Hendricks 2011, 167)

This study set out to explore the environment–behaviour nexus that has been the subject of research across many disciplines and given rise to research areas such as EBR, environmental psychology and neuroscience. Grounded in the space–behaviour nexus hypothesis, it drew upon the disciplines of architecture, education and behavioural sciences to study school spaces with the aim of analysing school buildings and how to design them to support learning—specifically for those with LDs. The study aimed to answer the key question of whether mainstream school environments can be designed to enable students to maximise their learning potential, including for those with LDs. To meet this objective via an exploration of school spaces and the pedagogical nexus, this thesis identified that the issue with school design is a result of interdisciplinary gaps between architecture and education and an intradisciplinary gap between architectural practice and research. Analysis of multidisciplinary literature reviews and the case studies suggest a clear link between spatial design and human behaviour and the need to rethink standard design approaches of producing generic school designs without consideration of the diverse nature of learners. This chapter concludes the thesis and highlights the significance of this study in the larger context of designing spaces for children with LDs. Further, it proposes potential pathways for future research in this context.

Twenty-first-century school designs need to follow integrated multi-modal approaches that are developed to respond to the diverse and complex needs of children with LDs. Children in particular age groups also vary in their temperaments and inclinations to learn; some are active, while others may prefer a quieter environment. The case studies in this research showed that one way to address these differences is to provide ‘space within space’. This concept is commonly seen in alternative pedagogies such as Montessori and Waldorf schools, and it is also seen intermittently in structured or DI-based classrooms in Australia. The complexities of users’ needs—specifically, behavioural and perceptual—were considered one of the foremost challenges in designing behaviour-based customised learning spaces. The literature analysis and case studies suggested that the ‘space within space’ concept

has significant potential to respond to user diversity and enable designers to begin addressing the challenge of designing spaces to respond to user diversity in the complex setting of a classroom. The recognition of this aspect is largely missing from architectural practice once standards, procurements and budget goals are met.

This thesis reiterates the often-repeated views of authors and studies that argue that the benefits to children's behaviour, abilities, health and well-being far outweigh the costs. The built environment factors and elements examined in the literature suggest that each element has both a physiological and psychological effect on children, influencing their motivation to learn, performance levels and behaviour. Factors such as efficient thermal comfort levels and noise management are known to have greater behavioural effects such as aggression, social behaviour and motivation, while others, such as chairs, colour and spatial arrangement, have both physiological (musculoskeletal) and behavioural (attention, socialisation) effects. The cumulative effects of schools' environmental factors on students' physical and mental health are substantial and cannot be ignored in favour of economisation and aesthetics. Students of both groups can feel these effects; however, children whose visual, perceptual and sensorial deficits and sensitivity alter their perceptions of their built environments feel these effects to a greater extent. This suggests that eliminating negative effects from the ambient and physical sources of built environments will be inclusive for children both with and without LDs.

This study's critical analysis of the literature shows that built environmental variables can be vital in impeding or enhancing learning for special needs children by influencing their physiological and psychological states. Consequently, based on the findings and literature from neuroscience (Eberhard 2007; Goswami 2004a, 2004b; Zeisel 2006) and learning space–behaviour links for special needs students (Carbone 2001; McAllister 2010; McAllister and Maguire 2012; Mostafa 2008; Shabha 2006; Weinstein 1977), the view is supported that school design can contribute to educational interventions for children with and without LDs by ensuring a match between school design, teachers' functional efficiency needs and students' learning, behavioural, sensorial, perceptual and cognitive needs. However, the success of educational buildings also depends on a holistic, multi-modal approach requiring interdisciplinary partnerships between design and education and an intradisciplinary

approach between architectural practice and research. Designers of schools need to address users' behavioural needs from educational buildings, especially for children who face the maximum effects of a school environment's poor design.

The case study's findings support the literature that highlights how nature and the outdoors form a significant part of children's ideas of school. Children of both groups believed they achieved learning, and they may not consider that learning only occurs in classrooms. The findings are also backed by literature and ongoing research into natural elements of school environments, which indicate that natural elements (e.g., lawns, gardens), including those providing opportunities to play and explore, have beneficial effects on behaviour—especially for those with inattention and impulsivity issues. The findings also reiterated the importance of green settings for children's emotional, physiological and behavioural health—all of which are necessary for a positive emotional state and a consequent motivation to learn. The issue of generic school designs has been extended to green settings, where questions have been asked regarding whether such settings allow children to meet their needs of exploring, engaging and learning in the process (Hendricks 2011). Based on the literature and the case studies of this research, it is evident that the significance of green settings is worth serious consideration so that school designs are beneficial in reducing symptoms of stress and anxiety and increasing attention in children with and without LDs. Thus, the focus in designing schools should be on making them spatially inclusive by extending concepts of behaviour-based customisation beyond the building into the exterior environs, allowing seamless connectivity between the building and the site. This overarching perspective of design would consequently act as a facilitator, allowing both groups of children to engage with learning spaces as needed to achieve optimum learning objectives.

10.3.1 Contributions of the research

Previous studies in the context of school architecture and students with issues impeding learning abilities (Tufvesson and Tufvesson 2009; Yang, Becerik-Gerber and Mino 2013) have been conducted from an adult perspective, providing valuable insights from special needs consultants and the use of statistical analysis. The current study contributes to this knowledge bank by adding insights into the perspectives of children and a critical appraisal of cross-disciplinary literature. It differs from

previous child-centred research by sharing insights into children's perspectives and arguing that such insights are not only possible, but also necessary for achieving an understanding of the behavioural, perceptual and sensorial needs of children with LDs. The case studies illustrated that the acquisition of such data is possible with the help of special needs consultants and teaching assistants, contrary to arguments of similar studies (e.g., Tufvesson and Tufvesson 2009) and supported by studies in the children's environmental context (Mostafa 2008). Designing schools without such insights and consideration could result in spaces that continue to obstruct teaching and learning processes.

The study also contributed to filling in both intra- and interdisciplinary gaps within architecture and education, thereby establishing a nexus between behaviour and spatial qualities in the context of mainstream school environments and the learning potential of children with LDs. The research has therefore achieved the following objectives:

1. It has added to the body of knowledge on the relationship between spatial design and education by showing that the cumulative influences of school environments have significant potential to assist in non-medication interventions in educational practice for children with LDs.
2. It has suggested potential positive design approaches towards the emerging knowledge bank on design strategies that respond to current educational policies of inclusion and mainstreaming.
3. It extends the understanding of behavioural and psychological relationships of space in terms of spatial perceptions, experiences and interactions that are vital to the success of learning environments as positive enclosures for students.

10.3.2 Significance of the research

This study questioned what we know about designing educational spaces, and it highlighted gaps in our understanding of the design of spaces. In discussing these gaps, it proposed new pathways from existing practice and a model of school design framework that may be used to design schools that respond to the behavioural needs of children and support their learning processes. It highlighted disciplinary gaps that

need to be bridged to develop solutions towards inclusive school architecture. Further, it argued that as architects and designers, we are accountable to the users of the spaces we design—specifically to those with LDs. In furthering this argument, it proposed pathways identified from unconventional examples of school design practice with the potential to address the issue of user diversity in a multi-user space such as a classroom.

10.3.3 Areas for future research

Due to the small sample size of children with LDs in this study, further research is required on a group with LDs exhibiting a broader range of symptoms to realise the effects on a larger population size. Empirical research is necessary on a larger, statistically significant sample size of children with LDs to identify design solutions that respond to diversities in children's learning processes. Based on this, further studies are needed to determine how designers can meet the objective of inclusion in mainstream schools, which requires them to seamlessly mesh the diverse spatial needs of typical children and those with LDs. Lastly, an exploration into the proposed iterative model of school design is essential because it can bridge design practice with research so the solutions are grounded in concrete human experience and developing child-centred design solutions.

10.3.4 Closing remarks

This study concludes with the view that if school designers maintain complacent attitudes by adhering to budgets, aesthetics and specifications, their designs will continue to fail to meet the diverse spatial and learning needs of users and impede the most basic objective of the learning space: to provide an optimum environment that is conducive to learning.

This study focused on learning environments and their influences on symptoms of inattention and impulsivity, which are commonalities of several LDs, including ADD, ADHD and ASD. This study supports previous views that the attributes of built environments can adversely or positively affect the children of both groups. Further, these influences are considerably powerful and can form part of non-medication interventions (or ecological interventions as they are known in education) to address the needs of children with LDs (Carbone 2001; Denney 2001). Designers

should consider the importance of responding, via design, to the needs of children with LDs by incorporating an understanding of their psychological, perceptual, sensorial and behavioural propensities in the context of learning. Such designs would not marginalise either children with LDs or typical children, and they would offer both groups opportunities to learn in a supportive environment that incorporates coping alternatives when factors other than the built environment cause stress. Alternative pedagogical models, such as those of Steiner and Montessori, and non-architect-built schools that are developed in accordance with such models can lay the foundation for conceptualising inclusive architecture prototypes grounded in the creation of learning environments from children's perspectives on engagement and development. This overarching approach will limit ambiguity and the challenges posed by designing spaces for a heterogeneous group of users. Where such space and pedagogies cannot be harmonised effectively, spatial design should at least not obstruct the teaching and learning processes.

Evidence exists regarding perceptual and sensorial difficulties among children with LDs in the context of negotiating their built environments. However, its fundamental application in designing inclusive school buildings is missing from school design practice. There appears to be endemic in school architecture of standardising spatial designs resulting in generic modular prototypes, which in itself is not a negative approach. Nonetheless, the design of school spaces requires further customisation to better suit the spatial needs of children including those with LDs. The relationship between learning and behaviour can only be articulated in a design language when it is expressed as an iterative process supported by EBD, POEs and partnerships with all stakeholders, and specifically its primary users, children. In offering a better understanding of the behavioural and perceptual dimensions of school spaces, this thesis demonstrates a broader need for school designers to understand these issues in the design of any learning space.

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Appendix A

Curtin University of Technology, Department of Architecture: Faculty of Built Environment and Design.

Informed Consent Form - Children

I have read the information sheet about the project on design of better school spaces.

- ✓ I have asked questions about the things I wanted to know more about.
- ✓ I know I do not have to work in this project if I don't want to.
- ✓ I know that it is OK for me to stop being a part of this project if I change my mind.
- ✓ I understand that no one will know who I am when the results of the project are made into a report
- ✓ I know I can contact my teacher or parent if I want to ask more questions or need help during the project.
- ✓ I would like to work in this project.

NAME OF CHILD:_____(Please print)

SIGNATURE OF CHILD:_____Date: _____

1 This study has been approved and reviewed by the Curtin University Research Ethics Committee **(Approval Number: HR 154/2008)** which can be verified via email on hrec@curtin.edu.au or telephoning 92662784.

Curtin University of Technology, Department of Architecture: Faculty of Built Environment and Design.

Consent Form - Parents

- ✓ I have read the information regarding the proposed doctoral research project to be conducted by Soma Mandal Datta.
- ✓ I have been provided with the participant information sheet and understand the procedures involved in the study.
- ✓ I give my consent to conduct the Mind and Architecture Research Project with my child whose name is .....
- ✓ I understand that I may upon request receive a copy of photographs that maybe taken as assurance of absence of any in it and a copy of outcomes of the research. I understand the confidentiality of the school, teachers and student identity will be maintained at all times.
- ✓ I understand that I am free to withdraw my child from this study at any time.

Parent's Name :.....

Signature: ..... Date:.....

Child's Name :..... School

: ..... Year & Class:

My child *has/does not have* a learning disability (please circle)

Type of Learning disability (if known).....

This study has been approved and reviewed by the Curtin University Research Ethics Committee **(Approval Number: HR 154/2008)** which can be verified via email on hrec@curtin.edu.au or telephoning 92662784.

Curtin University of Technology, Department of Architecture: Faculty of Built Environment and Design.

PARTICIPANT INFORMATION SHEET (for students)

Hello, I am Soma.

I am studying ways to design better schools and help you do better in your learning. I am going to find out if learning is easier if we change certain aspects of school spaces like wall colours, different ways of arranging the furniture, better heating and cooling systems and so on. Therefore, I need to find out what children like you would like to have in schools. The outcome of this study will help other architects and interior architects create better schools.

Participating in this study involves attending schools as usual and answering some questionnaires asked by your teachers. It also includes a wish poem, drawing and colouring activity.

I will be visiting your classrooms in progress, once in a fortnight to make notes and talk to your teachers.

You don't have to take part in this project if you don't want to and can stop at any point you change your mind.

You can also talk to your teacher or parent at any point if you are uncomfortable or unhappy.

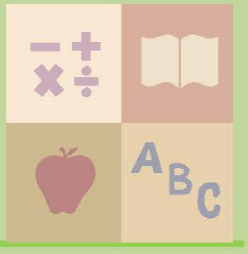
No one will know your names when the results of this study are made into a report.

Thank you for your time and participation in this research. Please keep this letter for your information.

This study has been approved and reviewed by the Curtin University Research Ethics Committee (**Approval Number .HR 154/2008**) which can be verifiec via email on hrec@curtin.edu.au or telephoning 92662784.

2011

Student Insights Into School Design



LD/Non L.D (circle one)
Name (Assign pseudonym):
Age:

Gender:

Curtin University

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PART 1/2: Built environment forms

Systems	Unique Design Features (for LD		User observations/comments	Researcher's comments/notes
	Yes	No		
Spatial arrangement (interior planning)				
Floor finish				
Seating systems				
Display space				
Circulation spaces				
Wall Colours and graphics				
Lighting systems				
Natural Light				
Ventilation				
Heating/Cooling(Thermal Comfort)				
Acoustical Features				

Student Insights into School Design

Site Visits/Primary School and Classroom Settings

Flexibility				

Visual Documentation: Record via sketches and Photography

Observations and Comments:

Student Insights into School Design

Site Visits/Primary School and Classroom Settings

Category	Behaviour/Emotions	
Behaviours	Quiet	active
Settings	indoor	outdoor
Groups	By self	With friends
Emotions	sad	happy
Time	Short time/weekends	Long time/vacations
Seasons	summer	winter

Part 2/2: Interviews with students

Allow 30 minutes or more if they are willing.

3.i) ACTIVITIES AND PLACES- WHAT, WHERE, WHY

NOTES

1. A) Can you tell me how you reached school- by car, bus or walked from home?

_____

_____

_____

1. B) How will you go back home/day care -is it the same way?

_____

_____

2. A) Which activity in school do you like best?(ask about games, hideaways, sports, art, etc.)

_____

_____

_____

_____

2. B) Why do you like this activity?

_____

_____

_____

3. Do you find your way easily in/around school building (to classrooms, other areas)?

_____

_____

_____

4. Which is your favourite spot in school and why?

(Probe for qualities of the physical environment that are most meaningful to children. Use an area map or have individual children draw a cognitive map of their favourite places on copies of the next sheet).

Ask about where they like to go to be the following:

Student Insights into School Design

Site Visits/Primary School and Classroom Settings

Child's Cognitive Map (If necessary use separate sheet for each child).

3.ii) USER SATISFCATION- Play areas

NOTES

4. Do you like .....? Yes ☐ No ☐ Other .....

Why?

_____

_____

_____

5. Which activities do you like most to do there? Why?(Probe for qualities of the physical environment that are most meaningful to children. Use an area map or get individual children draw a cognitive map of their favourite places on copies of the next sheet)

Activities	Reasons

6. How about the school building – do you like the building /classrooms?

Yes ☐ No ☐ Other

Why do you like it? What do like about it the most?

_____

_____

7. What are your favourite areas/places? Why?

Places	Reasons

8. What is the best area for

(Pick up activities for the children mentioned in Q. 5)

Activities	Places	Reasons

NOTES

9. (Optional – use only words/very verbal, patient group)

If you could have anything else here that you wanted, what would you most have?

_____

_____

_____

_____

Note: Use for independent play areas and play areas within the school such exterior play areas (outside school campus) and inside school campus. You will need to carry pictures of local playground.

10. Do you like .....? Yes No Other .....

Why?

_____

_____

_____

11. What sort of things do you most often do here? Why?

Activities	Places	Reasons

12. What are your favourite areas/places? Why?

Places	Reasons

13. What is the best place for _____

(Pick-up activities mentioned in Q.11)?

Activities	Places	Reasons

14a. (optional) Have you ever been to a different type of play-ground,like one without..... (swings, etc. ,mention subtractive differences from current play area)?

Did you like it? ☐ Yes ☐ No Other _____

_____

14.b(Optional)

If you could have anything else here that you wanted, what would you have ?

_____

_____

end

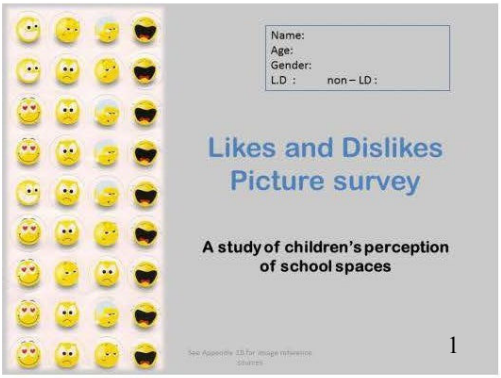
Art Survey

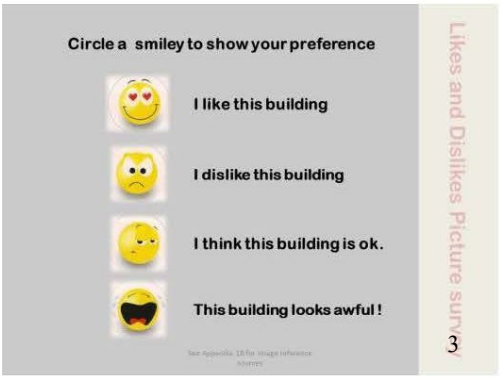
Draw a picture of your favourite place in school on paper supplied by Researcher/Teacher.

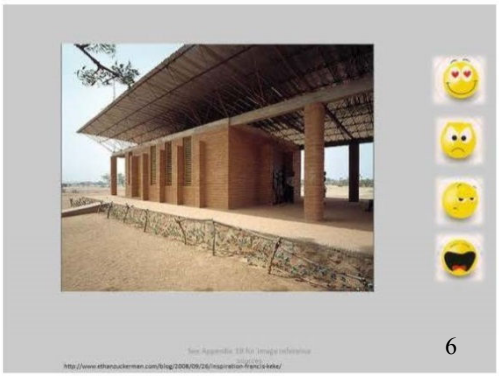
Wish Poem

- I wish my playground had
- I wish I had in my classroom
- I wish my school had
- I wish my classroom was
- I wish my school was
- I wish I had a magic wand
- To make all my wishes come true.

Image Survey Template



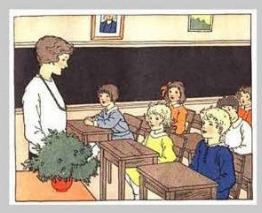




See Appendix 18 for image reference sources

http://www.e-architect.co.uk/images/jpgs/barcelona/castelldefels_primary_school_ecp100209_1.jpg

7



Set 2: Shall we look at a few pictures of <u>Classrooms?</u>

See Appendix 18 for image reference sources

10

See Appendix 18 for image reference sources

8

Likes and Dislikes Picture survey

- I like this classroom
- I dislike this classroom
- I think this classroom is ok.
- This classroom looks awful!

See Appendix 18 for image reference sources

11

Now look at the pictures of schools again and pick up your most favourite with a coloured dot and the one you like least of all with a black dot!

See Appendix 18 for image reference sources

9

See Appendix 18 for image reference sources

http://www.designshare.com/index.php/projects/lyndel-hughes-elementary-school/images#5023

12

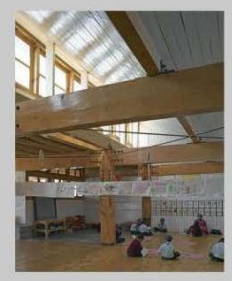
http://www.pgcps.org/~rosa/links/tour.html

See Appendix 18 for image reference sources

13

See Appendix 18 for image reference sources

16



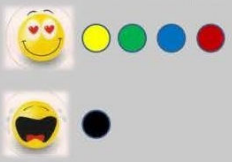
See Appendix 18 for image reference sources

14

WELL DONE!!

Set 3:LAST Question

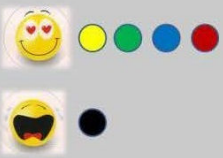
Now look at the following pictures select your favourite with a coloured dot and the one you like least of all with a black dot!



See Appendix 18 for image reference sources

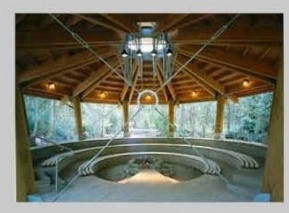
17

Now look at the pictures of classrooms again and pick up your most favourite with a coloured dot and the one you like least of all with a black dot!



See Appendix 18 for image reference sources

15



See Appendix 18 for image reference sources

18

http://www.designshare.com/index.php/projects/the-international-school/images/#5124

19

See Appendix 18 for image reference sources

20

See Appendix 18 for image reference sources

Well Done and thank you for helping me with this survey.

21

See Appendix 18 for image reference sources

Appendix B

Selection criteria for images

The images were selected on basis of significant contrast or similarity in appearance and opportunities from typical Australian Schools. A typical Australian school is considered as one which is single storey, with sloped roof, pre-fab or modular structure with exteriors affording opportunities to play and engage such as ovals and lawns. Likewise, images for classrooms were selected on the criteria of typical Australian classrooms with subtle colour palettes, availability of diversity of seating arrangements (group and independent work) with visual displays of student work present within the classroom.

Description and Image sources

Image B1: Multi storey school building, Australia is unable to be reproduced here due to (copyright restrictions). Image can instead be accessed via (http://www.colorbond.com/images/SourceImage/Nth-Melb-Primary-School-def.jpg).

Image B1: Multi storey school building, Australia (http://www.colorbond.com/images/SourceImage/Nth-Melb-Primary-School-def.jpg)

Image B1 is illustrates an Australian school, different in its appearance from most typical Australian schools by being multi-storeyed in form and appears aesthetically better with well-maintained lawns. However this school is similar to typical Australian schools in terms of site features in terms of materiality (prefab, colour

bond structure) and landscape. The intent was to discern how the children would rate this school where it is but almost similar to existing school sites and structures.

Image B2: Single storey Primary School, Australia is unable to be reproduced here due to copyright restrictions. Image B2 can instead be accessed via (http://www.rendelshps.sa.edu.au).

Image B2: Single storey Primary School, Australia (http://www.rendelshps.sa.edu.au)

Image B2 of a typical Australian school with prefab structure was selected as a second example of standard prototypical single storey school building prevalent around Australia. Although there are exceptions, this was mainly selected to gain insights into student's perception of aesthetically similar school buildings that they occupied. It was expected to get a either positive or neutral rating on account of it being culturally familiar looking building and also representative of their preconceived notion of what school buildings typically look like.

Image B3 (right) Rural School, Africa is unable to be reproduced here due to copyright restrictions. Image B3 can instead be accessed via (http://www.ethanzuckerman.com/blog/2008/09/26/inspiration-francis-keke).

Image B3 (right) Rural School, Africa (http://www.ethanzuckerman.com/blog/2008/09/26/inspiration-francis-keke)

Image B3 was selected for its stark contrast to typical schools in Australia. It must be noted however that this school won awards for responding to various difficulties – both social and economic in a remote village in Africa. The aim was to evaluate verify how children responded to the idea of such a school vastly different from their current cultural and social concepts of what a school should offer in terms of opportunities and experiences; this was based on literature (Rapoport, 1990) suggesting that users' perceptions are also governed by preconceived ideas of space informed by socio-environmental aspects and cultural conditioning which may require consideration while seeking to design user-centered spaces.

Image B4: Multi-storey modern School Building, Barcelona is unable to be reproduced here due to copyright restrictions. Image B4 can instead be accessed via (http://www.e-architect.co.uk/images/jpgs/barcelona/castelldefels_primary_school_ecp100209_1.jpg).

Image B4: Multi-storey modern School Building, Barcelona (http://www.e-architect.co.uk/images/jpgs/barcelona/castelldefels_primary_school_ecp100209_1.jpg)

Image B4 is of an award winning school in Barcelona winning accolade for responding sustainable to a difficult site on account of its proximity to railway lines and residential area where residents were concerned about their privacy and if the building 'fitted' into the existing structures of the locality. These aspects though were of no relevance to the survey. The building is structurally bigger than most local typical Australian school buildings with its most prominent feature being the unique roof profile and reflective surfaces thus being aesthetically modern and urban in its appearance. Again, this image was selected to evaluate how they would respond to a difference from typical schools in terms of appearance, materiality and form while also comparing their responses to image B3.

Image C1: Primary School Classroom, Barcelona is unable to be reproduced here due to copyright restrictions. Image C1 can instead be accessed via (http://www.e-architect.co.uk/images/jpgs/barcelona/castelldefels_primary_school_ecp100209_1.jpg).

Image C1: Primary School Classroom, Barcelona (http://www.e-architect.co.uk/images/jpgs/barcelona/castelldefels_primary_school_ecp100209_1.jpg)

Image C1 was selected as an example of typical classroom - spacious, well illuminated but with a unconventional seating arrangement. Pedagogically different schools of thoughts have different ideas on how school furniture, specifically desk-chair set ups should be arranged in a classroom. This particular classroom with its conventional (western-world context) colour palette and materiality in its interiors, differed in the seating arrangement with a zig- zag seating pattern. Literature highlighted the importance of seating arrangement and its quality in being influential on attentional capacities, socialisation with peers and teacher in addition to enabling better on-task behaviour (for eg. See Mitchell 2006). Based on this, image C1 aimed

to gain insights into children's their views towards seating in a classroom when it differed from norm and if their views impacted on overall rating of this classroom as a learning space.

Image C2: Rosa L. Parks Elementary School, Hyattsville, MD, USA is unable to be reproduced here due to copyright restrictions. Image C2 can instead be accessed via (http://www.pgcps.org/~rosa/links/tour.html)

Image C2: Rosa L. Parks Elementary School, Hyattsville, MD, USA (http://www.pgcps.org/~rosa/links/tour.html)

Image C2 was selected primarily for two reasons. Its layout was similar to most standard classrooms to be surveyed. And second on account of its prominent use of red and blue colours in the classroom interiors. Though spacious and uncluttered, the red-blue colours visually dominate the interiors. Literature indicates overtly coloured environments can be perceived negatively by users (Gaines and Curry 2011). The aim here is to determine if their response to this classroom would be influenced specifically on account of colours or if there is another element that influences their positive or negative rating of this classroom.

Image C3: Open Plan School Classroom, Druk White Lotus School, Himalayas, Tibet, Author: Patricia Donovan, pdonovan@buffalo.edu, Release Date: September 12, 2006, is unable to be reproduced here due to copyright restrictions. Image C3 can instead be accessed via (http://www.buffalo.edu/news/8155).

Image C3: Open Plan School Classroom, Druk White Lotus School, Himalayas, Tibet, (http://www.buffalo.edu/news/8155 Author: Patricia Donovan, pdonovan@buffalo.edu, Release Date: September 12, 2006)

Image C3 of an open plan informal classroom was selected for its difference in materials with the warm wooden tones and spatial qualities of openness and voluminosity. The researcher expected the respondents to favour such a space that looked informal and unstructured allowing free movement and engagement with space in keeping with the constructivist constructs which encourages free movement and interaction with space as part of learning. Other qualities of sustainability and technology were not considered as these were not relevant for the purpose of the survey-- the current study focuses on interpretations of the built space and how users perceived its qualities.

Image M1: Island Wood, US, Outdoor-indoor connections in learning environments is unable to be reproduced here due to copyright restrictions. Image M1 can instead be accessed via (http://www.solaripedia.com/13/169/1660/islandwood_friendship_circle.html).

Image M1: Island Wood, US, Outdoor-indoor connections in learning environments

(http://www.solaripedia.com/13/169/1660/islandwood_friendship_circle.html)

Image M1, is an *Outdoor Education centre*, *'Island Wood'*, built on sustainable architecture principles. The Island wood aimed to create a hands-on outdoor science education centre amongst nature with school and community participation while providing 'indoor exposure' to green architecture. However for the current study, image M1 was selected for its circular seating arrangement which appears to afford informal opportunity to engage and promote communication. The aim was to examine how participants interpreted this image in terms of affordances and opportunities for learning, further shedding light on how they read atypical school environments with these characteristics.

Image M2 is from an award winning school from Hague (Netherlands), with the school's design concept focused on creating school within a school, based on alternative schooling pedagogy. Architecturally, it set an example for transparency and light in architecture and in terms of spatial experience, aimed to provide the opportunity to play and engage in informal activities such as having lunch. The image was selected for these architectural and experiential qualities to examine if

these aspects captured the interest of the participants and if not, what defined their understanding of this space.

Image M2: Transparency and play of light in Architecture is unable to be reproduced here due to copyright restrictions. Image M2 via (http://www.designshare.com/index.php/projects/the-international-school/images).

Image M2: Transparency and play of light in Architecture (http://www.designshare.com/index.php/projects/the-international-school/images)

Image M 3.1 and M 3.2: Public school Panta Rhei in Amstelveen (NL) is unable to be reproduced here due to copyright restrictions. Image M3.1 and M3.2 can instead be accessed via (http://www.dezeen.com/2009/06/12/panta-rhei-school-interior-by-i29/)

Image M 3.1 and M 3.2: Public school Panta Rhei in Amstelveen (NL) (http://www.dezeen.com/2009/06/12/panta-rhei-school-interior-by-i29/)

The selection of images 3.1 and 3.2 were based on their austere colour palette. Minimalistic in its spatial qualities, these were intended to help determine how the participants would respond towards an environment devoid of colours and lent by various materials and assortment of student work displayed in school spaces. These

images aimed to follow up on the ‘colourful’ classroom images shown previously and gain deeper insights on what defines participants’ understandings on environmental excesses for colour.