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Architecture and Students' Physical Activity in Learning Environments

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Architecture and Students' Physical Activity in Learning Environments

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Declaration

To the best of the candidate's knowledge, this thesis contains no material previously published by another person, except where due acknowledgement has been made.

This thesis is the candidate's own work and contains no material that has been accepted for the award of any other degree or diploma in any institution.

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 2018). The proposed research study received human research ethics approval from Curtin University Human Research Ethics Committee with Cross-Institutional approval from The University of Notre Dame Australia Human Research Ethics Committee. Approval number: HRE2018-0188 and 2020-086F (see Appendix 10.1).

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Abstract

'Architecture and Students' Physical Activity in Learning Environments' is a doctoral thesis that aims to understand how the physical activity behaviours of Australian children are influenced by school architectural environments. Physical activity (movement) and sedentary behaviour (sitting) play a major role in the overall health of children, yet Australian children are failing to meet the government recommendations (Active Healthy Kids Australia (AHKA) 2016). As most children spend a significant amount of their time in schools, it is important to understand how the learning environments influence them. The architecture of schools is perhaps the least changed architectural typology within contemporary society, and traditional schools with students divided into classrooms ruled by a single teacher still prevail in most Australian schools. These classrooms typically promote teacher-centred pedagogy and encourage sedentary behaviours. In contrast, contemporary non-traditional learning environments promote student-centred pedagogies and encourage physical activity. This project used a case study methodology with a mixed-method approach and a social ecological model as the theoretical framework. A single Montessori primary school was used as a case study with data collection methods, including architectural analysis, ethnographic observation, quantitative recordings of students' physical activity behaviour and interviews with teachers and architects. The research provides new information for architects, school leaders, teachers and government organisations to inform the future architectural design of Australian primary schools. In the design of learning environments, I recommend that stakeholders focus on key factors that influence students' physical activity behaviours, including acoustic design, adaptable open spaces, furniture selection and arrangement and outdoor learning environments. The research demonstrates that to improve students' physical activity behaviours in learning environments, stakeholders must undertake a holistic approach that focuses on physical, social and organisation factors and involves architectural design, school policies and collaboration with all stakeholders.

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List of Acronyms and Abbreviations

AHKA	Active Healthy Kids Australia
CBPA	classroom-based physical activity
HPE	health and physical education
INC	inconclusive
ILE	Innovative Learning Environment
LEA	Learning Environments Australasia
MVPA	moderate to vigorous physical activity
n	number
NAPLAN	National Assessment Program Literacy and Numeracy
NGLE	New Generation Learning Environment
POE	post-occupancy evaluation
PrOE	pre-occupancy evaluation
SD	standard deviation
SOFIT	System for Observing Fitness Instruction Time
SOPLAY	System for Observing Play and Leisure Activity in Youth
TEC	Teacher’s Environmental Competencies
UK	United Kingdom
US	United States (of America)
WA	Western Australia

Glossary

Articulation	Fragmentation of a planar surface through creation of indents or a series of interconnected spaces (spatial articulation)
Built Pedagogy	Architecture of learning environments reflects the teaching style that it is designed to host
Environmental Competence	A persons ‘ability to effectively use the physical environment to meet desired goals’ (Lackney 2008, 134). Also referred to as ‘spatial literacy’
Learning Environment	A school setting. The physical, social and organisational environment of a school, including buildings, interiors, furniture, organisation, management and pedagogy. Also referred to as ‘learning space’, ‘learning setting’ and ‘classroom’
Openness	Actual or perceived open space. Physical openness relates to the volume or size of space and is linked to open-plan. Visual openness relates to available views to other spaces through use of glazing or interconnected spaces
Pedagogy	The practice, principles and styles of the teaching profession. Traditional pedagogies are teacher centred, and contemporary pedagogies are student centred
Physical Activity	Any movement of the body that requires energy to be expended and is categorised by levels of intensity, including light, moderate and vigorous physical activity that ranges from standing to walking or running
Physical Activity Behaviours	Physical activity and sedentary behaviours
Physical Inactivity	Insufficient levels of physical activity
Sedentary Behaviour	Any waking activity with low energy expenditure while sitting or lying
Traditional Classroom	An enclosed room in a school that supports teacher-centred pedagogies

1. Introduction

The design of learning environments influences students every day, usually without them knowing. The built environment forms part of a complex relationship between people and the spaces inhabited. This project uses a primary school in Perth, Western Australia (WA), as a case study and focuses on the influence the architectural design of learning environments can have on the physical activity and sedentary behaviours of participating students. Physical activity and sedentary behaviour play a major role in the overall health of children; however, only 12% of Australian primary school–aged children are meeting both the physical activity and sedentary behaviour guidelines (AIHW 2020). Individually, 26% of primary school–aged children are meeting the physical activity guidelines, and 35% are meeting the sedentary behaviour guidelines (AIHW 2020). The term ‘physical activity behaviours’ is used throughout this thesis, which includes both physical activity and sedentary behaviours. As most children spend a significant amount of their time in schools, it is important to understand how these learning environments influence their physical activity behaviours. Due to the multidisciplinary nature of researching architecture, education and health, this project uses a case study methodology with a mixed-method approach. A single Montessori primary school was used as a case study[1] to allow a deep understanding through the collection of architectural analysis, ethnographic observation, quantitative physical activity and interview data. The mixed-methods analysis highlighted that the non-traditional socio-spatial learning environments provided space for movement, but physical activity was not always encouraged. This chapter introduces the context, theoretical framework, objectives, approach and significance of the research project and provides an outline of the thesis.

Throughout this thesis, the term ‘learning environment’ is used to describe school settings, although the terms ‘learning space’, ‘learning setting’ and ‘classroom’ are often used interchangeably within the current literature. The term ‘classroom’ is still

[1] The Montessori primary school was chosen as a case study because the principal self-nominated the school and student movement is a key aspect of the Montessori pedagogy, which will be discussed in Chapter Five. The case study school selection will be further discussed in Chapter Four with the school described in detail in Chapter Five.

widely used in Australia; however, it is associated with traditional schools and teacher-centred pedagogies that historically related to the social ‘class’ of students (Woodman 2016, 53). Woodman (2016, 53) states that ‘new terminology has developed to reflect more student-directed environments with “learning spaces” becoming the preferred term turning the focus onto learning rather than teaching’. However, as Woodman (2016) points out, a debate continues on the meaning of the terms ‘space’ and ‘place’, which is a side argument beyond the scope of this thesis. The term ‘learning environment’ is more descriptive and more widely accepted by both academics and educators. This terminology is demonstrated through the 2015 rebranding of the worldwide Association for Learning Environments, previously named the Council for Educational Facility Planners International (A4LE 2021).

The term ‘learning environments’ also acknowledges the variety of environments that learning can occur within, such as various physical, social, organisational or virtual environments. Weinstein (1981) argues that the physical spaces of the school environment are as critical as the curriculum for learning due to the varied influences on children. However, the built environment cannot be studied in isolation since social and cultural factors also play a role in how the environment is ‘perceived, responded to, and used by the inhabitants’ (Weinstein and David 1987, 12). In this thesis, learning environments are defined as physical, social and organisational environments, including buildings, interiors, furniture, organisation, management and pedagogy.

Context within the Current Literature

The relationship between learning environment design and students’ physical activity behaviours in Australia is not clearly understood. Architects and designers influence behaviour through their design choices before the school buildings are constructed, so students’ physical activity is influenced long before they enter the school; however, there is very little research published on the design processes of architects who design learning environments. Australian research into students’ physical activity behaviours generally falls within the realm of urban planning or is singularly focused on specific school elements such as external play areas (see for instance Martin et al. 2013), standing desks (see for instance Clemes et al. 2016) or pedagogical programs (see for instance Salmon et al. 2011). Many researchers believe that the physical and social 'cues' within learning environments influence the behaviours of teachers and students (see for instance Woodman 2016; Smith 2017); however, very little strong evidence exists to support claims that specific elements of school architectural environments influence physical activity behaviours.

Children in Australia are consistently failing to meet recommended levels of physical activity and sedentary behaviour (AHKA 2014, 2015, 2016, 2018). Physical activity is defined as any movement of the body that requires energy to be expended (WHO 2017) and is categorised by levels of intensity, including light, moderate and vigorous physical activity that ranges from standing to walking or running. Physical inactivity is defined as insufficient levels of physical activity, whereas sedentary behaviour is considered any waking activity with low energy expenditure while sitting or lying (Pate et al. 2011; Tremblay et al. 2017). Australian guidelines recommend that school-aged children achieve at least 60 minutes of moderate to vigorous physical activity (MVPA) and accumulate no more than two hours of non-educational screen time each day, as well as breaking up 'long periods of sitting' (Australian Government Department of Health 2019).

There are many challenges that architects and other stakeholders face during design, construction and occupation phases that could be a barrier to improving students' physical activity behaviours. A key challenge is communication barriers between stakeholders due to a 'lack of shared vocabulary' (The Featherston Archive 2017). A secondary challenge, which is widely discussed in the literature, is the lack of environmental competence (Steele 1980) or spatial literacy of teachers (Fisher 2004), which is defined as 'the ability to effectively use the physical environment to meet desired goals' (Lackney 2008, 134). This causes particular problems in contemporary learning environments that rely on teachers to guide students in the best use of space. These spaces are often referred to as 'New Generation Learning Environments' (NGLEs) or 'Innovative Learning Environments' (ILEs) (Imms, Cleveland and Fisher 2016).

School architecture is considered reflective of the teaching style that it hosts, which is termed 'built pedagogy' (Monahan 2002); however, the architecture of schools is perhaps the least changed architectural typology within contemporary society.

Pedagogical theory can be simplified into three categories, including teacher-centred models of behaviourist theory; cognitivist theory, where children are expected to learn through completing tasks; and student-centred constructivist theory, which encourages children to construct their own understanding (Fisher and Dovey 2016, 161). Different design solutions support these differing pedagogies; however, the architecture of schools was slow to keep up with changing pedagogical ideas. The traditional school with students divided into classrooms ruled by a single teacher still prevails in the vast majority of Australian schools (Byers and Lippman 2018).

While major changes, such as in architecture, are slow to evolve, learning environments are constantly changing; everything from the temperature to the audio to the learning activities is in constant flux. Martin (2002) discusses the importance of viewing learning environments as complex ‘systems’ with multiple interconnecting elements. These elements include the physical structure, furniture layout, people and pedagogy (Martin 2002), as well as the culture, organisation and the physical and non-physical links to the whole school. Throughout a day, a week or over the years, these elements are in motion and can alter the behaviours of the people using those spaces. Martin (2002, 139) says, ‘we cannot ignore the fact that learning environments are both physical and organizational units and that the physical characteristics of a setting can influence both behaviour and educational programme’. The non-physical social elements within learning environments also strongly influence students’ behaviour. For example, the rules or expectations set by teachers on how students should behave in a school dictate how students can use the physical environment. Therefore, the physical, social and organisational factors within learning environments can act as facilitators and barriers to students’ movement. The social ecologic model by Zimring et al. (2005) provides the framework for studying these complexities within learning environments.

Current research on students’ physical activity behaviours tends to focus on specific elements such as furniture, landscaping or learning outcomes (see for instance Clemes et al. 2016; Andersen et al. 2015; Howie, Schatz and Pate 2015), which only sheds light on part of the influence that learning environments have. If we only understand part of the picture, we can only hope to solve part of the problem. Through this study, I will demonstrate that mixed-methods research using a single case study approach can provide a holistic understanding of school learning environments and their influence on students' physical activity behaviour.

Theoretical Approach Using the Social Ecologic Model

The relationship between society, primary school architecture and students' physical activity behaviours is complicated and multifaceted because no two schools are the same, and a multitude of factors influences students' behaviour. The social ecologic model was used as a theoretical framework to understand the various factors that influenced and are influenced by an individual. In this project, the social ecologic model is beneficial to use as a theoretical framework because it recommends that we study complex phenomena through a variety of lens and consider the entire environment where the phenomena occur. Social ecologic models have been used in health disciplines for decades. Richard, Gauvin and Raine (2011) highlight the importance of social ecologic models. They discuss how health promotion researchers call for behaviour change interventions to look outside the individual to include studies of their physical, social and cultural settings. Bronfenbrenner (1979, 1994) originally created and continually revised the 'socio-ecological' model to study human development where the individual at the centre of the model is surrounded by five interacting layers of influence: micro-, meso-, exo-, macro- and chromo-systems. These layers are the physical, social, cultural, political and economic factors that influence an individual's life over time. More recently, Zimring et al. (2005) created a revised social ecologic model, which focuses specifically on factors of the built environment that influence physical activity, which makes it more appropriate to use in this project.

The social ecologic model by Zimring et al. (2005) differs from others because it does not use nested layers and instead places the physical activity of individual people or groups in the centre surrounded by three influencing factors: personal, social/organisational and physical environment (see Figure 1.1). These factors influence and are influenced by physical activity as well as each other (Zimring et al. 2005). The personal factors include 'demographics, health variables, attitudes and beliefs related to physical activity, and psychological or behavioral attributes and skills' (Zimring et al. 2005, 187). The study of personal factors is limited to age and sex in this project due to limitations on data collection because of the young age of participating students. The social and organisational factors include ‘goals, philosophies, and culture of organizations, and social structures and supports that may facilitate or impede efforts to participate in physical activity’ (Zimring et al. 2005, 187). While social and organisational factors are strongly connected, they are two separate aspects that influence students’ physical activity behaviours. In this project, the social and organisational factors exist at varying scales from the Australian Government control of curriculum right down to small peer friendship groups. The social aspect also includes pedagogy, which in the case study school is Montessori pedagogy. Zimring et al. (2005) also acknowledge that the physical environment occurs on numerous scales: from large-scale urban design to small-scale elements such as stairs. This includes master planning of neighbourhoods and sites, and the design of buildings, interiors and furniture.

[redacted]

Figure 1.1 Social ecologic model diagram based on Zimring et al. (2005).

Personal Experiences within Learning Environments

Here, I will share my personal experiences within learning environments to acknowledge any preconceptions that I might hold. During my primary school education during the 1990s and early 2000s, I attended a public school in an inner-city Perth suburb with historical buildings. All classrooms were traditional rectangular rooms with an external verandah with access to a large, grassed area and multiple exterior play spaces. The pedagogies of the primary school were predominantly teacher centred, with classroom furniture generally arranged in rows facing the blackboard (later changed to whiteboards) or in small groups. In all of my primary school classes, seating was assigned each term, and personal materials such as stationery and notebooks were stored either in a draw under the desk or in a bag hanging from the back of the chair. I recall being unable to stand up or move from my allocated seat throughout the day without first raising my hand and asking permission, and generally, this was only to go to the bathroom.

I attended a private secondary school in the eastern Perth metropolitan area in the 2000s on a large site adjoining natural bushland. The school buildings were relatively recently constructed, doughnut-shaped and spread across campus with traditional rectangular classrooms, often with an external verandah. Education was predominantly teacher centred, with classroom furniture generally arranged in pairs, groups of four or a horseshoe shape facing the whiteboard at the front. There was generally not allocated seating within classrooms, and personal materials were stored in a locker and carried by hand to each class. I recall different teachers having various preferences for movement, but generally, movement required permission. This permission was sometimes required directly before movement, for example, to go to the bathroom, or the teacher explained the rules at the beginning of the term, for example, in art classes where I was permitted to move around to collect materials.

During my tertiary education, I attended a university in the southern metropolitan area in the late 2000s and early 2010s on a very large suburban campus. The buildings were constructed over a number of decades and all were large standalone buildings surrounded by landscaping. Most of my tertiary education was spent in three classroom types: lecture theatre, traditional classroom or large studio space. The lecture theatres were of varying sizes and solely supported teacher-centred pedagogies, whereas traditional classrooms supported a mix of teacher- or student-centred pedagogies, depending on the type of content and the set-up of the furniture. The large studio spaces were rectangular, and furniture remained primarily traditional; however, desks were larger and often tilted for ease of working with large drawings. The studio spaces predominantly supported student-centred pedagogies for collaborative or individual work, although they were sometimes used in teacher-centred lectures.

At all three levels of education, I have experienced similar learning environments with teacher-centred pedagogies dominating. Although the education buildings differed greatly in size and architectural style, the classrooms themselves were remarkably similar. None of the learning environments I have experienced as a student encouraged movement; however, the studio space during tertiary education did allow for movement during collaborative exercises.

I also have experience in learning environments as a teacher in tertiary education at university and college level. Similar to my own experiences at tertiary education, the pedagogies I use alter depending on the content. Through my experiences as a teacher, I have noticed many barriers to students moving in learning environments, such as furniture, acoustic design and expectations of students. One particular classroom remains vivid in my memory: with hard vinyl floor, concrete walls, large windows and a high ceiling, every sound echoed around the room. Every week the traditional furniture was arranged in rows facing the whiteboard, and I would rearrange the tables into groups to suit a collaborative pedagogy. I would ask students to assist, but they remained reluctant to move tables, as they did not feel ownership within the learning environment. Once collaborative tasks began, the noise would continue to rise, and I would need to wait for silence to address the whole class to provide instructions for the next task. During individual tasks, students were reluctant to ask questions or move around the room to avoid making noise and disrupting others. This type of classroom was not uncommon, and the physical learning environment did not support movement or collaborative pedagogies.

Problem, Aim, Approach and Scope

We do not know how the architectural design of learning environments influences students' physical activity behaviours. Research to date has generally focused on quantifiable aspects or very specific elements within learning environments such as standing desks (see for instance Clemes et al. 2016) or pedagogical programs changes such as 'active lessons', which are short physical activities used to break up academic lessons (see for instance Dinkel et al. 2017). As children spend such a large amount of their waking hours in schools, it is critical to understand how learning environments influence their physical activity behaviours.

To address this gap in knowledge, this research asks the question: how does the physical, social and organisational factors of learning environments and the processes of their design influence students' physical activity behaviours? This is achieved using a multidisciplinary mixed-method case study approach using a single case study school, with four project objectives:

1. document historical and contemporary architectural theory and design trends through review of professional literature and interviews with WA architects experienced in primary school design
2. evaluate current literature on influences of physical activity behaviours of children in learning environments to outline current knowledge
3. observe and analyse the physical, social and organisational factors of the selected case study school through ethnographic observations, architectural analysis and interviews
4. record and analyse the physical activity behaviours of children in the selected case study school.

While each objective on its own allows for data with a very specific focus to be collected in depth, the importance of the project lies in the synthesis of the data. When the data from each objective are brought together, the complex picture of learning environments emerges. This is where a holistic understanding of the influence learning environments has on students' physical activity behaviours can be gained. This research does not aim to propose a perfect learning environments design solution for improving the physical activity of children. Rather, I analyse how an existing learning environment and design processes influence the physical activity behaviours of students and provide recommendations for future research. The findings from the case study school suggest that a holistic approach must be undertaken by all stakeholders to improve students' physical activity behaviours in learning environments. This includes architects, government, the school organisation, teachers and students themselves.

This project applied a case study methodological framework with a multidisciplinary mixed-method approach. A single Montessori primary school acted as a case study with three classes involved in the research. Data collection methods included architectural analysis, ethnographic observation, quantitative recordings of students' physical activity behaviour and interviews with teachers and architects. Due to the complexities of students' physical activity behaviours in learning environments, the case study methodological framework and mixed methods were suited to record the physical activity behaviours of participating students and also to analyse why these behaviours are occurring. The ethnographic observation is critical to this project because it allowed me to personally observe behaviours that students may not be self-aware of or not able to articulate, which is particularly important due to the age of the participating students. Through combining this observational data with architectural analysis, quantitative physical activity data and interview data, I gained a holistic view of the case study learning environments and the physical activity behaviours of the participating students. Analysis followed the mixed-methods approach with quantitative analysis, thematic analysis and triangulation to build grounded theory. Grounded theory was inductively derived from the synthesis of the collected data to discover how the physical, social and organisational factors within learning environments influence students' physical activity behaviours.

The case study methodology was chosen because no two schools are the same, so drawing generalisations about 'all Australian schools' is beyond the scope of this project. The focus of this research is solely on the architectural design and physical activity behaviours of children in learning environments, thus students' learning outcomes and the design of playground spaces fall outside the scope of this project. Observations of teacher's behaviour was recorded in field notes, but only when this behaviour seemed to directly influence students' physical activity behaviours. Research into the legalities or equitable access for students or teachers with disabilities is also beyond the scope of this project.

Significance

Children in Australia are not meeting recommended levels of both physical activity and sedentary behaviours (AHKA 2018). Physical inactivity and high levels of sedentary behaviour are two 'separate and distinct risk factors for chronic, noncommunicable diseases' (SBRN 2012, 540) because children can be both highly physically active and highly sedentary (Wong and Leatherdale 2009). Both behaviours often track into adulthood as habits (Biddle et al. 2010), which is linked to 'cardio-metabolic disease, all-cause mortality, and a variety of physiological and psychological problems' (Tremblay et al. 2011, 2). Therefore, it is essential to target improvements in children's physical activity behaviours to encourage them to form good habits. Schools are a crucial location for health promotion interventions because most Australian children attend school. However, there is a gap in current literature, with research generally focused on specific singular aspects that may influence children's health or school design, but there are very few research projects that take the holistic approach that is needed to understand this complex problem. How can we hope to increase the physical activity levels of children if schools and their physical learning environments do not seek to support it? The significance of the project lies in the multidisciplinary focus that provides information to a range of stakeholders, which has the potential ability to influence the future design of primary school design.

No previous research has analysed the influence the architecture of the school has on the physical activity behaviours of students in WA primary schools. This research will fill a gap in knowledge about how the design of a WA primary school influences the physical activity behaviours of participating children. Although the research focuses on the single case study primary school, the lessons learned and theories developed apply to other learning environments. As the case study school has non-traditional learning environments similar to contemporary NGLEs, this thesis can also provide information for designers and schools seeking to build NGLEs. Current research on NGLEs in Australia is emerging; however, it generally focuses on the influence on learning outcomes or use of the facilities, with no existing research into the influence on students' physical activity behaviours.

Within architectural design, each school is often viewed in isolation as a unique project; however, if all schools are viewed as a collective architectural resource, then architects can learn from their own experiences and the experiences of other architects. Due to privacy concerns, post-occupancy evaluations completed by the architects, schools or governing bodies are often not made publicly available. This means that it is difficult for designers to learn from the mistakes and good qualities of previous school designs. Therefore, this project aims to provide detailed information about the design of the case study school that, when read in conjunction with the physical activity data, will provide information to assist designers in the future.

Primary schools generally do not encourage physically active behaviours within the learning environments and increasing movement of students is not a key focus of schools and designers during the design, construction or occupation of schools (interview with architect A, 20 September 2018; architect B, 8 October 2020; architect C, 13 October 2020). The design and construction of school buildings is an exceptionally expensive endeavour, and if the design can better support the physical activity behaviours of students as part of a broader approach to student wellbeing, then it is important to include these design considerations in new schools.

Thesis Outline

This chapter introduces the project. It began by outlining the context of the research and the social ecologic model as the theoretical approach before outlining the problem, aim, approach and significance of the thesis.

Chapters Two and Three present the background information needed to understand the research and situates my project within the current literature on learning environments and students' physical activity behaviours. Chapter Two outlines a general history of school designs and focuses specifically on the architectural evolution of Australia's primary schools before discussing how the design of learning environments has changed very little over the past 100 years. I outline how the current processes of school design, occupation and evaluation influence learning environments and highlight the challenges and opportunities that key stakeholders face.

Chapter Three focuses on the physical activity behaviours of children in Australia and outlines previous knowledge of how the design of learning environments influences those behaviours. The chapter opens with a discussion of current guidelines and literature concerning the physical activity of Australian children and highlights that students should be increasing their physical activity and reducing sedentary behaviours. I outline key literature regarding students' movement in learning environments and highlight the gap in current literature focused on improving students' physical activity through the design of Australian schools. I critique current knowledge of the influences that learning environment design has on students' physical activity behaviours, with discussion divided into four scales: external schoolyards, school architecture, interiors and furniture. The chapter concludes with a discussion of the few examples of international schools that have attempted to improve students' physical activity behaviours through design.

The methodology and methods are outlined in Chapter Four. The chapter begins by outlining the strengths of the case study methodology with a mixed-method approach as it allows for a deep understanding of the single case study school. Each of the specific qualitative and quantitative methods used to collect data is discussed in detail. I outline the methods of data analysis, including quantitative analysis, qualitative thematic analysis and my approach to triangulation to build grounded theory. The ethnographic methods of data collection and analysis are particularly important because they allow me to personally observe and understand the case study and analyse the complexities within the collected data in depth.

Before discussing the relevance of the research findings and the implications for future school design, it is critical that the reader understands the case study school in depth. Chapter Five summarises the results of the single case study, which provides an in-depth view of the school's architecture and organisation as well as the participating students' physical activity behaviours. This chapter provides an architectural analysis and thick description of the school, based on ethnographic observation and the interviews with the architect who designed the case study school. The summary of the results is separated into two sections to align with the two main types of data collected: observation and quantitative physical activity. Information from the interviews with the participating teachers is used throughout to provide context to the discussion. I conclude the chapter with a synthesis of the results and a summary of the key findings. Although these results are from a small sample, the research approach allows the complexities within the single case study to be understood in depth.

In Chapter Six, I discuss the critical findings of the research using the social ecologic model as the theoretical framework, and I situate the conclusions within the architectural discipline to highlight implications for future school design. The first part of the chapter examines the notion that movement in case study learning environments is considered bad behaviour due to acoustic issues, safety concerns and the distraction of other students. I discuss how this notion leads to classroom rules that restrict students' physical activity behaviours. Based on the case study, I argue that acoustic design and classroom articulation can support student movement. In the second part of the chapter, I argue that students' physical activity behaviours are influenced by socio-spatial factors within learning environments; this includes external spaces, the sense of openness, furniture and acoustic design.

Chapter Seven explains that social and organisational factors such as school policies, classroom rules and government policies influence students' physical activity behaviours within the context of the physical design of learning environments. The critical implications of the socio-spatial research findings for the architectural process are outlined. In particular, I argue that stakeholder consultation can provide tailored design solutions to better suit the needs of individual schools but also presents challenges in communication between stakeholders. I propose that formal pre- and post-occupancy evaluations (PrOEs and POEs) should be used with the evaluation of students' physical activity behaviours. I recommend that holistic changes across physical, social and organisational environments be made to design processes and the use and occupation of learning environments to improve the physical activity behaviours of students in primary schools. The changes range from classroom rules about student movement to architects collaborating with schools to evaluate potential interventions.

The final chapter, Chapter Eight, summarises the project and outlines the key findings and recommendations. I highlight that the physical, social and organisational factors of learning environments are all critical to improving students' physical activity behaviours. The thesis reveals that to improve students' physical activity behaviours in learning environments, all stakeholders must prioritise these behaviours throughout all stages of the design, occupation and evaluation of learning environments. I discuss the success of the mixed-methods case study approach and my recommendation that future research directions follow similar methods in traditional and contemporary learning environments in Australia. The research can inform future school design and design practices. I argue that a holistic approach to primary school design, occupation and use is needed to ensure the physical, social and organisational environments support improved physical activity behaviours of students. The holistic approach should be collaborative and involve all stakeholders such as students, teachers, schools, architects and government organisations.

2. The Changing Face of School Architecture

The evolution of school architecture tells us a great deal about the changing pedagogies and beliefs about learning environments. This chapter begins with a discussion of the theory of built pedagogy, which is the idea that the architecture of learning environments reflects the pedagogy that it is designed to support. I then provide a summarised history of school designs in Australia separated into four key categories: traditional schools that support behaviourist pedagogy; schools that support cognitivist pedagogy; open-plan schools that support constructivist pedagogy; and last, contemporary schools for the twenty-first century with flexible learning environments. While these four major trends throughout Australia's schooling design history are quite neatly linked to society and beliefs about education, the evolution of Australia's primary school architecture is much more complex, and the design of learning environments has actually changed very little over time. Rounding up this chapter is a discussion of the design processes of school design, including best-practice methods by architects, challenges of environmental competence when undertaking consultation or collaborative design and the methods of evaluating architecture, such as POEs.

Built Pedagogy

To understand the design of schools, we must first understand the theory of built pedagogy, which acknowledges that school architecture is reflective of the pedagogy it supports. The term was coined by Monahan (2002) in the article 'Flexible Space and Built Pedagogy: Emerging IT Embodiments' after conducting ethnographic research of schools in Los Angeles. As the title suggests, this research focused on the theory that flexibility within schools influences the behaviour of students and teachers, and the theory of built pedagogy was developed to explain this phenomenon (Monahan 2002). Newton and Fisher (2009, 139) state that 'pedagogy is the art or profession of teaching based on principles and practice'. Traditional pedagogies are teacher centred, and contemporary pedagogies are student centred. Monahan (2002) outlines that the built pedagogies exist 'along a continuum' with traditional pedagogies and schools at one end and student-centred pedagogies and flexible learning environments at the other.

While the term ‘built pedagogy’ was not recorded until 2002, earlier discussions of school design highlighted a clear link between pedagogy and the design of spaces for teaching and learning. For instance, in 1970, McClintock and McClintock write: ‘designs for classrooms not only tell us much about the didactic means that were used in them; they also reveal the essence of the pedagogy that directed the educative efforts of past times’ (quoted by Monahan 2002, 5). Therefore, architecture embodies pedagogy, and research suggests that by analysing schools, we are able to understand the type of learning that is facilitated by the environment. Since Monahan’s (2002) research, numerous researchers have built on and refined the theory of built pedagogy, and it has become a widely referred to theory in discussions of learning environments. For instance, Byers, Imms and Hartnell-Young (2014) use built pedagogy theory in their mixed-method study comparing traditional and contemporary learning environments. Cleveland’s (2016, 31) research into contemporary school design in Australia also refers to built pedagogy, but it is not used as a theoretical framework.

Many researchers support the general idea of the built pedagogy theory without specifically using the term. For instance, in their research of Montessori school architecture, Al, Sari and Kahya (2012, 1867) state that ‘different educational approaches require different architectural forms to support them; thus, school design and construction should match with the educational philosophy of the school’. Perhaps authors such Lackney (2015) avoid the term ‘built pedagogy’ because the theory focuses solely on pedagogy but excludes other aspects that may influence school design, such as the culture of school communities. Lackney (2015, 23) states that the ‘architectural form and layout of the school building has historically been influenced by the evolution of educational philosophy and goals, curricular objectives, instructional methods, and cultural values of schools’. Therefore, Lackney’s (2015) research suggests that pedagogy and space are connected but are also influenced by other factors.

The theory of built pedagogy is important to understand when researching learning environments; however, it does not allow for the full complexities of learning environments to be considered. For instance, if we focus only on the influence pedagogy has on the built environment of schools throughout history, we ignore other factors such as the possible changes in pedagogies; the government and school community's views on education; the architectural movements or popular styles; the opinions of architects; and many more factors that are unique to individual schools. So, while the built pedagogies may be useful when broadly analysing a large number of schools, it does not provide adequate detail when deeply researching individual schools, as in this case study research project. Therefore, in this research project, I chose to use the social ecologic model as the theoretical framework.

Australian School Architecture

Architecture is seen as a representation of the society where it was constructed (Forty 1986), and Australian primary school buildings are no exception. Through an analysis of the major trends in primary school design throughout recent Western history, it can be seen that Australia's school architectural history reflects society's beliefs about children and education, which I will explore through the use of a social ecologic model (Zimring et al. 2005). The changing trends of school design since the 1920s in Australia is thought to be linked to social ideology (Healy and Darian-Smith 2015), and as societal beliefs change over time, school architecture and pedagogy also evolve. Fisher and Dovey (2016, 161) simplify pedagogical theory into three categories—'behaviourist, cognitivist, and constructivist'—which ranges from teacher-centred models of behaviourist theory to cognitivist theory where children are expected to develop higher-level cognition through a specific hierarchy of tasks and finally, to 1970s constructivist theory, which links student learning to social context as children construct their own understanding. This section will provide a condensed summary of the history of school architecture in Australia and how it reflected the society and accepted pedagogy of the time. The summary does not cover all the different forms of educational architecture in Australia but instead notes key innovations in architectural or pedagogical thinking. Through this summary, I will demonstrate that although society and pedagogical ideas changed, the architecture of schools was slow to keep up.

I acknowledge that education in Australia was occurring before the twentieth century. This earlier history is not presented here because early school architecture was quite different from that of the schools after the twentieth century. It is important to note that formal education in Australia generally followed what was occurring in the UK, United States (US) and Europe; however, there was a delay in societal beliefs and pedagogical theory, often for many years or even decades.

Traditional Schools for Behaviourist Pedagogy

Traditional schools in Australia were built very similarly to those in England due to Australia's colonialist history. The origin of traditional schools in England is discussed by Burke and Grosvenor (2008) as the introduction of compulsory education in 1870. They discuss that before this time, education was conducted in church buildings, private homes and buildings and in large 'schoolrooms', all of which showed minimal signs of being education facilities. These facilities did not provide sufficient room to house all the children who needed compulsory education, so the government built purpose-designed schools (Burke and Grosvenor 2008). The new purpose-built school buildings had a civic role in society, as they attempted to physically represent state education and 'were held as symbols of modernization and urban pride' (Burke and Grosvenor 2008, 63). Traditional schools evolved from the time of the Industrial Revolution, which reflects the factory model of education:

> Put a homogeneous group of children in a confined space (called a classroom), process them for a year (fill them with knowledge), make sure they have learned the set and predictable curriculum (test them according to established standards), move them to the next processing container (another classroom), and continue the cycle until they have reached the age at which they are deemed ready to leave (and enter the workplace) (Upitis 2004).

Burke and Grosvenor (2008, 55) note that 'while local traditions, climate and levels of economic development have meant that educational architecture has followed very different courses in different countries, the actual process of building a school followed a general pattern'. Generally, in the pre-design phase, the government would appoint an architect (often through a competitive process) who designs the building and advertises it for construction tender. Builders then apply, and one is chosen to build the school as per the architect's design (Burke and Grosvenor 2008).

This competitive tender process still exists in Australia today for government-funded schools. Burke and Grosvenor (2008) discuss how architects have always been constrained by site conditions, time and budgetary limitations, laws and knowledge. These constraints limit the architect's ability for innovation, which leads to little change in the design of buildings over time.

Australian schools of the early twentieth century were generally teacher-centred spaces designed in an English style, and behaviourist pedagogy used didactic teaching where children sat at desks arranged in rows and listened to a stationary teacher at the front (Shield, Greenland and Dockrell 2010, 225). These traditional schools reflected society's belief that learning was achieved through discipline, and the teacher provided information students needed to learn (Dudek 2012). The school buildings themselves tended to have monumental external forms (Logan et al. 2013) to demonstrate power and reinforce the idea that the school and teachers were in charge and students should behave. Hertzberger (2008, 12) discusses the schools designed by the Public Works departments in the Netherlands during the 1920s and 1930s, which often had a single loaded corridor with classrooms facing south to capture sunlight. The main corridor usually faced the street with solid walls, horizontal windows and exaggerated stair towers, which created a monumental facade and led to a clearly identifiable front and back. The classrooms at the back usually had primarily glazed facades facing a sunny courtyard. Due to the consistency of the design and street presence, these schools were clearly identifiable within the neighbourhoods and 'were soon regarded as the "churches" of these new districts, culturally as well as contextually' (Hertzberger 2008, 12).

Traditional classrooms were designed to support didactic learning. They focus student attention on the single teacher providing information at the front of the room and limit any distractions; 'such classrooms are found all over the world and are deeply familiar to us all, which makes it difficult to envisage alternatives' (The Featherston Archive 2017). Traditional classrooms were large rectangular rooms that Getzels (1974) argues reflect the standard rectangular building layout, didactic pedagogies and the functional requirements of lighting. Long narrow spaces can be more easily well-lit from the sides than spaces with more depth from the external walls (Getzels 1974). Traditional classrooms often had high ceilings, wooden floors and hard surfaces to reflect sound, which helped to support lecture-style teaching methods by amplifying the teacher’s voice. This acoustic design also encouraged students to remain silent because if they made a sound, it would be amplified, and the teacher would immediately hear it. Blackboards and the teacher’s desk were positioned at the front of the classrooms and all desks were evenly spaced, sometimes even bolted to the floor, in neat rows with students facing the front (Getzels 1974). The room structure and furniture layout are a physical cue for students to only look straight to the teacher and disregard distractions from elsewhere in the classroom (Getzels 1974).

In the late nineteenth century, furniture specifically for schools was designed with a focus on bodily alignment in an attempt to allow students to remain sedentary for long bouts (Burke and Grosvenor 2008, 63). However, by the early twentieth century, studies found that traditional school furniture that forced students to remain sedentary ‘resulted in muscle fatigue, deformations and illnesses, especially short-sightedness and spine curvature’ (Burke and Grosvenor 2008, 69).

Schools for Cognitivist Pedagogy

From the 1930s, ideas about education shifted with more awareness of child-centred requirements to improve learning outcomes through ‘learning by doing’ (Logan et al. 2013, 48). The physical and psychological wellbeing of students became a central concern (Frith and Whitehouse 2009), which manifested in architectural design with classrooms focusing on natural light and ventilation (Logan et al. 2013). During the early to mid-twentieth century, beliefs about education in Australia were influenced by John Dewey and Maria Montessori, who recommended flexible learning environments that supported student-centred pedagogies which allowed students to move their bodies (Logan 2018). Traditional behaviourist pedagogical theory that focused on teacher-centred learning began to fall out of favour to be replaced by cognitivist theory in which children are expected to develop higher-level cognition by completing tasks themselves (Fisher and Dovey 2016). A major shift in pedagogical thought was during the 1930s in Australia when ‘KS Cunningham among others […] introduced progressive notions of child-centred education and learning by doing to mainstream educational thought and practice’ (Logan et al. 2013, 48). The traditional notion that classrooms needed to fit sedentary students positioned in rows was then considered outdated and a more progressive form of education was sought.

The new cognitivist pedagogy slowly began to infiltrate design thinking; however, it was not until the school building boom after World War II that architects translated this thinking into built form (Healy and Darian-Smith 2015). Architects sought to create school environments that fit this new pedagogy, and the design focused on internal spaces from a child's perspective instead of external monumentalism, which had been the previous design style (Logan et al. 2013). By the late 1940s, with rapidly growing populations, there was a move away from monumental architecture, and towards humble, functional and low-cost school buildings (Logan et al. 2013, 48). These changes seen in Australia during the 1950s were paired with modernist architectural ideas of form responding to function with the notion that schools should support children to learn through completing activities themselves which encourages overall well-being of the child (Frith and Whitehouse 2009).

The focus of school design shifted to creating so-called healthy environments. Hertzberger (2008, 19) discusses how architects began to use the connection between fresh air, sunlight and health, which was primarily visible in the exterior design through increased glazing. The changes to the interior focused on hygiene, natural lighting, airflow and temperature, but there were very few changes to learning (Hertzberger 2008, 19). Willis (2017) argues this is because educators were not trying to improve teaching but instead improve learning through the idea that children would concentrate better in bright, well-ventilated and hygienic environments.

Open-air schools were hailed as being healthier and were 'popular among architects, probably because they were an excuse for using masses of glass, but they brought no change to the authoritarian proportions of […] education' (Hertzberger 2008, 13). The Open Air School in Cliostraat, Amsterdam by J. Duiker built in 1929–1930, is a famous example; however, although it has expanses of glass, the children are still using traditional furniture inside as well as outside during suitable weather (Hertzberger 2008, 13). The open-air schools attempted to improve hygiene and increase student health through spaces with maximum daylight and minimal places where dust and bacteria could accumulate (Hertzberger 2008), which explains the simple planes and excessive glazing. They also sometimes included operable walls where the learning environment could open up to the outside to allow in fresh air (Hertzberger 2008). Perhaps the only influence on learning was the inclusion of outdoor learning spaces that could be used if the weather permitted. However, 'even so-called outdoor classrooms were in fact only indoor classrooms moved or placed outside, and functioning exactly as they did inside' (Hertzberger 2008, 15).

Popular design elements in schools constructed throughout Australia during the mid- to late-twentieth century include finger plans, pyramidal roofs, loaded central circulation, doughnut/hexagonal plans and clerestory windows (Melbourne School of Design 2017). These design elements are reflective of ideas related to student health and education through access to natural lighting and ventilation. The highly economical and functional finger plan schools were developed in the mid-twentieth century by architect Ernest J. Kump in California; 'the fingers—which were single story rows of individual classrooms—could be extended as needed, enabling the school to grow with its community' (Logan et al. 2013, 48). The classrooms themselves in finger plan schools are rectangular classrooms with blackboards at the front, which is very similar to traditional schools; however, Kump believed they were flexible spaces that allowed the teacher to use the areas in different ways (Logan et al. 2013). The hexagonal-shaped classrooms with clerestory windows were 'designed in 1946 by Victorian Public Works Department Chief Architect Percy Everett' (Goad 2015, 212) to provide better lighting, ventilation, temperature, material economy and field-of-vision (Logan et al. 2013). The cost of the hexagonal classrooms was prohibitive, which led Everett to develop the Light Timber Construction schools in the 1950s (Goad 2015).

Logan et al. (2013) points out that finger plan and hexagonal schools were in direct response to problems within traditional schools of the 1920s and 30s, which were innovative in their architectural response, but became out of step with innovations in pedagogical theory by the 1960s. The slowing of innovation in Australian schools might have been caused because in periods of high demand, there is often little room for innovation since governments are under pressure to build schools quickly. The demand for new schools in Australia continued throughout the twentieth century with growing populations and the change in 'expectations as secondary education shifted from being a preparation for university to a universal entitlement' (Logan 2018). Innovation then came in the master planning of the school site to better connect classrooms to the outdoor environment for lighting and ventilation. As Government Architect in the 1960s, Michael Dysart developed the doughnut-shaped classroom blocks with classes arranged around a central open space, which provided outdoor spaces for learning and social gathering (Goad 2015, 214).

Open-Plan Schools for Constructivist Pedagogy

The open-plan movement first began in the UK in the 1960s (Head 1983), following on from the cognitivist educational ideas, which began in the 1920s due to the beliefs that education should be child centred, not teacher centred (Lackney 2015). Educators such as Friedrich Froebel from Germany, Maria Montessori from Italy and John Dewey from the US were the key figures behind the progressive constructivist movement (Lackney 2015). Shield, Greenland and Dockrell (2010, 225) discuss how the progressive movement gained traction after World War II, with educators shying away from authoritarian teaching and instead embracing a more informal, individualised and student-centred learning. Classroom arrangement was altered to suit these pedagogical changes, with areas for individual activities and small group activities (Shield, Greenland and Dockrell 2010, 225). Constructivist pedagogical theory links student learning to the social context, as it was understood that children construct their own understanding (Fisher and Dovey 2016).

As urban schools in the UK were separating students into smaller classrooms divided by grade to be passive learners through didactic teaching, rural schools with limited student numbers were the starting point of the open-plan school (Head 1983). Due to the mix of student ages, the classroom was used as a shared space where students would work individually with a supervising teacher (Head 1983). The first rural school designed in an open-plan typology was built in 1959 in Oxfordshire and was a major influence in school design for two decades (Head 1983). This led to the first urban open-plan school: the Eveline Lowe School, built in London in 1967 (Head 1983). Open education was thought to provide increased opportunities, freedom, autonomy, self-responsibility and self-directed study for students while also requiring less supervision by a teacher (Lackney 2015).

The open-plan schools served both a pedagogic and economic purpose: ‘the emergence of child-centred teaching methods coincided with the introduction of post war economic restraints which affected the building of primary schools; designs which reduced the amount of non-teaching space while protecting the available teaching space were encouraged’ (Shield, Greenland and Dockrell 2010, 226).

Some schools were fully open-plan and referred to as 'schools without walls', whereas a more popular configuration was a communal area with semi-open rooms surrounding it, which could be closed off with partitions if needed (Shield, Greenland and Dockrell 2010, 226). The open-plan arrangement allowed for and encouraged student-centred pedagogies (Shield, Greenland and Dockrell 2010, 226). By the mid-1970s, open-plan schools accounted for 10% of all primary schools in the UK, while 50% of new primary schools in the US were partially or fully open-plan (Shield, Greenland and Dockrell 2010, 226).

Open-plan schools dictated a change in pedagogy to suit the architectural learning environments. In an open-plan school, collaboration is required between teachers to share learning spaces and resources (Head 1983, 31). Head (1983, 30) concluded that open-plan learning environments developed to support three different types of child-centred group organisation: family grouping, integrated day and team teaching. Family grouping (also known as vertical grouping) clusters students of varying ages together to allow them to learn at an individual pace (Head 1983). This requires flexibility in the learning environment and timetable, which leads to the strategy of the integrated day. Head (1983) describes the integrated day as student centred, where the teacher guides single students or groups of students to complete various tasks at their own pace. Family grouping needs to be combined with an integrated day, but an integrated day can be used without family grouping (Head 1983, 30). Team teaching allows for more flexibility within the supervision of students and was seen as necessary to facilitate the child-centred strategies (Head 1983). These three strategies led to the open-plan classrooms being first organised in pairs of rooms, which then evolved into schools with no classrooms, just a range of learning spaces clustered around learning tasks (Head 1983). The more open a school becomes, the more collaboration is required at both the teaching and organisational levels.

Although open-plan schools spread throughout the world, they continued to be seen as progressive rather than the norm, and they were often considered failures once in use (Lackney 2015). Lackney (2015) relates that the major complaints by US teachers were the noise levels and students distraction within the open-plan classrooms. However, Lackney also notes that there were much deeper systematic failures that led to the downfall of the innovative designs. A lack of funding for teacher training is the likely cause of open-plan classrooms failing (Lackney 2015, 34). Teachers were not provided with sufficient training in open education philosophies or methods, so they maintained traditional didactic teaching styles, which were at odds with the learning environments (Lackney 2015). Teachers were expected to teach in teams within the open-plan spaces, but they were not given support or time to coordinate the lessons (Ehrenkrantz 1999). The prevalent use of open-plan schools over other design alternatives lasted for an extended period. Ehrenkrantz (1999) explains that due to some successful examples of open-plan schools in the US, it was assumed that other open-plan schools would be a success given time. However, this assumption proved incorrect. Perhaps the few examples where the open-plan school worked was due to the teachers themselves embracing the open education pedagogy or those particular school organisations providing the necessary support. Socol (2014) states that 'open education, the open classroom and the schools-without-walls, succeeded when teachers understood the idea, had time to learn this radically new format, and were given the time, space, and resources to build a new system'. However, on the whole, as proven by the high percentage schools that converted back to smaller classrooms, the open-plan schools were not given the resources needed.

Open-plan school design became widespread in Australia during the 1970s, but by the 1980s, it was seen as a design failure, and many schools were divided back into traditional classrooms (Fisher and Dovey 2016; Cleveland and Woodman 2009). While the schools may have been innovative in their design, the Australian teachers had similar problems felt by those in other countries. There was a lack of training, so the teaching methodologies remained traditional and clashed with the classroom design (Cleveland and Woodman 2009, 60). This meant that although the designs aimed for flexibility, they instead created schools that were open but did not match teacher's pedagogies (Fisher and Dovey 2016, 160). Architecture alone cannot change education practices. Without teacher involvement in both the planning and implementation process, innovative design ideas are unlikely to succeed. Although the open-plan movement is not viewed as successful, the lessons learned from these schools have certainly influenced contemporary school design and student-focused pedagogy.

Contemporary Schools

Contemporary school architecture reflects beliefs about education and focuses on the importance of a combination of formal and informal learning environments to cater for varying learning styles (Fisher and Dovey 2016). Open-plan learning spaces are now re-emerging as ILEs or NGLEs in contemporary schools. While their definitions are often vague, they relate to spaces that are a far cry from traditional classrooms where the teacher was the focus for learning. Contemporary learning environments instead include a variety of spaces that are often flexible and have a multitude of uses. As teaching pedagogy changes, the new open-plan learning environments are now better suited to contemporary teaching methods and the incorporation of portable IT devices.

Cleveland and Woodman (2009) demonstrate that the design of contemporary schools is guided by similar ideas behind the open-plan schools of the 1970s. They are concerned that history will repeat itself with schools failing to perform as envisioned, and they state that to avoid failure, 'stakeholders need to address the critical issues of education, collaboration, and design' (Cleveland and Woodman 2009, 67). A key focus of the discussion by Cleveland and Woodman (2009) is on the importance of teacher training and support, especially before the teachers move into the new learning environments. They state that we cannot assume that teachers will change their pedagogy to suit new learning environments, as seen in the schools of the 1970s (Cleveland and Woodman 2009, 66). Imms, Cleveland and Fisher (2016, 3) argue that twenty–first century learning environments differ from the open-plan classrooms seen in the 1970s because contemporary spaces support various pedagogies and learning activities.

Contemporary schools are often referred to as ILEs, but there is no clear discussion on exactly what makes them innovative. It seems that any non-traditional school is described as 'innovative'. I believe the term 'New Generation Learning Environments' (NGLEs), coined by Imms, Cleveland and Fisher (2016), is a better term to describe contemporary learning environments because it acknowledges that they are different from traditional classrooms but not necessarily innovative. The similar term 'New Generation Learning Spaces' was coined by Byers, Imms, and Hartnell-Young (2014); however, for clarity, I will use NGLEs in this thesis because 'learning environments' is a more widely accepted term than 'learning spaces'.

Although they admit that it is a bold claim, Imms, Cleveland and Fisher (2016) argue that NGLEs exist and are becoming more widespread:

> These most recent designs are innovative in that they own features that—in the main—have only recently been embraced by schools and school planners, save for a short period in the mid-1970s. They exhibit qualities that through a lack of imagination or technological development have been absent in most school and classroom designs of previous generations (Imms, Cleveland and Fisher 2016, 23).

They describe the schools with NGLEs as ‘eye-catching, inspirational, imaginative and exciting’, with informal and formal learning spaces; contemporary materials and furniture; embedded sustainability and information and communications technology; sophisticated acoustics and lighting design; and well-planned site design for connection to landscape (Imms, Cleveland and Fisher 2016, 23).

What separates NGLEs from other types of learning environments is that they support all pedagogic modes: teacher centred, student centred and informal (Byers, Imms and Hartnell-Young 2014). The three pedagogic modes each require different elements within the learning environments. For instance, teacher-centred tasks may require elements similar to a traditional classroom. In contrast, student-centred and informal tasks may require informal or flexible furniture arrangements and access to specific equipment. Students will likely be working in different sized groups during each pedagogic mode, so contemporary learning environments need to accommodate this. Cleveland and Woodman (2009, 58) argue that contemporary learning environments not only support various pedagogies but also encourage students to develop social skills and independence to prepare them for the future.

An early guide to contemporary school architecture was outlined by Lippman (2007), who conducted video observations and interviews with students in 1995 and uncovered patterns of participation in learning tasks. This led to recommendations for contemporary learning environment design that Lippman (2007, 2) states should have areas in various sizes to ‘support large group, small group, one-to-one, and individual activities’. Students should be given the freedom to move between these different areas depending on the participation type they choose to use, which will change throughout the day. Lippman (2007, 2) therefore recommends that learning environments use a combination of six ‘primary patterns’: 1) the overall room should be ‘fat L-shaped’ as seen in Figure 2.1; 2) there should be a ‘porch’ as a transitional space between the enclosed learning environment and the overall school; 3) the learning environments should be clustered into a ‘neighbourhood’ of roughly 100 students; 4) there should be corridors connecting various learning environments that provide space for formal and informal learning; 5) facilities for the whole school community (e.g., libraries and gymnasiums) should be grouped; and 6) the main entrance should symbolise the school values and provide a transitional space with transparency. Lippman (2007, 3) also recommends the inclusion of three ‘secondary patterns’: ‘fixed features’ such as partitions, cabinets, and projectors; ‘socio-historical resources’ such as furniture, books and digital equipment; and ‘transparency’ for sunlight and views through windows and doors.

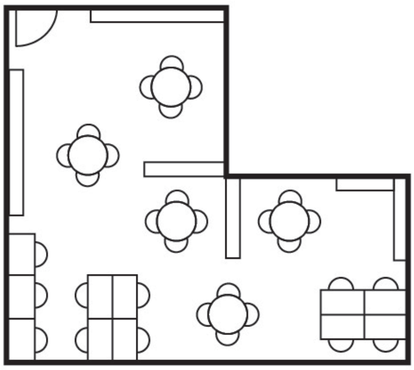


Figure 2.1 Example plan of a fat L-shaped learning environment.

Contemporary learning environments often include various fixed and flexible spaces that the teacher and students can use in different ways. This translates to schools with a wide variety of spaces that Fisher and Dovey (2016) label as classrooms, commons, streetscapes, meeting areas, fixed-function rooms and outdoor learning spaces. They define classrooms as traditional 20–30 student capacity learning spaces that are closed off, and similarly, meeting rooms are also closed off but can only seat up to 20 students. In contrast, commons are slightly larger rooms that cannot be fully closed (Fisher and Dovey 2016). Streetscapes are open thoroughfares used as learning spaces, and outdoor learning are spaces open to the elements specifically designated for learning. Fixed-function spaces are designed for specific purposes such as wet areas, music rooms or performance spaces (Fisher and Dovey 2016). Fisher and Dovey (2016) define these learning spaces in very specific terms; however, these spaces rarely exist in isolation. In reality, they often overlap or form a complex combination of spaces. Contemporary learning environments provide various spatial types to support a variety of learning modes and student groups and must be adaptable for future changes (Shield, Greenland and Dockrell 2010).

While contemporary school architectural trends in Australia are not widely discussed in academic sources because it is an emerging field, they can be seen in local, national and international design awards and magazines. The tendencies in contemporary education architecture lean towards flexible learning environments utilising technology. These types of schools can be seen in publications of the annual awards program by Learning Environments Australasia (LEA), which is described by the chair Chris Bradbeer as ‘an opportunity to celebrate success, highlight excellence, and showcase innovation’ (LEA 2020, 4). The awards program has a specific category for ‘innovative education initiatives contributing to learning environments’, but many of the projects in all award categories are also described as innovative. The importance of educational architecture within the 2017 WA awards is made clear as Willetton Senior High School by Hassell was first awarded the Hillson Beasley Award within the education category and then won the highest accolade, the George Temple Poole Award (Editorial Desk AAU 2017). Byford Secondary College by Donaldson and Warn Architects and Irene McCormack Catholic College Paul Rafter Centre by Parry and Rosenthal Architects were also awarded within the education category (Editorial Desk AAU 2017).

Flexibility in Contemporary Learning Environments

Contemporary learning environments rely heavily on flexibility, both within the architectural design and teaching and learning practices. Woodman’s (2016, 56) research found that within the literature, flexibility was generally used to describe ‘four main categories of change: time, space, use, and movement’. They discuss that flexibility in time refers to learning environments being able to change throughout the school term and into the future, which is referred to as ‘adaptable’. Learning environments space should be flexible and easily manipulated, allowing various furniture arrangements, which Woodman (2016) calls ‘transformable’. Flexibility in use refers to changes in the learning tasks able to be accommodated within the learning environment. Lastly, Woodman (2016) outlines that flexibility for movement is evident in a learning environment that allows for various types of physical movement, which they refer to as a fluid space. However, as can be seen in these various types of flexibility within learning environments, Woodman (2016) notes that because of these different aspects, the understanding of the word ‘flexibility’ within education and architecture literature is not clear. While ambiguity can often lead to confusion, in this case, the ambiguity within the term allows architects and educators to create their own versions of flexible learning environments. Architects and educators should clearly state the type of flexibility they are referring to, such as adaptable or transformable.

Flexible learning environments require time and skills to be best utilised, so some architects instead prefer ‘purposeful spaces’. Cleveland (2016) defines flexible learning environments as spaces that can accommodate various experiences, but Lackney (2008) argues these spaces rely on users to be proficient in adjusting the environment to suit their needs, which is not always the case. This is referred to as ‘spatial literacy’ or ‘environmental competence’ (Steele 1980), which I will discuss below regarding architectural design processes. With teachers often stating they are time-poor (see for instance Morgan 2008), the additional time required to rearrange furniture or move operable walls within flexible learning environments can exacerbate the problem (Wood 2017). Some designers instead prefer to make ‘purposeful spaces’ to distinguish zones for various learning tasks (see for instance Cleveland et al. 2018). Featherston (2009, 121) discusses the multiple benefits of purposeful spaces, stating they create a sense of permanence; save time; ensure that everyone within the learning environment knows where resources are located; and allow for ‘richness and complexity’ to be developed over time. Featherston (2009, 121) believes that this is important within contemporary learning environments with ‘dynamic and unpredictable’ learning programs. Purposeful spaces also provide visual spatial cues, which helps people with low spatial literacy since it allows ‘people to decide their own courses of spatial action because they have a range of possibilities and suggestions to draw from’ (Wood 2017, 79). Contemporary schools with NGLEs often utilise purposeful spaces to match student-centred pedagogies.

Schools Change Very Little over Time

When looking at the majority of schools across Australia, it is clear that the architectural design of learning environments has changed very little over the past 100 years. Many researchers believe that school designs around the world are not keeping up with current knowledge or pedagogy (see for instance Hertzberger 2008; Jerome 2012). While the exterior of school buildings may seem to be contemporary and 'moving with the times', the majority are still organised in traditional ways internally and are stifling a new understanding of best-practice education (Fisher 2004). Byers and Lippman (2018) state that roughly 75% of learning environments in Australian and New Zealand schools are traditionally planned—'we have reshaped how and what we want our children to learn. We have even created the measurements to assess their level of achievement. It would seem however, that we have forgotten to reshape our school facilities' (Jerome 2012, 2). A key critic of the static design of schools is Herman Hertzberger (2008), who argues that as a building type, schools are one of the least developed since their conception, arguing that school organisation remained unchanged and only the exterior form of school buildings changed with trends.

Hertzberger (2008, 13) discusses the contradiction of modernist architecture, which 'professed to be the face of social reform', yet did not respond to calls for learning spaces to better suit modern education, which was moving away from teacher-focused learning. Modernist architects focused instead on creating buildings with modernist aesthetics and more transparency within internal and external spaces through increased glazing (Hertzberger 2008). Hertzberger (2008, 13) states:

> There is no better example of architecture seen as largely a question of exteriors than schools. Their internal arrangement has always been the same: classrooms as opaque boxes off long straight corridors purely for circulation and for hanging coats. And though new ideas on education emerged, unrelievedly calling for greater independence among pupils and expressing increasing doubt about traditional teacher-fronted lessons, these never resulted in breaking down the classroom as a self-contained bastion.

That is not to say that no architects tried to change the design of schools, just that new design ideas have never become widespread changes. This may be due to the age of building stock on Australian school sites, the difficulty in refurbishing traditional schools and budget restrictions. Standard rectangular classrooms do not necessarily lend themselves to easily be altered into NGLEs that support student-centred pedagogies, as they require the removal of internal walls (Turner 2012). Due to budgetary limitations in place in contemporary projects, school buildings from the twentieth century are often adapted for reuse to fit contemporary teaching styles (Turner 2012). Changes can increase flexibility, natural lighting and ventilation while reducing restricted layouts such as corridors (Turner 2012). Turner (2012) discusses contemporary building requirements such as collaborative spaces and transparencies between learning environments that allow buildings to adapt to future pedagogies. The high numbers of students per class also create low levels of space per student, limiting schools and teachers' ability to alter the interior of learning environments easily. Studies by Fisher (2016) have ascertained that collaborative school settings should ideally allow three square metres per student, with more needed for universal access. Fisher (2004) also argues that widespread change in learning environments has not occurred because teachers are typically unaware of their surroundings and do not have access to funding to support changes.

In their mixed-methods research into school design in the US, Jerome (2012) is critical of the history and contemporary processes of school design. Jerome (2012, 2) states that 'while continuing revelations in educational research are pioneering substantive changes in curriculum and instruction, improvements to school facilities seem to lag behind'. The lag in school design is a real problem because, as we know from the built pedagogy theory, the design of learning environments can dictate the pedagogies, types of learning and behaviours of users. For instance, traditional schools support didactic pedagogies where students are encouraged (sometimes forced) to remain immobile and absorb information delivered by the teacher, and these classrooms are not designed to support contemporary student-centred pedagogies. Jerome (2012) argues that testing methods and improving students' learning outcomes and academic achievements are continually improved upon, but that same level of improvement seems to have been overlooked when it comes to the physical building improvements in US schools. This same argument applies within Australian schools, as education seems to be improving much more quickly than school architecture: ‘we know too much about how learning occurs to continue to ignore the ways in which learning spaces are planned, constructed, and maintained’ (Van Note Chism 2002, 5). Jerome (2012) is also critical of the enormous amounts of money spent on improving and replacing school infrastructure with no clear research into how these changes influence students’ learning outcomes. Black (2007, 40) concurs, arguing that ‘politicians, school officials, and school designers often proclaim that new schools will raise student achievement, but they’re hard pressed to explain how or why’.

Contemporary School Design, Use and Occupation Processes

The processes of design, use and occupation of contemporary schools involve various processes by architects. Research into all the processes undertaken by architects falls outside the scope of this project. This section provides a brief overview of the role of architects within educational design and an outline of the stages of the design process to allow an understanding of the processes that could be altered to improve students’ physical activity behaviours. Four key stages of school design, use and occupation are discussed: 1) the initial briefing stage focusing on the constraints of Australian Government school briefs; 2) the design stage focused on the role of the architect in managing challenges of consultation and collaboration with all stakeholders; 3) the use and occupation stage where teachers and students re-design learning environments to suit their educational goals; 4) the evaluation stage, which relies on formal POEs or informal feedback from schools to inform future design, use and occupation of learning environments. Students’ physical activity behaviours can be considered at all stages of learning environment design, use and occupation, which will be further discussed and key recommendations provided in Chapters Six and Seven.

Constraints of Government School Briefs

In Australia, the design of government-owned schools is often dictated by what is generally referred to as the ‘standard pattern brief’. Each state and territory has developed their own brief for both primary and secondary schools, which dictates all design aspects. In a 2009 interview published in the book *Take 8 Learning Spaces:*

The Transformation of Educational Spaces for the 21st Century (Newton and Fisher 2009), Geoffrey London, Victoria's Government Architect (and previously WA's Government Architect) and Jennifer Calzini, Principal Policy Officer at the Office of the Victorian Government Architect, discuss the primary school briefs which they refer to as 'templates'. London states that New South Wales has utilised school templates for many years, but Victoria only recently developed their own in response to the Building the Education Revolution federal stimulus package (Newton and Fisher 2009). London also believes that in comparison to New South Wales, Victoria's school templates have more flexibility to respond to changing educational requirements (Newton and Fisher 2009, 81). Calzini believes that 'templates by themselves might not necessarily be a bad thing. The quality of the template and its ability to be customised, appropriated and adapted by schools is the key thing' (Calzini quoted by Newton and Fisher 2009, 87).

In WA, the school briefs are controlled by Building Management and Works as part of the Department of Finance, for the Department of Education, with private architects contracted to design the schools. The school briefs 'are designed to assist consultants and builders to quickly build new government schools in a consistent and functional way—ensuring durability, value for money for government and consistent facilities across the state for the benefit of students' (Department of Finance 2020). The WA primary school brief provides detailed 'operational and technical requirements' (Department of Finance 2020) for architects to follow and dictates everything from the size of the school down to the material selection: 'they include models and templates which can be used at short notice on varied sites with minimal design changes. This helps to enable fast construction for additions, renovations and new schools' (Department of Finance 2020). While the case study school in this project is not a government school, it is important to understand the design processes architects follow and the limitations for these schools.

The WA primary school brief is not made publicly available and is only available for 'authorised consultants' (Department of Finance 2020), so there is little published information available; however, through studying contemporary public schools, some key elements of the brief are clear. For instance, most contemporary public primary schools are single storey with clusters of classrooms placed in a checkerboard layout, creating smaller courtyard spaces between buildings. The clusters have two to four ‘classrooms’ with amenities such as bathrooms and staff rooms in each cluster as well as outdoor undercover learning spaces. The clusters are often designed with pairs of learning environments able to be joined or separated with operable walls. Due to the lack of publicly available information about the primary school brief, it is not clear if the design of the classroom clusters is based on evidence-based design, best-practice design or whether this is just a preference of the brief designers.

School Design Processes and Challenges

The Role of Architects

The role of architects in any design and construction project is extensive, and the expertise they provide is invaluable; however, architects tend not to publish information about their practice methods or design processes, which prohibits an in-depth understanding by other stakeholders and wider society. In educational design, the role of the architectural team is the designer of the learning environments, the project manager and as an intermediary between all stakeholders. Historically, discussion of architects has uplifted a single architect as the ‘genius’ of the project (Bunting 2001); however, typically, architects do not work in isolation, and the architectural team is comprised of many people who contribute to the process in different ways. So, in this section, when I refer to the roles or practices of a singular architect, it is as the principal or leader of the architectural team.

Architects act as leaders within school communities because they create change in learning environments through their varying roles (Bunting 2001). Bunting (2001) breaks this down into seven different aspects of leadership that the architects undertake during learning environment design: authoritarian, visionary, instructional, transformational, pedagogical, stewardship and abandonment leadership (Bunting 2001). Authoritarian leadership, although outdated, involves a small team of architects providing coordination throughout the process to ensure the cohesiveness of the various contributing voices. Visionary leadership comes from the architects’ imaginative ability to ‘conceptualise in three dimensions a physical form from a written brief’ (Bunting 2001, 45) to create unique solutions for individual school communities. The architect’s role as a transformational leader is to create changed learning environments that ‘question the status quo, encourage re-thinking and urge people to take greater responsibility for their own environment’ (Bunting 2001, 46).

Instructional leadership relates to the architects' role in educating stakeholders to ensure they understand the process and outcomes and continually educating and evaluating themselves and their architectural team. Architects of schools must also be pedagogical leaders through a deep understanding of teaching and learning to create dynamic and adaptable learning environments (Bunting 2001). The architects' role as stewardship leaders is to take into consideration the life cycle of the school in respect to its economic, maintenance, functional and pedagogical goals. Last, the abandonment leader refers to the architects' role in questioning existing built environments for suitability of current educational goals and feasibility of future use (Bunting 2001). These seven aspects of architects' leadership roles within learning environments provides a succinct, although somewhat oversimplified, overview of vast processes and expertise that architectural teams provide. Through acting as leaders within school communities, architects are able to create change across various aspects of school design, use and occupation, which is relevant to this thesis project, to create change for students' physical activity behaviours.

The processes that the architectural team undertake are individualised and highly dependent on the particular project. Anderson (2010) summarises the design process into five stages, each with common activities being undertaken. They outline that the first stage is meeting the client and developing the brief through diagrams, consultation, observation and sketching. Stage two involves understanding the location and context by undertaking site visits, photography, research, surveying and collaboration. The third stage is generating ideas, with activities, including sketches, models, research and consultation. Stage four involves developing the design through drawings, models, research, material samples and collaboration with various consultants. The final stage is construction, followed by occupation, including construction drawings, liaising with the builder, site visits and building evaluation (Anderson 2010). Although this is a simplified description of the architectural process, it provides an overview for those outside the design disciplines, including educators and other school stakeholders; and it also highlights the importance of consultation and collaboration throughout all five stages.

Consultation and Collaboration with Schools and Teachers

Collaborative design in relation to school environments is where all stakeholders, such as children, parents, teachers, managers and government organisations, work with architects in the design process. To facilitate collaboration, the architects will hold workshops or meetings with various stakeholders to ascertain their opinions on design outcomes. While collaboration is generally viewed as important to ensure learning environments are fit for purpose, often this process could be more accurately described as consultation, with stakeholders involved in the briefing process rather than in the design process itself. Consultation and collaboration are essential for many aspects of learning environment design, especially in NGLEs. True collaborative design for learning environments in Australia is relatively uncommon; however, consultation is a key aspect of most architect's processes. Lippincott (2009, 22) argues that if teachers are aiming to change their pedagogies when moving into newly designed learning environments, then they 'need to be deeply engaged in the planning process'. Without their involvement, meaningful changes will not be obtained, and 'the result is often a gap between what is perceived (by planners, administrators, and others) to be the value of the renovation or the new learning space and what actually results' (Lippincott 2009, 19). Although Lippincott's (2009) research is specific to universities, the findings are even more relevant to primary schools. This is because, in a university, the teachers move between various rooms and can nominate the type of learning environments required for a particular class (e.g., a lecture theatre or smaller classrooms), whereas primary school teachers are often allocated to a single learning environment for the whole school year.

Fisher (2004, 2) relates that within contemporary learning environments, although innovative change has been a key driver, the approach to this has been 'primarily from the top down'. As can be seen in the open-plan movement of the 1970s, the top-down approach can often be unsuccessful because stakeholders feel like they are forced to make changes rather than being self-motivated (Ehrenkrantz 1999). For long-lasting change, genuine collaboration with all stakeholders is required because it allows them to lead the design process and not feel like they are having a foreign building type pushed onto them (Clark 2002). Wilks (2009, 21) recalls a personal conversation with Mary Featherston, a specialist educational designer in Australia, who 'believes that design professionals need to be involved in long-term action research projects with educational consultants, practitioners and students in order to develop effective design briefs'. This leads to the school community feeling a sense of ownership over the learning environments: 'people feel more attached to an environment they have helped to create; they will therefore manage and maintain it better, reducing the likelihood of vandalism, neglect and costly replacements in the future' (Martin 2006, 100).

Collaboration with Students

There is a growing interest in involving students in the design of learning environments; however, this is often done on a superficial level. Jerome (2012, 2) relates that 'as true stakeholders in 21st-century learning, students should be given a role in the design process'. Students can be viewed as the primary stakeholder that schools are designed for, and they can provide valuable information and feedback to designers. Flutter (2006) outlines that if students are not consulted prior to major changes being implemented in their learning environments, then they might resist them. Within NGLEs, students' social dynamics are important because students are given the freedom to move around the learning environments and work in various sized groups. The dynamics of these social interactions would likely not be immediately understood during brief periods of observation by adults, so discussions with students can provide this information. Jerome (2012) discusses that students have the knowledge and experience to implement successful alterations to learning environments, such as rearranging furniture and other physical elements. Schools are diverse communities, and all students should feel like the learning environments and school facilities support them. Speaking to a wide range of students ensures multiple voices are taken into account during the design process. Collaborative design with students can provide them with a sense of community and ownership, which reduces the risk of vandalism and ensures the learning environments are fit for purpose (Martin 2006).

Environmental Competence is a Challenge for Collaborative Design

Collaboration and consultation rely on stakeholders understanding architectural terminology, and these processes can be limited by a lack of knowledge. This architectural knowledge is referred to as 'environmental competence' (Steele 1980) or 'spatial literacy' (Fisher 2004). Environmental competence, as explained by Steele (1980), is defined as 'the ability to effectively use the physical environment to meet desired goals' (Lackney 2008, 134). Fisher (2004) uses the term 'spatial literacy'. Teachers need environmental competence to maximise their use of learning environments (Imms, Cleveland and Fisher 2016, 7). When teachers cannot effectively use the built environment within their schools, it can lead to negative teaching and learning experiences. These terms suggest it is purely a breakdown in verbal communication; however, Fisher (2004) differentiates ‘spatial literacy’ from ‘spatial vocabulary’ and suggests they are two interconnected but separate problems. They also point out that one of the causes of a lack of spatial literacy and vocabulary is budget restraints (Fisher 2004), which leads to a lack of funding for both training and physical changes to learning environments.

Martin (2002) categorised teachers into three categories, denoting the varying levels of environmental competence. The first is those who do not perceive the influences the physical environment has on their teaching practices and do not create improvements in the learning environment. The second is ‘awareness without competence’ (Martin 2002, 154), which includes those who are aware of the factors within the physical environment that influence teaching but do not have the skills to make improvements. Martin (2002) believes that this ‘environmental awareness’ is the initial step to achieving environmental competence, but their research identifies that many teachers also lack this. The third category includes those teachers who could manipulate their learning environments to best suit their teaching, for instance, by moving furniture, but teachers falling into this last category are uncommon (Martin 2002). Martin (2002) argues that only environmentally competent teachers who fall into the third category are active users of the space: the teachers in the first two categories are passive users. Through becoming environmentally competent, ‘every teacher becomes a designer, responsible for preparing the environment to achieve his or her educational purposes’ (Martin 2002, 154). These categorical definitions are not only relevant to teachers but also to all stakeholders within learning environments. Using the three categories of environmental competence, it is possible to identify where a stakeholder is currently sitting and determine the type of training required to assist them towards being more competent in fully utilising the learning environments.

It may be true that ‘awareness is the first step’ towards environmental competence, but stakeholders may still have insufficient motivation or skills to reorganise a learning environment (Martin 2002, 154). Martin (2002, 154) states that teachers must actively choose to alter learning environments through experimentation of ‘spatial alternatives’, rather than passively accepting existing environments. In their research, Martin (2002) discovered that teachers who were aware of their learning environments tended to be dissatisfied with the physical environment, which provides an initial incentive to create changes. Therefore, short-term dissatisfaction with a learning environment could be a positive step towards teachers developing environmental competence. Teachers need to be trained to critique their learning environments, and be supported to make positive changes (Martin 2002, 154). If teachers feel confident to experiment with arrangements of their learning environments, they will be more satisfied and move towards environmental competence. Martin (2002, 140) highlights that ‘the learning environment can be a powerful teaching instrument at the disposal of the teacher, or it can be an undirected and unrecognized influence on the behaviours of both children and teachers’. Lackney (2008) posits that a lack of environmental competence causes two key problems for teachers and students: 1) they are not able to best use the physical learning environment to suit their learning goals; 2) a lack of perceived ownership over the space. This is supported by Featherston (2009, 119), who states that innovative learning environments are unsuccessful when teachers and students do not feel like they own or are supported by the physical environment.

Lackney (2008) is a preeminent researcher on the topic of environmental competence and believes that often teachers do not consider how they can alter the environment and instead work with what they are provided. As teachers’ expertise lies with pedagogy, this is their focus within the learning environment, and they likely have no formal design training. Lackney (2008, 136) relates that ‘any knowledge that teachers have about the role of the physical setting on teaching and learning was likely gained from direct experience and trial and error experimentation, rather than from formal education and training’. Lackney (2008) argues that most teachers do not have environmental competence and cannot communicate how the built environment affects or supports their teaching because they generally have no formal training in this area. However, Martin (2002) outlines that it would not be difficult to create teacher training programs such as self-evaluation and learning environment audit tools. One available tool is the Teacher’s Environmental Competencies (TEC), which ‘aims to uncover a measurement for TEC, and subsequently refine the tool to aid teacher training in this area’ (ILETC 2017, 9).

The topic of environmental competence needs further focus in education disciplines (Lackney 2008). Often, the published literature on teachers' environmental competence is written by those from the design discipline and can seem overly critical of teachers—seemingly shifting the blame off designers. Miller's (2017, iii) doctoral research is written from an education point of view and found a 'need for professional learning opportunities to increase teachers' environmental designing competence through learning modules and school-based participatory design projects'. However, London believes that this spatial illiteracy is more widespread within the community and 'is certainly not confined to educators' (quoted in Newton and Fisher 2009, 83). A specialist in education design in Australia, Featherston, believes that a key difficulty of collaborative design is the 'lack of shared vocabulary' between stakeholders (The Featherston Archive 2017).

Re-Design of Learning Environments through Teacher Use

One of the benefits of teachers being both environmentally aware and competent is their ability to find spatial solutions to learning environment problems. Martin (2002) recommends that teachers test arrangements of changeable fittings to identify the ideal environment for them and their students: classrooms should regularly be 'questioned, challenged and transformed' (Martin 2002, 154). The importance of this proactive altering of learning environments is made clear within NGLEs, which rely on teachers to guide students in the best use of space: 'there is an emerging need to evaluate [NGLEs] efficacy, ensuring teachers have the environmental capability to guarantee the affordances are being utilized to maximize their potential' (ILETC 2017, 9). Otherwise, NGLEs, just like the open-plan schools of the 1970s, will be used with traditional pedagogies that they are not designed to support.

Another benefit of environmentally competent teachers is their ability to control student behaviour and assist students in themselves becoming environmentally competent. Martin (2002) discusses how experienced teachers can anticipate the behaviour of students in a variety of situations; therefore, environmentally competent teachers could control students' behaviour through the manipulation of the physical learning environment. Teachers' environmental competence is a strong focus in the literature, but students also require environmental competence. Martin (2002) argues that after teachers completed environmental competence training, they could share this skill with their students, who could then implement the knowledge within learning environments. Students' environmental competence is especially important within NGLEs, as students need to move around and use the learning environments to best suit their activities.

While a lack of spatial literacy can seem like a communication problem between designers and teachers, it has much wider consequences, especially in NGLEs. ILETC (2017, 8) state that 'innovative spaces only become innovative when teachers recognize the affordances within these spaces'. On top of already shrinking budgets, teachers with low spatial literacy are not equipped to adequately use the resources at their disposal to support their teaching. Therefore, opportunities within learning environments are being squandered. Although it may seem simple to rearrange furniture to suit a particular task, if a teacher is unsure how to best layout the learning environment, then the flexible furniture is unlikely to support teaching and learning. Byers (2015, 35) states that the transition phase when a teacher moves from a traditional classroom into an NGLE 'is incredibly important to its longer-term pedagogical success'. This is because teachers tend to continue with the traditional pedagogies that they are comfortable with when NGLEs challenge their environmental competence (Byers 2015). Byers (2015) conducted a pre–post research project where teachers in traditional classrooms were studied before and after they moved into NGLEs that were designed through a collaborative process. They found that teachers utilised the affordances of NGLEs and spent significantly less time in traditional teacher-focused pedagogies, which allowed for more student-focused learning modes (Byers 2015).

Evaluating Architecture through Post-Occupancy Evaluations

Evaluation of learning environment design is important to understand the influence on students' physical activity behaviours. The most common method of formal architectural analysis is through POEs and, less commonly, PrOEs. Lackney (2001, 2) defines post-occupancy evaluation (POE) as 'the process of systematically evaluating the degree to which occupied buildings meet user needs and organizational goals'. PrOEs are generally the same, but they are conducted before the users occupy the building. The general understanding of POEs among architects is consistent since they are usually conducted shortly after the users have settled into the new building; however, exact definitions are contested (Hay et al. 2018). Understandings of PrOEs can differ depending on the relevancy to a particular building, for example, a PrOE for a school relocation or renovation may take place in an existing school prior to the design of the future school, whereas a new school PrOE may occur immediately before the school moves in.

PrOEs and POEs can serve various purposes depending on the types of information collected during the process. Jerome (2012, 21) explains that data collected during PrOEs and POEs are used for numerous purposes, ‘but is primarily intended to provide feedback to planners and architects of buildings so that lessons may be learned both from the successful and unsuccessful elements of a building’s design’. PrOEs and POEs can also provide valuable information to building users and other stakeholders within a project, depending on the types of questions asked in the evaluations. Lackney (2001) argues that POEs of schools generally focus on whether the physical school buildings support the educational objectives of the school. In other words, formal POEs of learning environments ask, ‘how well does the physical environment support the users teaching and learning aspirations?’. Knowing the answers to this question has many advantages to both the school itself and potentially to other future schools.

Conducting a formal PrOE and POE is not a compulsory part of many learning environment design and construction projects, and these are often only conducted when specifically requested by the client. However, they are usually conducted informally by the architect as part of their initial site analysis and handover processes. Hay et al. (2018) explains that an architect’s understanding of the definition of a POE can limit their evaluation practices because they generally only consider formal evaluations to be POEs.

Conducting PrOEs and POEs has numerous advantages. They can support stakeholder communication, provide methods for monitoring and comparing buildings, inform decisions and policies, encourage improvements to the buildings and reduce recurrences of failures (Lackney 2001, 2). Cleveland and Fisher (2014) argue that conducting POEs is especially important for contemporary learning environments because they can inform architects about design factors and educational factors for teachers and students. PrOEs can also provide additional benefits for the process of learning environment design. Conducting a PrOE at an existing school before the design of a new school can provide baseline information that can be compared to future data collected through the POE. This can provide data to allow for the analysis of changes implemented within the design. For example, data can be recorded before and after interventions to understand the implications of altering learning environments.

Evaluations of schools often focus primarily on the physical building rather than the educational goals of the learning environments to evaluate whether the construction quality meets the original brief. This notion is supported by Imms, Cleveland and Fisher (2016, 13), who state that ‘previous approaches to post-occupancy evaluations of learning spaces have been less concerned with pedagogy and more focussed on issues related to indoor environment quality, construction and building quality’. This idea is also brought up by Goad (2015), who discusses the complication of analysing only the architecture of schools without also understanding the teaching and learning that occurred within them. When the data provided by POEs focus on the physical building, any improvements to the learning environments based on the information will likely also be focused around the physical building, which is a missed opportunity. While the evaluation of a school’s physical building may be important to designers, the evaluation of the influence of that building on learning is likely to be more important to the users. Jerome (2012) discusses the importance of engaging with all stakeholders, including students, when conducting school building evaluations to provide information that captures various voices and discovers how effectively the learning environments support the school’s objectives.

PrOEs and POEs generally focus on physical and quantitative elements (Hay et al. 2018) such as size, energy use, materials, ventilation and air quality, lighting and acoustics. The qualitative elements such as how a building feels, if the building is fit for purpose or if users enjoy spending time in the spaces are not generally included in ‘existing POE toolkits’ (Hay et al. 2018, 706). This means that qualitative elements can be viewed as less important, which perhaps is just because they are perceived as harder to record. However, architects are trained to analyse buildings through both a qualitative and quantitative lens, so they should have the skills to record intangible elements, but they may not have witnessed it done in this way before. While skills may not be a barrier for architects conducting qualitative POEs, often POEs are completed by other stakeholders such as facility managers (Vischer 2001) who do not have a design background and may be untrained in analysing architecture or collecting qualitative data.

Conclusion

The evolution of school architecture tells us a great deal about the changing pedagogies and beliefs about education; however, although society and pedagogical ideas have changed, the architecture of schools has been slow to keep up. The processes of school design, use and occupation influence how learning environments are used and can therefore influence students' physical activity behaviours. There are challenges and opportunities that key stakeholders face within the stages of design, use and occupation of learning environments. Environmental competence is a key challenge of teachers but is especially important for teachers within contemporary non-traditional learning environments. Architects play a crucial role in all stages of planning and building learning environments and have a leadership role in the collaborative design process. Thus, POEs are critical. Through this leadership role, architects are uniquely positioned to encourage improvements to students' physical activity behaviours at all stages of learning environment design, use and occupation.

3. Physical Activity of Children in Learning Environments

Children in Australia are failing to meet recommended levels of physical activity and sedentary behaviour (AHKA 2018), and as children spend a large portion of their time in schools, it is crucial to understand how the architectural environment of schools influences physical activity behaviours. This chapter outlines the available research about the relationship between the built environment of schools and children's physical activity behaviours, starting with a discussion of the key terms used and the health benefits of increasing physical activity and reducing sedentary behaviour. I discuss Australian physical activity guidelines and evidence of children's current physical activity behaviours. I outline the current literature on students' physical activity behaviours in schools and outline the critical role that teachers play, with a particular focus on various classroom-based physical activity interventions. The built environment influences individuals' behaviour in various ways (Scott-Webber, Strickland and Kapitula 2013) and often provides clues as to how individuals should behave in specific spaces (Smith 2017). I outline the current knowledge of the influences that learning environment design has on students' physical activity behaviours specifically, with a discussion of external schoolyards, school architecture, interiors and furniture. The chapter concludes with examples of international schools that have attempted to improve students' physical activity behaviours through design.

Children's Physical Activity

Physical activity is defined as any movement of the body that requires energy to be expended (WHO 2017) and is categorised by intensity levels, including light, moderate and vigorous physical activity. Light physical activity includes standing and slow walking, whereas moderate physical activity 'requires a reasonable amount of effort that accelerates the heart rate, whereby an individual is able to talk comfortably but not sing' (AIHW 2018, 1), which includes activities such as climbing stairs and fast walking. Vigorous physical activity, such as running, skipping and jumping, significantly elevates the heart rate and makes both talking and singing difficult

(AIHW 2018, 1). MVPAs are frequently joined into a single category, especially when there are low amounts of vigorous physical activity recorded.

Within physical activity literature, there are many key terms, and it is important to understand the distinction between each. Incidental physical activity is a by-product of an everyday activity where gaining physical activity was not the aim, such as walking to school, doing chores or taking the stairs (Zimring et al. 2005). Sedentary behaviour is any waking activity with energy expenditure between resting metabolic rate and light physical activity while sitting or lying (Pate et al. 2011). This is separate from physical inactivity, which is defined as insufficient levels of MVPA (SBRN 2012). Physical inactivity and high levels of sedentary behaviour are two 'separate and distinct risk factors for chronic, noncommunicable diseases' (SBRN 2012, 540) as it is possible for children to be both highly physically active and highly sedentary (Wong and Leatherdale 2009; Biddle et al. 2004). A sedentary bout is a period of constant stillness (time spent still before moving) that lasts for at least 10 minutes (Chinapaw et al. 2014).

Worldwide studies have found that sedentary behaviour, especially when displayed in long bouts, contributes to decreased health outcomes such as an 'increased risk of cardio-metabolic disease, all-cause mortality, and a variety of physiological and psychological problems' (Tremblay et al. 2011, 2). Sedentary behaviour negatively influences 'cognitive development', 'gross motor control and bone and muscle development' and 'musculoskeletal outcomes via prolonged or repetitive stress on tissues' (Straker et al. 2016, 181). Categorical definitions of sedentary bout length vary across studies. Diaz et al. (2019) define a short bout of sedentary behaviour as between one and 29 minutes, a moderate bout as between 30 and 59 minutes, and a prolonged as more than 60 minutes. To follow the generally accepted sedentary bout definition by Chinapaw et al. (2014), in this project, I define a short bout as 10 to 29 minutes, with moderate and prolonged bouts following the recommendations by Diaz et al. (2019). A break in a sedentary bout is defined as a minute or longer of non-sedentary behaviour (Saunders et al. 2013). Research suggests that the health risks associated with long bouts of sedentary behaviour can be reduced by introducing short regular intervals of light activity such as standing or slow walking (Healy et al. 2008; Peddie et al. 2013).

Increased levels of physical activity have numerous health benefits for children. A systematic review by Janssen and LeBlanc (2010, 13) found that the highest benefit to children's overall health was through 'aerobic-based activities that stress the cardiovascular and respiratory systems' and for the health of bones specifically, 'high-impact weight bearing activities are required'. Active Healthy Kids Australia summarises the various benefits to children's health:

> The evidence tells us that children and young people who are active on a daily basis are at lower risk of conditions including overweight and obesity, Type II diabetes, metabolic syndrome and other comorbidities. They are also more likely to have a higher level of aerobic fitness and bone health and experience positive mental and cognitive health benefits. Furthermore, research shows that children who are physically active achieve greater academic success and maintain higher attention levels during class at school (AHKA 2018, 6).

An Australian study also found a positive relationship between students' improved 'health-related quality of life' score and physical activity during the school day, with a stronger positive association for MVPA specifically (Shoesmith et al. 2020, 2). Enhanced health-related quality of life is essential for children's wellbeing now and in the future and is calculated by a parent questionnaire that provides an indicator of overall health, including physical, social and psychological aspects (Shoesmith et al. 2020).

Australian Guidelines for Children's Physical Activity

Health guidelines are provided for Australian children, and while they provide clear recommendations for high-intensity physical activity, the recommendations for sedentary behaviour and light-intensity physical activity are unclear. It is recommended that school-aged children (five to 17 years old) achieve a minimum of 60 minutes of MVPA each day and limit time spent in sedentary behaviours (Australian Government Department of Health 2019). School-aged children should break up long intervals of sitting and accumulate no more than two hours of non-educational screen time (Australian Government Department of Health 2019); however, more specific recommendations for sedentary behaviours are unavailable.

National guidelines in Australia stipulate that every primary and lower secondary school must provide at least two hours of physical activity ‘in the curriculum’ per week to all students (Australian Government 2016). With an average of 25 hours of class time per week, the School Curriculum and Standards Authority (SCSA 2016) recommended that two hours per week are spent on ‘health and physical education’, which equates to 8% of class time (excluding recess and lunch). In England during 1904, physical education made up 5% of the curriculum and again in 1988, it remained at 5% even though other aspects of the curriculum were given more priority, such as art and music, which both increased from 5% in 1904 to 10% in 1988 (Ross 2000). In comparison, depending on student age English is now recommended as between 12% and 24% of the curriculum (SCSA 2016), increasing from 10% in 1988 (Ross 2000). Although not a guideline, ‘The 2018 Active Healthy Kids Australia Report Card on Physical Activity for Children and Young People’ (AHKA 2018, 46) recommends that schools provide students with 150 minutes of physical activity in addition to health and physical education (HPE) classes, to better align with international guidelines. The AHKA (2018) recommendation excludes recess and lunch time but could include physical activity embedded in traditionally academic lessons.

I have identified many problems within the Australian national physical activity guidelines for schools. First, the guideline states that at least two hours of physical activity should be provided ‘in the curriculum of the school’ (Australian Government 2016, 35) per week, but it is not made clear whether this includes recess or lunch breaks. Second, the level of physical activity intensity to be gained during the required two hours is not stipulated, so it is unclear whether students should be achieving MVPA for those two hours. Third, there is no minimum time required to be spent on curriculum-based HPE, which educates children more widely on health (please see the ‘Australian Health and Physical Activity Education’ section below for further discussion). Last, the Australian curriculum guidelines also fall below recommendations in other countries such as Canada and the US, which recommend students accumulate at least 30 minutes of MVPA over the whole school day (McCarthy et al. 2021, 1). Canada also specifically outlines that across the whole day, children should accumulate 90 minutes of MVPA, which includes ‘60 minutes of moderate activity (e.g., brisk walking, skating, bicycle riding) and 30 minutes of vigorous activity (e.g., running, basketball, soccer)' (Janssen and LeBlanc 2010, 2).

Children's Physical Activity in Australia

'The 2018 Active Healthy Kids Australia Report Card on Physical Activity for Children and Young People' (AHKA 2018) aims to illustrate the physical activity levels for Australian children through the synthesis of the available evidence. Since the first Active Healthy Kids Australia (AHKA) report in 2014, two more full reports have been published in 2016 and 2018, with a progress report also published in 2015 (AHKA, 2014, 2015, 2016, 2018). As can be seen in Table 3.1, the report card summarises the results from 12 indicators contained within the reports and each was given a grade from A to F or scored as having inconclusive (INC) evidence (AHKA 2018). While no indicators were graded as a fail, the only indicator to score significantly well is 'community and the built environment' with A− grades across the three reports. This A− indicates that 81–100% of people have neighbourhoods that are safe, provide play space and adequate public transportation near homes, as well as good footpaths and roads networks (AHKA 2018). 'Overall physical activity levels' and 'screen time' both scored D− across the three reports which indicates that only 21–40% of children met the guidelines for overall physical activity levels and sedentary behaviours (AHKA 2018). The report card also commended schools with grades of B+/− because many employ specialist physical education teachers and provide adequate facilities and time for students to be active (AHKA 2018). I should also note that the increase in the school grade from B− to B+ in the latest report is not due to any improvements in schools, but rather the calculation metric was altered from the recommended 150 minutes of physical activity per week to the guideline of 120 minutes (AHKA 2018). A more recent Australian study by McCarthy et al. (2021) found that 61% of students were meeting the minimum recommended amount of MVPA (30 minutes) during school time and that only '3.8% of students met break time guidelines, spending at least 40% of break time in MVPA' (McCarthy et al. 2021, 3).

The report card demonstrates that overall, Australian children are failing to meet physical activity and sedentary behaviour guidelines, though facilities provided by schools and communities are adequate (AHKA 2018); however, Straker et al. (2016) argue that the report card may not be wholly accurate, as the sedentary behaviours are calculated based purely on screen time. Straker et al. (2016, 180) state that Australian children's 'total daily sitting time is high from age 9 to 17 years and is composed of around 3.5 hours of screen time and 6 hours of nonscreen time'. Therefore, screen time does not accurately represent total sedentary behaviour by children and underestimates the problem (Straker et al. 2016). Time spent at school is associated with long bouts of sedentary behaviour (Abbott, Straker and Mathiassen 2013), which is not necessarily accounted for in screen time results. Thus, scores in this category may be worse than initially thought. It is unclear why such a large percentage of children are not meeting recommended levels of physical activity behaviours if schools and communities are thought to be providing adequate infrastructure, policies, programs and safety (AHKA 2018).

Table 3.1 Summary of Active Healthy Kids Australia report card (AHKA 2018).

Indicator	**AHKA Report Card**		
	2014	**2016**	**2018**
Overall physical activity levels	D−	D−	D−
Organised sport and physical activity participation	B−	B	B−
Physical activity participation in school sports	INC	INC	B
Active transport	C	C−	D+
Active play	INC	INC	INC
Screen time	D−	D−	D−
Family and peers	C	C+	C+
School	B−	B−	B+
Community and the built environment	A−	A−	A−
Strategies and investments	C+	D	D
Physical fitness	INC	C−	D+
Movement skills	INC	D	D+

Australian Health and Physical Activity Education

HPE is a subject that encourages students 'to enhance their own and others' health, safety, wellbeing and physical activity participation in varied and changing contexts' (SCSA 2017, 4). As a subject, this includes learning about health but is separate from physical activity itself, although likely included within the subject. As previously stated, the School Curriculum and Standards Authority (SCSA 2016) recommended two hours per week are spent on HPE with no mention of the specific amount of time to be spent on physical activity specifically. Noble et al. (2008) explain that the HPE curriculum in WA centres on four skills for student development: physical activity, individual safety and wellbeing, self-management skills and interpersonal skills. In practice, perhaps only a quarter of the HPE curriculum is devoted to physical activity. For children in Australian primary schools, physical activity behaviours are just a single factor of their overall health; however, it is vital because it has the ability to influence 'physical, lifestyle, affective, social, and cognitive' development domains considerably (Bailey 2006, 399).

In Australian primary schools, classroom teachers are commonly required to teach all aspects of the curriculum, including HPE. A study by Morgan and Hansen (2008) found that teachers commonly believe physical activity has wide-ranging benefits for students, but some teachers are not confident in their abilities to successfully teach physical activity programs (Morgan and Hansen 2008). While most teachers understand the varied benefits of physical activity within the curriculum, including positively affecting behaviour and academic outcomes, Morgan and Hansen (2008, 205) state that 'PE is devalued when it is rationalized in terms of how it enhances a child's achievements in more academic subjects'. The benefits of physical activity to children's development should be recognised in its own right for its physical, physiological and educational benefits (Tinning et al. 1993). A similar problem arises when physical activity is viewed as a break from traditional learning or reward for good behaviour.

Physical activity within schools has historically been provided to students through HPE classes; however, due to policy, budget and time factors, HPE classes alone cannot provide students with the minimum MVPA requirements (Sallis et al. 2012). Fedewa et al. (2018) suggest that physical activity should be incorporated throughout the school day using innovative methods to reduce sedentary behaviour. Classroom-based physical activity (CBPA) is one such innovation that I will discuss in depth in the following section. Fedewa et al. (2018) discuss the role of the teacher acting as a role model during CBPA to encourage students to be more active. They found that students' physical activity behaviours improved when the teacher moved and danced more, although they are uncertain exactly why this is the case (Fedewa et al. 2018, 585). They propose that the increase in CBPA could be due to the relationship being similar to a parent–child relationship since 'research suggests that parents who provide support and encouragement for their children to be active are more likely to have active children' (Fedewa et al. 2018, 591).

Physical activity behaviours are also linked to physical and health literacy, which are skills learned and refined throughout our lives. Physical literacy is defined as the ability of any person to move with poise and self-confidence in a variety of situations and perceive the environment to react suitably (Whitehead 2001). Physical literacy is learned through structured physical activity such as curriculum-based HPE in addition to unstructured physical activity commonly referred to as play (Ridgers et al. 2011). As individuals improve their physical literacy, they are able and more likely to participate in physical activity and less likely to suffer from illness associated with sedentary behaviour (Jurbala 2015). Health literacy is defined as 'the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain good health' (Nutbeam 1998, 357). It is essential that both health and physical literacy continue to be taught to students from a young age.

Interventions to Improve Physical Activity in Schools

Schools have been identified as a critical area of focus for health promotion due to the significant influence on children's development (Gorman et al. 2007; Jones and Harrison 2014). Australian children spend roughly six hours per weekday at school for 40 weeks of the year (SCSA 2016). Health promotion researchers stress the importance of improving children's sedentary behaviour habits (see for instance Tremblay et al. 2011; Straker et al. 2016). Children spend more than half of their school day in sedentary behaviours (Brittin et al. 2017), and Ridgers et al. (2012) found that in Australia, students spend 63% of the school day in sedentary behaviours. Studies have shown that it is important to decrease the total time spent in sedentary behaviours, both in and out of school environments, as it provides various health benefits for children (Abbott, Straker and Mathiassen 2013). As both physical activity and sedentary behaviour often continue into adulthood (Biddle et al. 2010), it is important to influence physical activity habits during childhood. It has been found that sedentary behaviour is more likely than physical activity to continue into adulthood, so reducing sedentary behaviour is more critical than increasing the physical activity of children (Biddle et al. 2010). Research suggests that the health risks associated with long bouts of sedentary behaviour can be reduced by introducing short, regular intervals of light activity such as standing or slow walking (Healy et al. 2008; Peddie et al. 2013).

Research has identified a difference in the amount and intensity of physical activity by children of different ages and sex/gender. Many studies have found children are more sedentary and less physically active as they grow older and reach adolescence and that boys are more physically active than girls, who are more sedentary (see for instance McCarthy et al. 2021; Farooq et al. 2018; Dunton et al. 2020; Andersen et al. 2015; Cooper et al. 2015; Basterfield et al. 2011; Trost et al. 2002). It has been proposed that the differences by age and sex are due to differences in play preferences during recess within schoolyards, and some studies use GPS to track where on the school campus different categories of students choose to spend their time (see for instance Pawlowski et al. 2016; Andersen et al. 2015). Andersen et al. (2015) and Pawlowski et al. (2016) found that children spent more time in MVPA on grass with higher results for boys compared to girls. Playgrounds and multi-court areas were also found to support MVPA to a slightly lesser extent, again with boys gaining more MVPA than girls (Andersen et al. 2015; Pawlowski et al. 2016). Girls were often sedentary in multi-court spaces, which could be because the perception of accessibility and enjoyment differ between girls and boys (Andersen et al. 2015, 89). Girls were also more likely to prefer indoor sedentary socialisation activities due to a perceived 'lack of attractive outdoor activity possibilities' (Pawlowski et al. 2016, 11). Children are more sedentary and less physically active as they reach adolescence; however, as demonstrated by Brittin et al. (2017), schools designed to promote physical activity behaviours can prevent this expected behaviour. Martin and Murtagh (2015b) point out the irony of school focused physical activity interventions when traditional classrooms are dominated by long periods of sedentary behaviour.

Student movement in learning environments 'has traditionally been seen as a behavioural issue', with teachers often viewing classes with student movement as lacking discipline (Woodman 2016, 65); however, in contemporary learning environments with student-centred pedagogy, movement is often perceived as a normal part of education. Woodman (2016) studied the classroom movement of teachers and students in a secondary school in Australia with a focus on the flexibility of classrooms. They found a clear relationship between the classroom pedagogy and the movement of students (Woodman 2016). Unsurprisingly, 'students in traditional teacher-directed learning environments are typically static and immobile', whereas many students in student-centred learning environments were very physically active (Woodman 2016, 63). The research also highlighted that there was not a relationship between student movement and the physical learning environment, but other studies have frequently cited limited space or lack of flexibility as a barrier to classroom movement (Dinkel et al. 2017). Woodman (2016) also observed that irrespective of the pedagogy utilised, teachers do not frequently make significant spatial changes to classroom layout (Woodman 2016, 61), but it was not clear why this was the case. In interviews with students who were static during lessons, Woodman (2016, 75) reported 'that the lack of movement was not due to the space but was due to teacher control', and it could be assumed that the same control would apply to students' ability to make spatial changes such as moving furniture.

Classroom-Based Physical Activity

Health promotion experts have recommended that classes with long bouts of sedentary behaviour are broken up with short bouts of physical activity, preferably MVPA (Martin and Murtagh 2015a). Long bouts of sedentary behaviour not only have detrimental effects on students' health, but they also lead to fidgeting behaviours and decreased concentration (Mahar et al. 2006). Drummy et al. (2016, 745) states that 'classroom-based activity breaks are characterised as short duration (5–15 min) sessions of PA led by the teacher inside the usual classroom'. These are referred to by many names, depending on the method of physical activity incorporated. For instance, if they are a short break in a traditionally 'academic' subject, then they are often referred to as 'brain breaks' (Dinkel et al. 2017) or 'energizers' (Mahar et al. 2006). If the physical activity is included within lessons, then they are often referred to as 'active lessons' (Martin and Murtagh 2015b) or 'active curriculum' (Martlew, Stephen and Ellis 2011). The term 'classroom-based physical activity' (CBPA) (Stylianou, Kulinna and Naiman 2016) is often used as an umbrella term to refer to all physical activity incorporated into academic subjects. Many benefits of CBPA have been identified: 'in contrast to PE or recess, classrooms provide an opportunity for all students to participate in MVPA that is not skill dependent and without having to make a conscious choice to do so' (Szabo-Reed et al. 2020, 7). Carlson et al. (2015, 69) reported that students were '75% more likely to meet the recommended 30 min/day of MVPA during school' if their teacher implemented CBPA.

While most CBPA is based on increasing students' MVPA, other studies have focused on reducing sedentary behaviour, which is important because research has shown it is possible for children to be both highly physically active and highly sedentary (Wong and Leatherdale 2009; Biddle et al. 2004). To combat the health risks of physical inactivity and high levels of sedentary behaviour, Salmon et al. (2011) recommend introducing light-intensity physical activity breaks into classrooms to break up long periods of sedentary bouts. The intervention improved physical activity and health outcomes for participating students and perceived improvements in student 'concentration and behaviour in class' (Deakin University 2021). Other classroom interventions that can limit sedentary behaviour include incorporating furniture that encourages standing, which I will discuss below.

Numerous studies have focused on the effects of physical education on academic performance; however, there is uncertainty whether children's education is affected by physical activity in general (Rasberry et al. 2011) or by active classrooms (Erwin et al. 2012). Learning outcomes are a difficult factor to measure with great certainty as students learn in different ways and perform differently. In Australia, NAPLAN testing is the most widely used measure of learning outcomes in primary school education. It tests literacy and numeracy. Studies differ in the way they test both physical activity and learning outcomes, so it is often difficult to compare results (Watson et al. 2017).

Research has identified that the time taken out of the academic curriculum to include additional physical activity does not negatively affect academic performance (Ahamed et al. 2007) but may have a positive relationship with children's cognition (Sibley and Etnier 2003). For instance, Mahar et al. (2006) found that students' 'on-task behaviour' was significantly improved after 10 minutes of CBPA. For students who were frequently 'off task' and disruptive in the classroom, the improvement was higher and, therefore, 'extremely beneficial to classroom control and performance' (Mahar et al. 2006, 2093). Howie, Schatz and Pate (2015) found that maths results were improved after at least 10 minutes of CBPA when compared to a sedentary lesson and that shorter bouts (five minutes) of CBPA did not negatively affect cognition or academic performance while still providing increased physical activity. These improvements in academic performance, cognitive function and on-task behaviour are not found in all studies (Watson et al. 2017). For instance, the 'Academic Achievement and Physical Activity Across the Curriculum' intervention project found that over three years, students' academic achievement did not change in the intervention group compared to the control group (Donnelly et al. 2017, 140). Donnelly et al. (2017) suggest that the contrast in findings for academic achievement could be due to insufficient improvement to students cardiovascular fitness, stating 'increased cardiovascular fitness has been associated with improved cognitive function, brain structure and function and academic achievement' (Donnelly et al. 2017, 144). They recommend that further research be conducted to develop higher intensity CBPA that is appropriate for learning environments (Donnelly et al. 2017).

There are barriers and facilitators to CBPA, including time, space, furniture obstacles, teacher perceptions and teacher training (Dinkel et al. 2017). The most important aspect of CBPA is the willingness of teachers to incorporate movement into the curriculum as 'students cannot be physically active in a classroom setting without the support and guidance of the teacher' (Martin and Murtagh 2015b, 122). Donnelly and Lambourne (2011, S40) found that CBPA 'are cost effective, do not require additional teacher preparation time, are enjoyable for teacher and student, and result in improved academic achievement scores'. However, they also noted that a key challenge was designing high-intensity activities that could be undertaken without rearranging furniture (Donnelly and Lambourne 2011, S38). Donnelly et al. (2017, 144) also discuss how the classroom structure can affect CBPA, as they found that:

> Changes in classroom structures from the traditional (i.e., 1 teacher/class) to alternative structures, including open and blended classrooms, team teaching, etc., and limited classroom space due to the increased use of computer technology, may have impacted the ability of teachers to deliver physically active lessons on a consistent basis.

Szabo-Reed et al. (2020, 7) reported that a significant barrier for teachers in the US consistently implementing CBPA was implementing the MVPA within academic lessons. They recommend that CBPA focus on physical activity as 'breaks' in lessons, assisting teachers with delivery and encouraging higher intensity physical activity, which may increase cardiovascular health and academic achievement (Szabo-Reed et al. 2020, 7).

Teachers in learning environments that allow students free movement (NGLEs, ILEs or dynamic classrooms) found that ‘specified movement breaks were no longer necessary because students could move their bodies when they needed’ (Kallio 2017, 69). However, CBPA usually aims to introduce MVPA rather than just light activity, which is unlikely to be gained during standard learning activities with students walking slowly around the room. This is supported by Cardon et al. (2004) through an intervention project in Germany that compared a traditional classroom to a dynamic classroom that allowed students to move around and occupy various furniture types. They found that while the activity levels were higher, the mean activity level in the dynamic classroom was light-intensity physical activity because students ‘do not run through the classroom’ (Cardon et al. 2004, 139).

Built Environment Influences Behaviour

Behaviour Change

It is clear that the built environment influences people’s behaviours. However, research and theories surrounding the topic are generally written in broad terms rather than specific architectural elements. In the book *Nudge: Improving Decisions About Health, Wealth and Happiness*, Thaler and Sunstein (2009) discuss how the built environment can influence people’s behaviour through both significant and subtle design decisions. They believe that architectural design can never be ‘neutral’ because every decision an architect makes will influence someone’s daily life and experience within the building (Thaler and Sunstein 2009). Some architects may not be aware of the effects of their decisions; however, through the power of design, architects can ‘nudge’ people towards certain behaviours while not prohibiting others (Thaler and Sunstein 2009, 6). With careful design, the built environment can encourage people to increase their own incidental physical activity. For instance, through the arrangement of a building with key facilities on different floors and the placement of a beautiful staircase, building users can be encouraged to choose the stairs rather than a lift when navigating a building (Thaler and Sunstein 2009). A building can also be designed to make desirable behaviours easier and undesirable behaviours harder (King, Thompson and Darzi 2014, 336).

Built Environment Influences on Physical Activity

A relationship between people's physical activity behaviours and the built environment has been identified; however, further details are constantly emerging due to the complexity of this relationship. Often, this research focuses on adults and their workplaces (see for instance Creagh et al. 2017; Jancey et al. 2016; Buckley et al. 2015) and does not relate specifically to children or architectural design of school environments.

By analysing the literature of primary school environments influence on physical activity behaviours, a gap in Australian knowledge becomes clear. Most research studying the built environment's influence on health is based in the US, the UK or Nordic countries. This research tends to focus on overall health through urban green space (see for instance Hunter et al. 2014); active transportation (see for instance Sallis and Glanz 2006; Timperio, Reid and Veitch 2015); healthy eating (see for instance Gorman et al. 2007); ground surfaces (see for instance Andersen et al. 2015); overall space per child (see for instance Cradock et al. 2007); or teacher interventions such as active classrooms (see for instance Donnelly and Lambourne 2011; Martin and Murtagh 2015a). The focus of many of these studies fall outside the scope of this project and will not be discussed further.

Australian research into children's physical activity behaviours generally focuses on urban design affecting walkability (see for instance Curtis, Babb and Olaru 2015), which falls within the realm of urban planning. Research specific to architectural elements or architectural sites includes studies that focus on standing desks (see for instance Clemes et al. 2016) or teacher interventions such as CBPA (see for instance Salmon et al. 2011), which were previously discussed. While there is a range of international research projects studying how the built environment influences children's physical activity behaviours (see for instance Brittin et al. 2015), a gap exists in Australian research on primary school architecture.

Learning Environment Spatial Cues

The physical learning environment is not a 'passive backdrop for educational activities' but an active and changing influence on all aspects of learning (McLane

2013, 21). Mulcahy, Cleveland and Aberton (2015, 590) state that we should change how we think about learning environments:

> Thinking the term learning spaces as verb rather than noun, that is, as something we do (a matter of encounter), rather than something we have (a new learning environment, a finished design) affords acknowledgement of the multiplicity and mutability of spatial and pedagogic practices.

Smith (2017) discusses that the spatial cues within learning environments direct teachers and students to how they should be used. Thus, teachers and students will generally use the pedagogy that the learning environment indicates (Smith 2017, 59). The influence of learning environment design on students' behaviour is discussed by Woodman (2016) as being the result of spatial and cultural cues. Woodman (2016) argues that students act like other students within the learning environment and based on past experiences in similar spaces. In a learning environment with insufficient spatial cues, students may become confused as they do not know what behaviours are expected of them (Woodman 2016, 55). This is more likely to occur in NGLEs or open-plan learning environments, as there are no strict boundaries between various spaces (Woodman 2016).

Architectural Influence on Learning

Just as learning environment design influences behaviour, it can also influence learning. Studies have shown a relationship between learning environments and student engagement or academic outcomes (see for instance Barrett, Zhang et al. 2015; Barrett and Zhang 2009); however, the evidence is still emerging. Cleveland (2016) outlines the limited research within the literature of associations between space and learning, as well as how pedagogy and student engagement is influenced by the physical environment. A systematic review by Bradbeer et al. (2018) found that before 2016, only 21 peer-reviewed articles reported quantitative changes to students learning outcomes after design-based interventions within primary or secondary schools. They found that most studies focused on the general type of learning environment, such as traditional, open plan or NGLEs, with NGLEs seeming to improve learning outcomes when compared to traditional classrooms and open-plan classrooms having a negative effect on learning outcomes (Byers et al. 2018).

Overall, there is a ‘lack of substantive, empirical evidence about the impact of different spatial layouts on student outcomes’ (Byers et al. 2018, 36).

Many researchers believe that studying learning environments as complex systems through the social ecologic model allows for a deeper understanding of the varying influences on students learning. For instance, Blackmore et al. (2011, 4) discuss how the design of learning environments is just one of several factors that can influence students’ academic outcomes, but it is difficult to identify the specific factors that most affect students’ academic outcomes. McLane (2013, 11) also discusses that ‘buildings themselves and their spatial configurations alone cannot make students learn’; however, the design supports certain pedagogical practices that can influence students’ educational outcomes. Imms and Byers (2016, 3) state that the use of learning environments is just as important as the physical design of the learning environments when studying the effects on students’ academic outcomes. Similarly, Blackmore et al. (2011, 4) refer to the use of learning environments as a temporal factor that changes over time and is constantly in motion due to the way teachers or students use a learning environment at any specific point in time.

Studies in the US have identified elements of the interior design in schools that can influence academic achievement (see for instance Barrett, Zhang et al. 2015; Barrett and Zhang 2009). They found that naturalness, individuality and stimulation are three important factors within primary schools that improve academic achievement (Barrett, Zhang et al. 2015; Barrett and Zhang 2009). However, there is little specific research that looks into the physical factors of classrooms or school environments that improve physical activity or affect sedentary behaviour.

School Architecture Influences Physical Activity

Encouraging students to improve their physical activity behaviours in learning environments is ideal because ‘children spend approximately 40% of their waking week during term at school and accumulate a quarter of their total daily physical activity while at school’ (Martin 2010, 74). Little discussion of how primary school architecture influences the physical activity behaviours of children exists beyond discussions that neighbourhoods and schools should provide sports facilities and open space for general health (see for instance Giles-Corti and Donovan 2002). The

Australian study ‘Play Spaces and Environments for Children’s Physical Activity’ (University of Western Australia 2017) aims to determine barriers and facilitators of physical activity in pre–school aged children within early childhood centre environments. Research into specific design interventions to improve physical activity is still emerging; however, a critical factor that seems to be agreed upon is that designers should ‘ensure staircases are clearly signposted and are attractive to use’ (NICE 2008, 9).

Generally, discussions of students’ physical activity behaviour are focused on external environments. In schools, the focus of improving physical activity remains firmly in the playground, with designers recommended to ‘ensure school playgrounds are designed to encourage varied, physically active play’ (NICE 2008, 10). While it is true that students are more physically active outdoors compared to indoors, that is because high-intensity physical activity behaviours are typically not permitted inside learning environments or schools (Brittin 2015, 116). There is a lack of research surrounding the interior design of Australian schools in general and even more so when looking at influences on physical activity behaviours.

External Schoolyards

The external schoolyard influences student physical activity behaviours, predominantly during recess or HPE when the outside environment is most used. It has been identified that ‘larger school campus, building, and play areas per enrolled student were associated with increased physical activity in middle school students’ (Cradock et al. 2007, 110). The ground surfaces within the schoolyard are shown to affect children’s physical activity behaviours, with grass and playgrounds generating the most time spent in MVPA, whereas solid surfaces such as asphalt or paving demonstrated higher rates of sedentary behaviour (Andersen et al. 2015; Pawlowski et al. 2016). As discussed in the previous section, there are also differences in gender where females are often more sedentary since they tend not to partake in competitive sports played on large ovals or sports courts that are dominated by boys (Andersen et al. 2015).

Martin’s PhD dissertation ‘School, Classroom and Child-level Correlates of Children’s Class-time and Recess Physical Activity’ (2010) studies the physical, policy and socio-cultural environments influences of physical activity in Perth primary schools, but the focus is on recess and physical education classes. Martin (2010) found that key influences relate to teachers' roles regarding physical education, size of grassed areas and access to sporting apparatus. The architecture and interior learning environments of the schools are not analysed in depth, but rather the analysis of the physical environment factors relates to sporting facilities (Martin 2010).

Several studies focusing on outside environments have interviewed primary school students to provide information on the perceived barriers and facilitators of physical activity in primary schools. A study in Denmark found that there were five main perceived barriers to physical activity: 'weather, conflicts, lack of space, lack of play facilities, and use of electronic devices' (Pawlowski et al. 2014, 8). These barriers are repeated throughout many studies, and often, the barriers can have a compounding effect when occurring together. For example, a lack of space or facilities can lead to conflicts or the increased use of electronic devices. Each of these conflicts will be discussed below.

Bad weather and the school policy regarding the weather can affect students' physical activity behaviours, both during recess and physical education classes. A study in Finland found that weather could also facilitate students' physical activity because children were motivated to play during sunny and wet days, as long as they had access to appropriate clothing such as waterproof jackets (Eskola et al. 2018). Students also preferred to run during cloudy weather rather than on warm days, as it was considered more comfortable (Eskola et al. 2018). In an Australian study, Stanley, Boshoff and Dollman (2012) found that the school policy was a barrier that differed according to schools. For instance, one school required students to stay inside during rain and temperatures over 36 degrees Celsius (Stanley, Boshoff and Dollman 2012). Instead, schools could encourage physical activity during all weather using covered outdoor areas or indoor facilities during rain and excessive heat.

An Australian study by Parrish et al. (2012) found that school policies can either positively or negatively influence students' physical activity behaviours. Policies that encourage high levels of activity or limit sedentary activities such as access to digital devices could be positive, whereas policies that limited play to only portions of break time, not allowing students to play when they do not have a hat or not permitting running on hard surfaces would have a negative effect (Parrish et al. 2012). Pawlowski et al. (2014, 7) found that students were aware that their use of electronic devices was inhibiting their physical activity behaviours during recess, and many had a desire to have a ‘device-free recess’ policy because they were tempting to use; one student commented ‘it attracts us like a magnet’. School policies and teacher intervention could be important factors in motivating and improving students’ physical activity behaviours.

The common theme of a lack of space and facilities is referred to in many studies as a perceived barrier to students’ physical activity; however, often, it is how the space is used that seems to be the real barrier. Stanley, Boshoff and Dollman (2012) found that students perceived space as a barrier when there was inaccessible space due to policies, other students or other activities. For instance, there may be policies that limit students of certain ages to remain in specific areas of the schoolyard or for certain areas to be used for specific types of activities. There may also be ‘peers taking up the space for sedentary activities (sitting and talking) [or] space being used for other school-related activities (e.g. training)’ (Stanley, Boshoff and Dollman 2012, 46). The perceived lack of space and facilities as a barrier could also be due to the high density of students in schoolyards (or in particularly desirable areas), which can cause conflicts between students and excess noise, which Pawlowski et al. (2014) found led to some students, particularly girls, preferring inside or secluded spaces for sedentary activities. When there was high demand for specific facilities (such as fixed swings or unfixed sports equipment), some students discussed having to wait for them to become available and perhaps choosing sedentary behaviours if their preferred activity was not available (Pawlowski et al. 2014). These perceived barriers demonstrate the importance of schools providing large schoolyards with a variety of facilities (both fixed and unfixed) to provide opportunities for all students to be physically active.

The literature has minimal discussion of the barriers or facilitators to physical activity within the physical school buildings. A study interviewing primary school students in Finland by Eskola et al. (2018, 418) identified that children viewed the physical school building as a facilitator to physical activity because it was seen ‘as a place that collected friends together, leading to comfortable playing: buildings were also used, for example in games of hide-and-seek’. The physical school building could play a role in reducing the barriers that students have identified, as described above. For instance, articulation of the external walls of the building could provide spaces for students who seek out secluded areas for small groups. These spaces could be large enough to support physical activity while still providing a sense of seclusion. The school building could also provide shelter from bad weather through covered external spaces or internal sports halls. Lackney (2000) outlines the importance of transitional spaces such as verandahs that can act as learning spaces, mediating the zone between indoor and outdoor, but the discussion does not extend to the influence these spaces could have on physical activity.

School Architecture

Internationally, little robust evidence exists to support claims that specific elements of school architectural environments influence physical activity behaviours. Across the literature, there is a clear agreement on the importance of evidence-based design, as demonstrated by texts such as the 'Physical Activity Design Guidelines for School Architecture' (Brittin et al. 2015) and 'Active Design Guidelines: Promoting Physical Activity and Health in Design' (The City of New York 2010) where literature and strategies are ranked by the strength of their supporting evidence. Both guidelines ranked studies by duration, randomisation, control and the number of cases/samples. While this is common practice in academic research, it does not necessarily transfer strongly into the design discipline. This is supported by Brittin et al. (2015, 6), who attempt to answer the two questions 'what does the evidence tell us about designing schools to promote [physical activity]?' and 'what do design practitioners need to know to create schools that promote [physical activity]?'. They found that, often, evidence answering 'the first question often do not sufficiently answer the second question, supporting a need for both scientists and designers to engage in the other group's knowledge bases and perspectives' (Brittin et al. 2015, 6). So, although evidence exists on the effects of schools on students' physical activity, this does not seem to translate into adequate information for school designers to implement into their own practices.

Brittin et al. (2015) break down school architecture into 10 categories and review the available literature informing each category regarding physical activity:

1. school siting and community connectivity
2. building massing and programming

3. smart fitness facilities
4. active classrooms
5. outdoor learning areas
6. active play and leisure areas
7. active navigation areas
8. signage and wayfinding
9. furniture specification
10. mobile technologies and virtual designed environments.

Four of these are of particular importance to this research project: building massing and programming, active classrooms, outdoor learning areas and furniture specifications (Brittin et al. 2015). Strategies to improve physical activity of children within each of these domains include: 'building connections and spatial patterning as opportunities to promote physical activity'; 'ample room for children and teachers to move in and around the classroom'; 'outdoor classrooms adjacent to outdoor and natural learning opportunities'; and 'dynamic furniture that is ergonomically appropriate for age, and embraces children's natural tendency to move and fidget' (Brittin et al. 2015). Although these strategies may increase opportunities for physical activity within schools, supporting evidence is preliminary or based upon best practice (Brittin et al. 2015). The majority of the available research is based in the US or the UK, and while this may be applied to Australian conditions, the implications are not studied in detail.

Traditional behaviourist schools supported didactic learning, discouraged movement by students and relegated physical activity behaviours to outside spaces. With the rise of constructivist pedagogies and the focus on the physical and psychological wellbeing of students (Frith and Whitehouse 2009), school architecture opened to the outside to bring in natural light and ventilation (Logan et al. 2013). From early the twentieth century, the external design of schools was altered to ensure adequate sunlight and airflow in classrooms and the location of schools ensured adequate space for physical activity (Willis 2017, 2). Willis (2017) stated that educational experts of the time acknowledged the importance of physical activity and recommended dedicated space for exercise and play, both inside and outside; however, the idea that physical activity is separate from learning and should primarily be undertaken outside prevailed. These educational ideas led to school buildings with large windows surrounded by large open spaces for exercise, which differentiated them from other types of public buildings (Willis 2017).

Similar to the external schoolyard, school policies related to the building can influence the physical activity behaviours of students. For instance, if the school policies allow students to remain inside during recess in the library, computer facility, 'canteen' or classroom, they are likely to remain in sedentary behaviours (Parrish et al. 2012). School policies that limit play on the school building itself, for instance, on verandahs, steps or hard surfaces, can also influence students' physical activity behaviours (Parrish et al. 2012). The barrier of school policy is supported by Stanley, Boshoff and Dollman (2012, 47), who report that a student stated 'we are only allowed to run on the grass but we're not allowed to run around the hall, around buildings and if we do we'll get time out'.

Interior Learning Environments and the Role of the Teacher

There is a lack of research surrounding the interior design of Australian schools in general and even more so when looking at influences on physical activity behaviours. It is thought by Frith and Whitehouse (2009) that this gap is due to the quantitative focus of interior design analysis as well as budgetary limitations. These budget restrictions result in school projects where architects and designers are only contracted to design the overall building; thus, the interior fit-out and furniture selections are left to principals, teachers or facility managers (Frith and Whitehouse 2009). Since the interior is where children spend most of their school day, further focus is needed on how the interior design of learning environments influence physical activity behaviours.

Research evaluating how learning environments influenced behaviour has previously focused on the behaviour or concentration of students. For instance, Wheldall and Lam (1987) observed students with learning difficulties in traditional classrooms to identify the influence that various table arrangements have on students' concentration and disruptive behaviour. They found that when the students are sitting in rows, they spend more time in on-task behaviours, and the teacher expressed less disapproval of student behaviour (Wheldall and Lam 1987).

Martin's (2002) research, based in the UK, studied the effects learning environments have on teacher practices in both primary and secondary schools. Although students' physical activity was not a focus of the study, there are some reported relationships and influences from teacher movement. Data were collected through observations and interviews focusing on physical learning environments, pedagogy and teacher movement, which led to three key findings relevant to this project. First, Martin (2002) found a positive relationship between teachers' movement around learning environments and the density of students and believes that this is because when children do not have room to move around the room freely, they remain seated, and the teacher moves around. Second, Martin (2002) found a relationship between the space per child and teacher-focused teaching practices, where learning environments with a higher density showed more teacher-centred pedagogies, and lower density supported more student-centred pedagogies. Third, a relationship was observed between the organisation of furniture and teachers' pedagogies: 'the most "teacher-centred" classrooms are organised as circles/horseshoe. Again, this appears counter intuitive as we tend to think of circles as "inclusive", but they are really controlling. The circle could be considered as one long continuous row', which lends itself to teacher-centred pedagogies (Martin 2002, 147). These three findings are important for this project because, clearly, there are complex relationships between teachers' and students' physical activity behaviours and the learning environments they inhabit. The findings show that to improve students' physical activity behaviours, learning environments should have low student density and furniture should not be arranged in row or circle formations.

Martin's (2002) observational research discovered a relationship between the organisation of furniture and teachers pedagogies and discussed the importance of interviews to identify the environmental competence of teachers. They interviewed teachers to find out whether they change their pedagogy to suit the learning environment organisation or alter their rooms to suit their preferred pedagogy. However, Martin (2002, 152) observed some teacher behaviour that contradicted the statements those teachers made in their interviews, specifically, 'that teacher-centred teachers tended not to take into consideration their physical space when planning, contradicting their comments on how they felt that the rooms affected their teaching style'. This demonstrates the importance of the mixed-method approach.

Learning environment interior design provides spatial cues that indicate to students what behaviours are acceptable in an environment. Whitehead (2001, 130) argues that as children develop physical literacy skills, they can ‘read the environment’ to ascertain acceptable physical activity behaviours: ‘the shape and size of the spaces, the furniture, and the finishes are silent influences on the behaviour of educators and students’ (Newton and Fisher 2009, 6). Kilbourne, Scott-Webber and Kapitula (2017) discuss how the design and arrangement of an ‘activity-permissible classroom’ (which could be considered a NGLE), demonstrates to students when they enter the room that they can act differently than they would in a traditional classroom. The spatial clues include the shape of the room, the type and arrangement of furniture, the lighting and acoustic design, the colour scheme and any other design choices made. Kilbourne, Scott-Webber and Kapitula (2017) relate how the ‘activity-permissible classroom’ provides opportunities for both prompted and unprompted physical movement. Prompted movement includes when the teacher directs students towards certain activities or requests that furniture be rearranged, and unprompted movement includes students moving around to collaborate or ‘micro-movements’ on the swivel chairs (Kilbourne, Scott-Webber and Kapitula 2017). The learning environment design supports both students and the teacher having choice and power in certain situations.

Learning environments hold power, and ‘teachers draw on space to assert their authority, often through the control of movement, noise and even light in the classroom’ (McGregor 2004a, 3). Teachers’ desire to control student behaviour relates to traditional classrooms and didactic teaching methods because some teachers believed that student movement related to a lack of discipline (Woodman 2016). Through controlling rules that students must follow and the arrangement of the learning environment ‘such as furniture layouts, certain behaviours are encouraged or suppressed, which function almost invisibly to display teacher expectations and reinforce adult control of knowledge, teaching and learning’ (Fenwick 1998, 621). For instance, the circle or horseshoe table arrangement, discussed by Martin (2002), seems inclusive but actually forces a focus onto the teacher. An alternative to this is tables clustered into small groups, which can support child-centred pedagogies and collaborative work.

Furniture

Emerging evidence suggests that students’ incidental physical activity may be influenced by the furniture in learning environments (The Partnership for a Healthier

New York City 2015). Research surrounding the influence furniture has on physical activity in learning environments is still emerging, and often, it focuses on specific types of furniture such as standing desks or dynamic furniture. The terms ‘active sitting’ and ‘dynamic sitting’ are sometimes used interchangeably; however, active sitting is defined as involving a minimum of quantifiable energy expenditure, whereas dynamic sitting is when the upper body moves while the lower body remains in a seated position (van der Berg et al. 2019). In a study of adults, it was found that those who spend more time in dynamic sitting had lower BMI and smaller waist circumference (van der Berg et al. 2019). There is also emerging evidence that dynamic sitting can improve learning outcomes for students (Brittin et al. 2015).

Children naturally sit in a dynamic way by frequently shifting their posture and position (Cardon et al. 2004), and dynamic furniture can support this movement, which may increase physical activity and decrease sedentary behaviours. In a small comparative study based in a laboratory setting, Garcia et al. (2016, 557) found that children’s physical activity behaviours were significantly improved when sitting on a dynamic chair that ‘promotes micro-movement’ compared to a traditional chair. They also reported that 75% of the participants preferred to use the dynamic chair rather than the traditional chair in their own learning environment due to both comfort and enjoyment, although one child was worried about the stability of the dynamic chair (Garcia et al. 2016, 558). A larger intervention study by Cardon et al. (2004) compared a traditional classroom to a classroom referred to as a ‘moving school’, which used a variety of factors to improve physical activity, such as policy and pedagogy changes and dynamic furniture. Through observation methods, they found that students in the traditional classroom spent 92% of the time in static sitting, with only 3% in dynamic sitting, 2% standing and 3% walking; whereas students in the moving school only spent 1% in static sitting, 52% in dynamic sitting, 30% standing and 17% of the time walking (Cardon et al. 2004). Accelerometers confirmed quantitatively that the students in the intervention classroom were significantly more active, with mean physical activity of 538 (229) counts/min in the intervention classroom and 134 (94) counts/min in the traditional classroom (Cardon et al. 2004). Although both of these studies used accelerometers to record physical activity quantitatively, the published data are limited so comparisons cannot be drawn to other physical activity studies; however, the results suggest that dynamic sitting may involve more light-intensity physical activity rather than purely sedentary behaviour.

There is evidence that sit-to-stand desks and stand-biased desks can improve students' physical activity behaviours within learning environments; however, both of these furniture types have complications due to the varying heights of students. In this section, I will discuss standing desks and provide three examples of recent interventions that aimed to reduce sedentary behaviour and increase standing in classrooms using various methods. Sit-to-stand desks are those that are adjustable to varying heights where students can choose to sit with their table at standard height or can adjust the table to suit their individual standing height. This allows individual students to control the height of their individual desk as preferred but may prove a barrier to collaborative work between students due to differing tabletop heights. Stand-biased desks are fixed at a height appropriate for standing and paired with a stool for students to sit if they choose to. While these may make collaboration easier since there is a consistent table height throughout the classroom, the furniture heights may not be ideal for students falling outside the average height range (Marmot and Ucci 2015). This problem also exists for traditionally seated classrooms as there is typically one type of furniture throughout the whole class.

The height of a tabletop should be elbow height, whether the student is in a seated or standing position. Aminian, Hinckson and Stewart (2015) use the term 'height-appropriate desks'. Often standardised school furniture is based on the average height of an age group, and there are inconsistencies among available data. The average heights of children are provided by CSIRO (2012) in 'The 2007 Australian National Children's Nutrition and Physical Activity Survey—Volume Five: Physical Measures'; however, children are categorised in large age ranges: two- to three-year-olds; four- to eight-year-olds; and nine- to 13-year-olds. These categories with large age ranges do not account for the differences in the height of individual students and do not prove useful when attempting to ascertain the appropriate furniture dimensions for classrooms. The book *The Measure of Man and Woman: Human Factors in Design* (Tilley and Henry Dreyfuss Associates 2002) shows detailed measurements of each age group based on large sample sizes; however, these are based on samples from children in the US. The average heights given by the CSIRO (2012) are, on average, 50 mm higher for children aged two to 13 years old when compared to the data provided by Tilley and Henry Dreyfuss Associates (2002) and when compared to the ‘Growth Charts’ from Australasia (APEG 2020) and the US (CDC 2000). This suggests that Australian children are not taller than US children but that the large age group categories used by CSIRO may have skewed the data. There are also no current anthropometric data published on Australian children’s average elbow heights (measurement from elbow to floor while standing) or resting elbow heights (measurement from elbow to seat while seated); however, the similarity in growth charts suggest the data from the US would be appropriate to use.

The Australian Standard for educational furniture outlines the requirements of classroom furniture (Standards Australia 2020). They provide eight categories called ‘size marks’, which denote the stature of students so their heights can be matched to appropriate furniture; however, the Standard does not cite its anthropometric data source for the allocation of furniture heights in relation to size marks. When analysing the furniture heights provided by Standards Australia (2020), there are discrepancies of up to 110 mm compared to the elbow heights provided by Tilley and Henry Dreyfuss Associates (2002). For instance, the table height requirements of size marks B, D and E (those most likely to be used in primary schools) of 465 mm, 585 mm and 635 mm are, respectively, 77 mm, 110 mm and 106 mm higher than what would be recommended using the data from Tilley and Henry Dreyfuss Associates (2002). The height of standing tables is very similar when comparing the two documents. Resting elbow height (elbow height about chair) is the dimension used to determine appropriate table height (Gouvali and Boudolos 2006). The dimension given in the recommendations is 205 mm, 235 mm and 255 mm, respectively, for size marks B, D and E (Standards Australia 2020); however, the mean resting elbow heights of those students would be 147 mm, 166 mm and 168 mm, respectively (Tilley and Henry Dreyfuss Associates 2002). Thus, the resting elbow height is overestimated by between 58 mm and 87 mm, which is significant. Comparing this data is critical since table heights (both seated and standing) should be appropriate for all students to ensure comfort and correct posture. A German study found that in a case study classroom, all the desks were too high for students, ranging from 2.5 to 16 cm too high (Cardon et al. 2004, 138).

Furniture in learning environments can also influence students' physical activity behaviours through physical space and flexibility. When the density of the learning environment becomes too high, students are not able to move around between the furniture easily; however, spatial design that provides sufficient space can support incidental physical activity, as can specific physical activity programs such as active breaks (Brittin et al. 2015). Flexible furniture can also provide opportunities for teachers and students to easily alter the classroom arrangement to suit physically active behaviours (Brittin et al. 2015). Furniture available for schools can 'often stifle' design or pedagogic intent, although furniture suppliers are improving their available designs (Ty Goddard, quoted by Newton and Fisher 2009, 31).

Standing in the Classroom

There is evidence that standing desks can improve students' physical activity behaviours within learning environments. An intervention project found that students' energy expenditure significantly increased with the use of stand-biased desks, with students in the intervention class burning 17% more calories than the students in the control class when completing similar tasks (Benden et al. 2011). After becoming accustomed to the stand-biased desks over 12 weeks, '70% of the students were not using stools at all, standing 100% of the time at their primary homeroom workstation, and the other 30% were standing, on average, approximately 75% of the time' (Benden et al. 2011, 1433). Although quantitative data on sedentary behaviour were not collected in this study, it can be inferred that there was a considerable effect on sedentary behaviour because the time spent standing would likely have previously been spent sitting. The intervention is feasible for many schools as stand-biased desks, and chairs only cost 20% more than standard classroom furniture as an initial investment with no continuing costs or instructional time required (Benden et al. 2011, 1435).

Clemes et al. (2016, 2020) conducted two intervention pilot projects in Australia and the United Kingdom (UK) to study the effect of sit-to-stand desks on students' sedentary behaviour. Both interventions significantly reduced the total mean sitting time per school day (Clemes et al. 2016, 2020). As part of the first intervention, the Australian students and teachers were all provided with sit-to-stand desks and a standard chair; whereas, in the UK classroom, only six desks were replaced with sit-to-stand desks and tall stools, which students rotated around throughout each day

(Clemes et al. 2016). The UK students achieved not only lower rates of sedentary behaviour but also significantly higher step counts, which has been attributed to the increased movement around the classroom as part of the desk rotation roster (Clemes et al. 2016). The second pilot study was based solely in the UK, with eight participating schools and a stronger focus on the feasibility and acceptance of the sit-to-stand desk intervention (Clemes et al. 2020). They found that both teachers and students accepted the desks easily, and some students noted that classroom behaviour improved with the intervention (Clemes et al. 2020, 13). Clemes et al. (2020, 13) reported that the 'findings are consistent with others who have concluded that sit-stand desks can be introduced into the classroom environment without having a negative impact on student learning, behaviour, musculoskeletal comfort, or causing classroom disruption'.

Another example of an intervention study aiming to reduce sedentary behaviour is that of Aminian, Hinckson and Stewart (2015), who created a dynamic classroom with a combination of standing desks, beanbags, exercise balls and floor space. The standing desks were somewhat height adjustable, but the adjustment was not easy to achieve, so they were set up at the start of the intervention to suit students grouped by similar height (Aminian, Hinckson and Stewart 2015). Students were not provided with any chairs or stools, and exercise balls were not suitable height to use with the standing desks; however, lower desks were placed around the room that could be used when seated on beanbags or the floor. They reported improvements in students standing and sedentary behaviours from baseline to the end of the intervention and importantly noted that students did not compensate for the increased standing and reduced sitting after school hours (Aminian, Hinckson and Stewart 2015), which had been found in a previous study (Mallam et al. 2003). 'School staff were supportive of the dynamic classroom environment as it offered increased space, social interactions, happier children, and better, quicker and easier supervision'; however, the use of multiple exercise balls at once was described as 'disruptive' (Aminian, Hinckson and Stewart 2015, 643).

International Case Studies

Examples of school design that attempts to improve students' physical activity behaviours generally follow the pervasive idea that physical activity is to be conducted outside and rarely attempts to improve incidental physical activity as a specific aim. For example, Fuji Kindergarten in Japan, designed by Tezuka Architects in 2007, is a large doughnut-shaped building where the circular roof is used as a play space for the students (Gregory 2007). The school follows the Montessori pedagogy and has large open-plan learning environments and sliding windows to connect the interior and exterior environments (Gregory 2007). It has been reported that students at the Fiju Kindergarten travel eight times more than an average student (Hundred 2021), but it is unclear if this is due to the design or the pedagogy of the school.

Many examples of schools that have used innovative solutions to encourage students to be physically active seem to be those that have constraints that would have otherwise limited physical activity. For example, schools in cold climates often provide indoor play facilities to ensure students can play throughout the year.

One example of a primary school building specifically to improve the physical activity behaviours of students is the Carter G. Woodson Education Complex in Virginia, US. It was designed as a collaboration between VMDO Architects, multidisciplinary researchers and school stakeholders to improve students' overall health (Brittin 2015). Improving students' physical activity using the 'Physical Activity Design Guidelines for School Architecture' (Brittin et al. 2015) was one aim of the project, which was analysed through Brittin's (2015) doctoral thesis. The school aimed to include features that could support both MVPA and incidental physical activity and limit long bouts of sedentary behaviour. Two large indoor fitness areas and large outdoor play spaces were included in the school, with large windows used so students could view others completing MVPA (Brittin 2015). Learning environments had sufficient space with dynamic furniture to encourage increased physical activity and decreased sedentary behaviour (Brittin 2015, 88). Other elements described as 'movement temptations' such as elements to climb over and under, bright open staircases and 'animal footprints were imbedded in the terrazzo flooring for children to follow, as part of the eco-themed wayfinding system' (Brittin 2015, 88).

Quantitative research by Brittin (2015) found that the students in the Carter G. Woodson Education Complex were less sedentary and achieved more light-intensity physical activity than students in a comparison school; however, time spent in MVPA was lower. The improved sedentary behaviour and light physical activity could be explained through the large buildings and classrooms, dynamic furniture and open staircases. Brittin (2015, 116) notes that the lower time spent in MVPA could be due to the large school buildings, which often required students to use interior hallways to move between various spaces, for example, from the classroom to the canteen or playground; however, the school had a 'policy of no running in the building and "speeding tickets" for doing so'. which would have limited the opportunities students to achieve MVPA. In contrast, the comparison school had shorter distances between spaces and external pathways, which could have facilitated running in a safer manner (Brittin 2015). The findings by Brittin (2015) demonstrate the importance of the holistic approach to improving students' physical activity behaviours within learning environments, with the design of space being only one factor to be considered.

After completing the collaborative design and research project, VMDO designed Discovery Elementary, guided by the 'Physical Activity Design Guidelines for School Architecture' developed by Brittin et al. (2015). The school was designed to be multi-storey and set into the side of a slope to retain the existing external play spaces (Logan 2018). The designers utilised contemporary learning environments and provided flexible furniture and 'a variety of specialized, customizable, and flexible areas, linked by programmable open spaces and clear lines of sight' that allow and encourage movement to be incorporated into everyday learning activities (Logan 2018). Transparency between adjacent spaces is viewed as a critical element for physical activity since teachers can supervise students without being physically in the same space, which enables relaxing of school policies (Logan 2018). Although the quantitative research into students' physical activity behaviours has not been reported on for Discovery Elementary, the design is similar to Carter G. Woodson Education Complex, so it could be assumed to improve physical activity behaviours in similar ways.

Contemporary learning environments (NGLEs or ILEs) often allow students to be more physically active; however, this is rarely written about as a specific aim to improve physical activity behaviours. For example, the primary school at Mother Teresa Catholic College in the southern metropolitan region of Perth has newly constructed learning environments that support child-centred pedagogies with strong connections between interior and exterior spaces. The circular design focuses on natural lighting, heating and ventilation with a strong connection to nature through landscaping and 'nature play' (LEWA 2018). In describing the learning environments, one student was quoted as saying, 'we can choose what furniture we want to use—and we can stand up to learn or sit in different places or even lie on the floor to write if we want to' (LEWA 2018, 44). This description of learning makes it clear that students can be more physically active in the primary school learning environment compared to a traditional classroom. However, it seems to be a by-product of child-centred pedagogies rather than any specific attempt to improve students' physical activity behaviours.

The design of contemporary Australian sports facilities in schools demonstrates a wider acknowledgement that physical activity can be achieved in various ways that are often individualised, for example, the Artemis Centre at Melbourne Girls Grammar School constructed in 2017 as a 'physical performance and health centre', which includes a range of facilities for the holistic wellbeing of students (Sier 2017). The centre includes 'a 25-metre indoor pool, multi-use sports courts, a gymnasium, a spin fitness studio, consultation rooms, change facilities, classrooms, a mind and body studio, a high-energy studio, cafe space, and an administration hub' (Sier 2017). The building incorporates open staircases internally and an external landscaping component that connects the facilities to green space and the wider school campus. The variety of spaces that encourage both incidental and high-intensity physical activity promotes students' ability for choice within their movement. The school recognises the innate benefits of physical activity and the benefits to learning outcomes (MGGS 2021).

Conclusion

Increased levels of physical activity and reduced time in sedentary behaviours has many health benefits for children. Yet, a high proportion of Australian children are failing to meet the recommended levels. Further, Australia's guidelines fall below the recommendations of other countries such as the US and Canada. Schools have been identified as a critical area for intervening in children's physical activity behaviours, as most children spend a large proportion of their waking hours in school and traditionally, schools have encouraged highly sedentary behaviour. Many studies have focused on school environments to understand how students' physical activity behaviours can be improved with a central focus on CBPA or standing desk interventions. A broad range of research is available on how the built environment influences physical activity behaviours; however, this research often focuses on adults or large-scale urban design, such as neighbourhood walkability. Strong evidence is needed to support research that focuses on the influence of school architectural environments on the physical activity behaviours of Australian children. Emerging evidence suggests that the physical, social and organisational aspects of learning environments need to be considered in health promotion research. There is currently inconclusive evidence to support the notion that non-traditional learning environments improve students' physical activity behaviours. This research project asks the question: how does the architecture of non-traditional primary schools influence the physical activity behaviours of children at school?

4. How to Understand Students' Behaviours in Learning Environments

This project applied a case study methodology with a mixed-method approach to investigate how the architectural design of the learning environment influences the physical activity behaviours of Australian primary school students (see Figure 4.1). Considering issues such as age, consent and environmental awareness in studies of students in schools, this chapter proposes a case study methodology with a mixed-methods approach as a solution to obtain a reliable and detailed understanding of the multifaceted problem influencing students' physical activity in learning environments. A single case study was used with qualitative and quantitative data collected by architectural analysis, ethnographic observation, interviews with participating teachers and quantitative recordings of students' physical activity behaviour. The additional data collection method of interviews with architects included one with the architect of the case study school to provide contextual information about the school and other interviews with WA architects with extensive experience in school design (and no relationship to the case study school). This chapter opens with a discussion of the overarching case study methodology, followed by an outline of the methods used to collect the qualitative and quantitative data. The chapter ends with a discussion of the data analysis methods, including quantitative analysis, thematic analysis and triangulation.

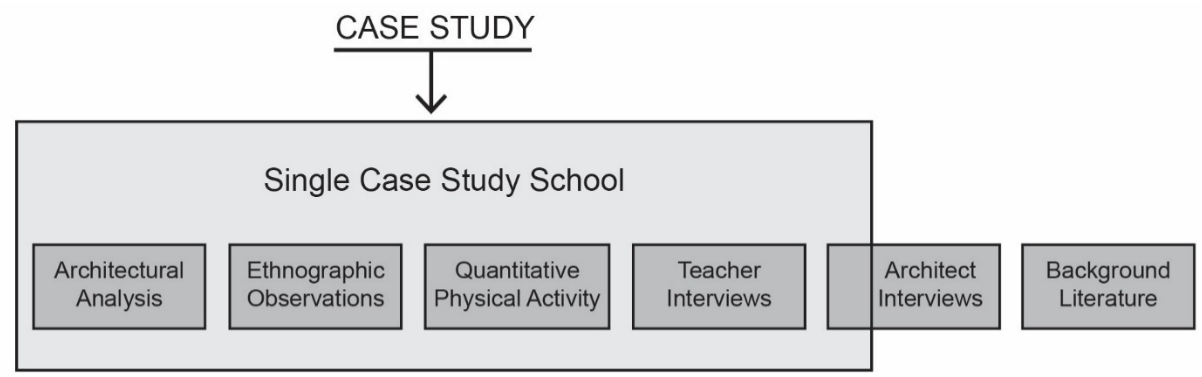


Figure 4.1 Methodology structure diagram.

Case Study Methodology

This project uses a case study methodology with a single school focusing on the influence architectural design has on the physical activity behaviours of students. As an expert on case study methodology, Yin (2018, 15) defines case study research as 'an empirical method that investigates a contemporary phenomenon (the "case") in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident'. However, Groat and Wang (2013, 418) highlight that in architectural research, the setting of the case study is a critical focal point for enquiry. Thus, they revise Yin's definition and state that an architectural case study is 'an empirical inquiry that investigates a phenomenon or setting' (Groat and Wang 2013, 418). Both definitions are useful for this project due to its multidisciplinary nature. I focus on the architectural setting of the case study as outlined by Groat and Wang (2013) while also investigating students' physical activity behaviours, which more closely aligns with Yin (2018). Yin (2018) differentiates between the three different terms used within case study research: first, case study methodology, which is the overarching research framework; second, case studies as a research method; and third, the case, which is the individual focus of inquiry. Yin (2018) also discusses the common use of the term 'case studies' to describe non-academic research. In the field of architecture, the term 'case study' is often used to describe a precedent study and is 'sometimes used even just as a synonym for an "example"' (Sarvimaeki 2013, 338). Precedent studies are not as rigorous as a genuine case study research project, but they are an essential aspect of the architectural design process.

In this research project, the case study methodology is the overarching framework that guides the research decisions. The case study methodology was chosen because no two schools are the same, so drawing generalisations about the architectural influences on the physical activity behaviours of students in all Australian schools is not possible within the scope of this project. Thus, the primary school chosen for this case study does not act as an average example or an example of what Yin (2018, 38) refers to as 'like cases'. The single case study primary school acts as an instrumental case study. As defined by Stake (1995), an instrumental case study is one where a broad issue is being studied through a single instance of that issue. This differs from an intrinsic case study where the individual case is fundamental to the question itself or of particular interest (Stake 1995). So as an instrumental case study, the primary school studied in this research project is the focus, but it is just one instance of learning environments that influence students' physical activity behaviours.

Research focusing on a single case study provides scope to understand and analyse that particular school in depth, which also leads to theory building and provides information for further research. As Yin (2018) explains, the detailed understanding of a single case study leads to analytic generalisations through the development of theory through analysis. This is different from statistical generalisations that can be drawn from research where the research uses a sample of the population. So, although the focus of the research is on the single case study primary school, the lessons learned and theories developed apply to other learning environments for further testing and theory building. The single case study is the place the data was collected from, but the reflections and analysis relate to broader ideas of students' physical activity behaviours and the architectural design of learning environments. Although only a single case study is used, there is also a comparative element to the research because three classrooms spanning various student age groups were used. The school was first studied as a whole before each of the three classrooms was studied separately.

The overarching aim of the research project is to develop grounded theory based on a single case study that can prove useful to the design of future learning environments to improve students' physical activity behaviours. However, Groat and Wang (2013, 430) argue that 'too great a focus on generalizing to theory can obscure the intrinsic value and uniqueness that each case can offer on its own terms'. In this research, I recognise the importance of the single primary school that acts as the case study while also acknowledging the possible future effects for broader school communities. As each school environment is unique, due to history, location, management, teachers, architectural design and students, among other factors, no particular school can be seen as a typical WA primary school. Thus, random sampling was not used to select the case study. Gebel et al. (2015, 298) relates that 'as randomization is virtually impossible to achieve in this research field, there have been calls for more opportunistic evaluations of environmental interventions'. A single Montessori primary school in Perth, WA, was selected because the principal self-nominated the school due to their particular interest in understanding the students' physical activity behaviours, as movement is a crucial aspect of the Montessori pedagogy. Opportunistically, the Montessori case study school provides relevance to NGLEs as the pedagogy and spatial arrangements are similar in both types of learning environments. Due to time and resource limitations, including lengthy delays in approval processes, it was not feasible to study multiple schools for this research project.

Mixed-Method Approach

The chosen methodology and methods allow me to understand and analyse the complexities of the case study school in detail through both a qualitative and a quantitative lens. The importance of the combination of carefully selected qualitative and quantitative observational methods is outlined by Wragg (2013). They discuss how the positivist approach of quantitative observation is helpful to collect data on frequencies of events in the classroom while the qualitative approach allows the observer to discern the 'significance, meaning, impact, individual or collective interpretation of events' (Wragg 2013, 9). Thus, in this project, qualitative data such as my observations and interviews provide context to the quantitative data collected to allow me to understand and then analyse the complex relationship in depth. The mixed-method approach is becoming more common within health-focused fields. The value of qualitative analysis to provide context and meaning is now more widely accepted (Castleberry and Nolen 2018). The analysis is undertaken following a mixed-method approach with quantitative analysis, thematic analysis and triangulation, which together builds grounded theory informed by the social ecologic model. As it is not yet known how the architectural environment influences the physical activity behaviours of students in the case study, the data are collected before grounded theory is inductively derived.

Mixed-Method Data Collection

Qualitative data were collected through ethnographic observation of students and school environments as well as interviews with teachers and architects. In contrast, quantitative data were collected on students' physical activity behaviours within school environments using accelerometers (see Figure 4.2). Some aspects of the architectural and physical activity observations also provide quantitative data, with information recorded on the dimensions of the learning environments and the number of students present within the learning environments. Denzin and Lincoln (2000, 5) discuss the nature of qualitative research as 'inherently multi-method' focused due to the endeavour to understand the phenomenon in great depth. The benefit of the mixed-method approach is that quantitative methods allow measurements of behaviours in terms of 'amount, intensity or frequency', whereas qualitative methods allow for analysis of the meanings and contexts of these behaviours (Denzin and Lincoln 2000, 8). Therefore, I collected quantitative data on students' physical activity behaviours within the case study school while also observing these behaviours to understand the reasons behind the behaviours and the architectural influences. This mixed-method approach provides a comprehensive understanding of the phenomena being investigated (Given 2008).

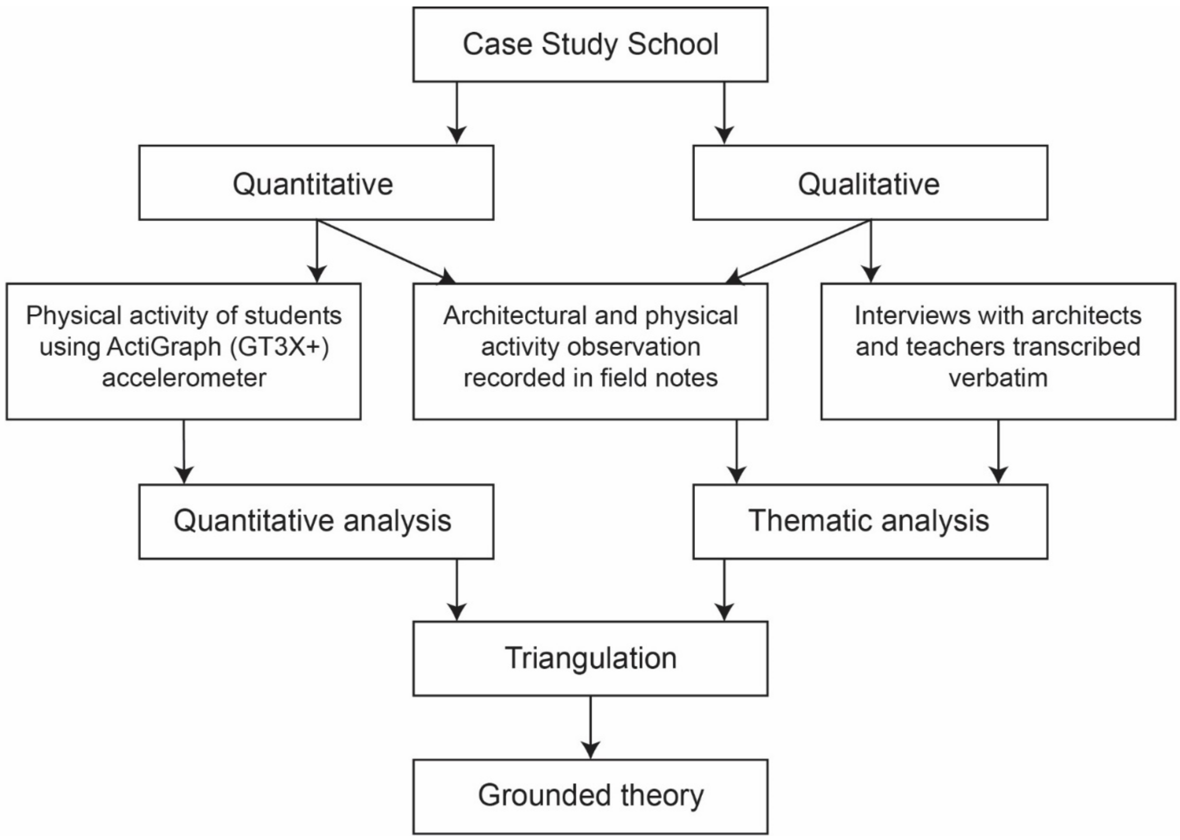


Figure 4.2 Outline of data collection and analysis methods.

Mixed-Method Data Analysis

The analysis of the collected data followed an ethnographic mixed-method approach, with each set of data analysed individually before being brought together and analysed using triangulation (see Figure 4.2). The mixed-methods analysis allowed me to use the variety of data collected to look for trends in physical activity behaviours and links to themes within qualitative data. As previously discussed, quantitative data were analysed first to ascertain significant differences between participating classrooms and highlight trends in physical activity behaviours. Qualitative data were then investigated using thematic analysis to establish patterns in observations and interviews. Themes were organised using the social ecologic model as the theoretical framework so data was grouped according to personal, physical, social and organisational factors influencing the physical activity behaviours of students. The thematic analysis process is discussed in more depth later in this chapter. Last, the quantitative and qualitative data were brought together through triangulation to allow manual analysis and identify elements of the school architectural design that influence students' physical activity behaviours. This data triangulation may reveal 'converging results, complementary results, and contradictions' (Flick 2014, 189). The theories developed from the combined data analysis are the beginnings of grounded theory.

Architectural Data Collection and Analysis

Recruitment at the Case Study School

Once the school agreed to participate in the study, the school principal was asked to nominate three classrooms, one each in lower, middle and upper primary, to provide a spread of age groups among participating students. The teachers in the nominated classrooms were invited to participate in the study, and after signing an informed consent form, they were asked to provide all students in their class with parental/guardian informed consent forms (see Appendix 10.2). In addition, upper primary students were provided with a student informed consent form since they were considered old enough to provide consent alongside their parent/guardian.

Architectural Data Collection

The case study primary school was analysed in detail through multiple site visits. Dalgamoni (2014) discusses the notion of the site as a relationship between the physical location of a place with the people, nature, culture and sensory factors over time. A 'site' can be defined as a combination of physical and spatial properties, where the physical properties focus on obvious aspects while 'spatial variables link a site to the surrounding context' (Dalgamoni 2014, 16). Burns and Kahn (2004) discuss the theoretical issues of site analysis in their edited book *Site Matters: Design Concepts, Histories, and Strategies.* For architects, a site is considered a legal boundary where a building is located, which can lead to tangible factors being the focus of analysis. Intangible factors and the effects the site or design itself may have on external factors outside this boundary may be forgotten (Burns and Kahn 2004). The identity of a place cannot be fully understood without analysing the broader context of a site (Massey 1994). So, the concept of a site must be analysed at different scales to take into account not only the site itself but also the surrounding context—often referred to by architects as contextual analysis. Most architectural texts discuss site analysis in relation to pre-design processes; however, the methods used for site analysis before the design and construction of an architectural project are the same as those used to analyse a completed project. Burns and Kahn (2004) categorise the site into three aspects. The first is the legal site boundaries, often owned or controlled by the client. This is the most common definition of 'site' and the one used in this thesis. The second aspect is factors outside these boundaries that affect the site, and the third aspect is the realms influenced after the design outcomes are realised on the site (Burns and Kahn 2004). In this thesis, the second and third factors are referred to as 'context'.

White (1983) outlines the critical factors for site analysis: location, neighbourhood context, size and zoning, legal issues, natural physical features, artificial features, circulation, utilities, sensory, human and cultural and climate. The architect or architectural researcher usually decides which issues hold the most importance, depending on the particular site, and therefore focuses their time more strongly on specific issues more than others. For example, in this project, I focus my analysis on case study learning environments and the main amenities for children with very little focus on staff facilities. I record both 'hard' and 'soft' data. White (1983, 16) describes 'hard data' as those that 'involve no judgements about their existence or nature', such as physical buildings, whereas 'soft data may involve some value judgements' by the architect such as sensory influences or how a space feels. Site analysis was achieved through a variety of sources, including external sources such as maps, aerial photography, reports and statistics, as well as personal data collection and direct observation onsite through sketching, drawing, diagramming, measuring, photographing and taking field notes (White 1983).

Generally, architects and designers must experience the site for themselves to understand the complexities of the design through observation, participation and recordings. Site analysis was not completed merely to document the site but also to analyse the site critically to understand the various levels of complexity at play within the site itself and how it links to the larger community. Primary schools are more than a collection of classrooms; they are influenced by design, materials, orientation, layout, vegetation, climate, people and managerial factors. All schools also exist as part of a larger community of parents, neighbours and local people. Additionally, the environment of the surroundings also affects the school through urban design, road networks and natural resources such as parks and water sources.

Many architects have their own methods of recording and analysing during site visits, but most stem from methods prevalent in site analysis in recent decades, as outlined by Dalgamoni (2014). These include the technical method by Lynch and Hack (1984), and the context-sensitive method by LaGro (2008). In this project, I used a method of site analysis that sits most closely with the technical method of Lynch and Hack (1984) but also considers the importance of the site, as outlined by LaGro (2008). The technical method includes site visits, an analysis of site history, a systematic survey of relevant data and data synthesis (Lynch and Hack 1984). The importance of context is discussed by Lynch and Hack (1984); however, it is not a key component of their systematic stages of analysis as it is in LaGro's (2008) methods.

For this study, I recorded objective and subjective elements through drawing while also reflectively note-taking. Drawings include architectural representations such as plans, sections, elevations, maps and diagrams, as well as other visual methods such as photos and sketches. Drawings and notes record the physical aspects of the building and my observations and subjective analysis within the school. The case study school was first analysed broadly as a whole campus through the lens of spatial typology, orientation, design, materials, topography, sightlines, use and landscaping. Participating classrooms were studied in further detail using both objective and subjective measures. Objective measures include fixed dimensions of space, windows, doors, furniture and distance to amenities, as well as notation of lighting, ventilation, materials, colours, layout, orientation and landscaping. Subjective analysis includes the appropriateness of the objective measures and the design of the school, the use of space and the atmosphere of the school and classrooms. The subjective analysis recorded was based on my educated opinions as a graduate with a Master of Architecture and informed by an interview with the architect who designed the case study school. Similar subjective and objective observational methods have been used by other architectural researchers; for instance, Newton (2016) used similar mixed methods in their project focusing on learning environments and school buildings. Spatial syntax methods are often used within architectural analysis to obtain quantitative data of buildings (see for instance McLane 2013); however, due to the detailed observations undertaken in this project, it was deemed that the spatial syntax methods were unnecessary. The mixed-method investigation using both objective and subjective analysis allowed me to analyse the case study school to understand how it fits within the local community and how it influences its users.

The design of the school was categorised using spatial typologies, which were broadly outlined by Purves (1982) and discussed more specifically for school design by Fisher and Dovey (2016). Spatial typologies specific to schools include classrooms, commons, streetscapes, meeting areas, fixed-function rooms and outdoor learning (Fisher and Dovey 2016). These spatial typologies were further outlined in Chapter Two. Architectural site analysis links to ethnographic methods, as everyone analyses a site differently depending on a multitude of factors.

Architectural Data Analysis

The qualitative data collected from the school were analysed using thematic analysis, which will be outlined later in this chapter after the discussion of ethnographic observations. The quantitative data collected from the school architectural design were analysed using Microsoft Excel to identify space per student and the dimensions of materials within each participating classroom.

Physical Activity Data Collection and Analysis

Quantitative Physical Activity Data Collection

Accelerometers were used to collect quantitative data to describe the current physical activity behaviours of participating students. ActiGraph (GT3X+) accelerometers are a small device on an elastic strap that sits around the waist on the outside of clothing, with the device positioned above the right hip. They record data such as intensity, duration and frequency of physical activity and sedentary behaviour as well as step counts (ActiGraph 2021). Accelerometers are a relatively non-invasive form of movement tracking since they are worn around the waist and are thought not to affect physical activity levels, as wearers tend to forget they are collecting data (Janz 1993). Other forms of physical activity data collection, such as those worn on the wrist, can provide the wearer with feedback and may affect physical activity levels (de Vries et al. 2006), which was not desired for this project. There are many different physical activity monitoring devices available, but the ActiGraph accelerometer used in this research is the most commonly used with children (Trost 2007). ActiGraph accelerometers have a large amount of research supporting the reproducibility of physical activity data for children aged four to 18 (de Vries et al. 2006). The objective data collected with the accelerometer are reliable and considered strong evidence, with the intraclass correlation coefficient ranging from 0.31 to 0.87 and showing improved reliability with additional days of data collection (de Vries et al. 2006). Accelerometers are more invasive than other data collection methods such as self-recall surveys, but due to the young age of the participating children, it is unlikely that accurate quantitative data on physical activity behaviours could be collected with other methods (Welk, Corbin and Dale 2000).

Similar to the research project by Martin (2010), no data collection in the case study school took place during the first or last weeks of term or during July due to non-habitual behaviour and heavy rainfall, respectively. Any disruptive activity during the school day, such as swimming lessons or excursions, are thought to influence the behaviours of the students. Therefore, this project did not collect data on students whose day has been disrupted by school activities or extreme weather, as it may not be habitual data.

All participating students were asked to record accelerometer data for 10 school days, generally beginning with the start of my five-day observation period. Before the data collection of each classroom, I demonstrated how to use the clip on the elastic strap to attach and remove the accelerometer and how to position it on the waist above the right hip. I advised teachers to remind students to attach the accelerometer each morning and remove it before leaving class each afternoon. Dollman et al. (2009) argue that habitual physical activity behaviours can be captured in one week, but many projects use different data collection time frames. Ojiambo et al. (2011) state that the suggested number of days required to record children's physical activity behaviours through accelerometry reliably was previously three to five days, but they now believe it should be at least six hours per day for seven to nine days to obtain habitual data. Chinapaw et al. (2014) recommend that at least six days of data are required to characterise children's sedentary behaviour adequately. For this project, I recorded students' physical activity behaviours for 10 school days, and due to the small numbers of participating students, I included within the statistical analysis data of any student who recorded four or more valid days.

Quantitative Physical Activity Data Analysis

Analysis of quantitative physical activity data, collected via accelerometers, relies on a rigorous and detailed data reduction process. Accurate analysis of data gathered from accelerometers relies on four key decisions during the data reduction process: cut points for intensity of movement, epoch length, definition of wear time and definition of a valid day. These data reduction decisions are important to ensure that the recorded data represent 'usual' physical activity behaviours of students.

Cut Points

Cut points are the thresholds of activity intensity used to differentiate various levels of sedentary behaviour and physical activity. This study used the cut points outlined by Evenson et al. (2008), which include behaviour counts per minute of 0 to 100 as sedentary, 101 to 2,296 as light, 2,297 to 4,011 as moderate and more than 4,012 as vigorous. These cut points are recommended for use by Trost et al. (2011) as ideal for recording children's behaviour across all intensity levels. Of five widely used cut point sets tested, only the Evenson et al. (2008) 'cut points exhibited acceptable levels of classification accuracy for all four levels of physical activity intensity' (Trost et al. 2011, 1366) for all ages of children.

Epoch Length

The Evenson et al. (2008) cut points are calibrated using 15-second epoch length, which was used for this project. Epoch length is the time allocated to sum activity counts, so for 15-second epoch length, all activity measured during each 15-second interval is summed and converted into an intensity of activity. While a one-minute epoch is most commonly used in physical activity interventions (Cain et al. 2013), it is thought to be less accurate when recording the activity of children due to their sporadic movements, which change more frequently (McClain et al. 2008; Nilsson et al. 2001). Banda (2016) discusses the common practice of converting validated analysis algorithms to suit various cut points and epoch length: ‘for example, the [sedentary behaviour] activity cut point of 100 counts/60-second epoch is sometimes converted to 50 counts/30-second epoch or 25 counts/15-second epoch’ (Banda et al. 2016, 2). While this may seem satisfactory, it is not known how this conversion affects the final data set. Therefore, this project uses only the validated cut points and epoch lengths, as outlined above.

Wear Time

Wear time is calculated by removing non-wear time from data; however, various studies use different definitions of non-wear time. Non-wear time is generally referred to as ‘zero counts’, as the accelerometer has no data counts while it is stationary. Cooper (2015, 2) defined non-wear time as 60 consecutive minutes of zero counts tolerating for two minutes of ‘non-zero interruptions’, whereas van Cauwenberghe (2011) defined it as only 10 consecutive minutes of zero counts. As related by Zhou et al. (2015), these time frames can be arbitrary, but it is important to identify non-wear time correctly, as misclassification can lead to errors within the results. As this project only records students during school hours, absenteeism and withdrawal of consent are the only anticipated reasons for non-wear time. During observation, non-wear time was recorded by the researcher and the teachers were requested to note non-wear time on non-observation days; however, the teachers did not note down lateness or early departure. Data were also screened for 60 minutes of consecutive zero counts with one-minute interruptions, as outlined by Evenson and Terry (2009) and recommended by Chinapaw et al. (2014). The interruptions in consecutive zero data are referred to as ‘spurious data’ and are thought to be the movement of the accelerometer during non-wear time (Evenson and Terry 2009). Any data found to have these periods of non-wear time were removed from the analysis.

Valid Day

A valid day of data collection is the minimum number of hours per day that are needed to illustrate the physical activity behaviours of participants. Various studies use different definitions of a valid day in the data reduction process, which can create difficulties in comparing studies. Studies that record all waking hours of children’s activity commonly define a valid day as eight or 10 hours (Cain et al. 2013). Chinapaw et al. (2014) suggest eight hours is ideal. This study recorded an average of six hours per day, so the 75% ratio of time as recommended by Van Der Ploeg et al. (2010) was used. Therefore, a valid day is defined as four and a half hours of wear time. However, this was reduced to three hours for students who are part time and attend school for an average of four and a half hours per day.

Bouts of Sedentary Behaviour

A bout of sedentary behaviour is generally 'defined as a period of at least 10 consecutive minutes < 100 counts' (Chinapaw et al. 2014, 2). As discussed in Chapter Three, many studies discuss the health implications of prolonged bouts of sedentary behaviour but often discuss it in vague terms without a clear definition. Other studies differ in their definition of a prolonged bout of sedentary behaviour. Thorp et al. (2012) defined a prolonged bout as more than 20 minutes and more than 30 minutes due to differing research findings and health guidelines. However, Diaz et al. (2019) provide the most comprehensive definitions of sedentary bouts and define a short bout as between one and 29 minutes, a moderate bout as between 30 and 59 minutes, and a prolonged bout as more than 60 minutes. To follow the generally accepted sedentary bout definition by Chinapaw et al. (2014), in this project, I define a short bout as between 10 to 29 minutes, with moderate and prolonged bouts following the recommendations by Diaz et al. (2019).

Data Analysis Software

After collecting quantitative data from ActiGraph (GT3X+) accelerometers, the digital data were processed through three software programs. The data were downloaded using ActiLife software (version 6.12.1) and exported in .agd format. The .agd file was reopened in ActiLife for data manipulation, as per the criteria outlined above before being exported in .csv format. The .csv file was opened in Microsoft Excel software to be checked for formatting errors and exported as .xlxs format. IBM SPSS Statistics (version 25 and 27) software was then used to calculate mean time and percentages of time spent in different intensities of activity; mean and maximum average lengths of sedentary bouts; mean step counts per day and per minute; and comparisons of these by sex. The calculations are imported into Microsoft Excel for summary, graphing and analysis.

Quantitative Data Analysis

The quantitative data from the accelerometers describe the mean physical activity behaviours of participating students. The data were first tested for normal distribution using Skewness and Kurtosis tests. Data were then analysed using paired sample t-tests to ascertain if there were statistically significant differences in participants' mean physical activity behaviours during periods of observation or non-observation. Independent sample t-tests were conducted to identify if participants' mean physical activity behaviours significantly differed by sex. Data from each class were analysed using paired sample t-tests to identify if the mean physical activity behaviours of the participants in the three classes significantly differed when comparing morning to afternoon times and comparing class time to recess time. Analysis of variance tests were conducted to compare the participants' mean physical activity behaviours across the three classes.

Collection and Analysis of Ethnographic Observations and Interviews

Ethnographic Observations of Classrooms

This project used ethnographic observational methods to study the influence architectural design of learning environments has on the physical activity behaviours of students. 'Ethnography is the art and science of describing a group or culture' (Given 2008, 288); therefore, ethnographic research studies people, their views, behaviour and settings, using experience in the field to understand the group through observations and interviews comprehensively (Given 2008; Reeves, Kuper and Hodges 2008). Ethnography is a form of social science that has a long history of incorporating qualitative and quantitative methods (Hammersley and Atkinson 2007), which complements a mixed-methods approach. Ethnographers must first observe what the people are doing before attempting to understand why they are behaving in that manner (Hammersley and Atkinson 2007). As there is limited research on the physical activity behaviours of children in Perth primary schools, I first needed to observe what the children were doing and collect detailed description, which is often referred to as 'thick description'. Bryman (2004, 544) notes that thick description is a 'detailed account of a social setting that can form the basis for the creation of general statements about a culture and its significance in people's social lives'. I was able to combine all data collected to finally analyse why children behave in specific ways and ascertain how this might be influenced by the architectural design of the learning environments.

A form of ethnography referred to as 'naturalism', proposes that the researcher should, without interfering, study people in their 'natural' spaces, for instance, the spaces they occupy (Hammersley and Atkinson 2007). The benefit of naturalism in this project is that I was attempting to better understand how the spaces children occupy at school influence their behaviour; therefore, the observation cannot be disconnected from the school environment. However, as the main method of ethnographic data collection is in-person observations and interviews, it is impossible not to influence the participants' lives as the mere presence of a researcher can affect behaviour. A more appropriate form of ethnography for this project is reflexivity, as it acknowledges the researcher's role in studying, analysing and writing the research (O'Reilly 2009). Therefore, I reflected critically on my own role within the research and how my own interpretations affect the data and analysis.

Ethnography generally focuses on a small number of case studies so that each one can be studied in depth (Reeves, Kuper and Hodges 2008). I used ethnographic methods with fieldwork as the primary data gathering source in a single case study primary school. The process of observation in fieldwork becomes data through field notes, drawings, photos, videos and reports. These data were collected on a variety of observed elements, including spaces, people, activities and feelings. Interviews are an important part of ethnographic research and usually take the form of casual conversations as well as more structured interviews with a specific agenda (Given 2008). However, due to the age of the children and a desire to minimise the influence on behaviour and limit disruption on learning, I did not conduct casual conversations or formal interviews with students. Some students and teachers did provide comments or ask questions during the observation period, but these were not prompted. Ethnographic methods allow me to use my own observations and personal understanding of the data to provide in-depth evaluation. I used ethnographic observation as a way to bridge the gap between the architectural and physical activity data collected from the case study school, and through the use of the social ecologic theoretical framework, I was able to analyse the complexities within the relationship between school environments and students' physical activity behaviours.

Ethnographic observation was a key method used in this project. My observation style moved between being a complete observer and being an observer-as-participant (Denzin and Lincoln 2000). The role of a 'complete observer (no interaction between the observer and the observed) [… is] to remain relatively nonobtrusive and to not disrupt the normal flow of activities' (Given 2008, 574); however, when the situation arose, I acted as a minor participant in the classroom through informal discussions. Angrosino and Mays de Perez (2000, 677) discuss how the role of observer-as-participant is 'to interact casually and nondirectively', and the authors note that this is of particular importance in observation of classroom environments. Wragg (2013) and King (1984) discuss the complications of acting as a complete observer within a classroom due to students attempting to treat the researcher as a teacher through asking questions or for assistance. As recommended by King (1984), I referred questions from students to the teacher and only engaged with students in informal discussions about their physical activity behaviours when the situation arose. I did not prompt any informal discussions with students, and most students seemed to ignore my presence within the classroom during observation. Any relevant discussions are recorded in field notes, but not audio-recorded. Similarly, I did not act as a complete participant due to the nature of primary school education, as I cannot take on the role of either a teacher or student.

Friedrichs and Ludtke (1975, 4) discuss one of the benefits of ethnographic observation as it 'avoids the discrepancy between real and verbal behaviour', which is particularly problematic in interviews where the participant may say one thing but behave in another way. As Hays and Singh (2012, 226) put it, observations in research determine 'what people do rather than what they say they do'. Observation also allows the researcher to observe behaviours participants may not be willing to discuss or may not be aware of (Hays and Singh 2012). For example, a student may not be aware that their physical activity is influenced by the placement of a staircase, so an interview or questionnaire would not capture this, whereas observation could. The observation in this research project aims to capture data on what physical activity behaviours are carried out when students are interacting with or influenced by certain architectural elements.

The observation was conducted for five school days within each classroom, which is considered by Wragg (2013) as sufficient to collect habitual behaviour. If only singular lessons are observed, students and teachers 'may attempt to provide what they think the visitor expects, and this will vary according to the impression or stereotype they form of the observer concerned' (Wragg 2013, 15). As recommended by King (1984), after their extensive observations in classrooms, I initially scheduled a short 30- to 60-minute visit to each classroom during which I did not take any notes to allow the students and teachers to observe me and feel at ease before beginning my observations the following day or week. This process aims to ensure the students' behaviour is normal and not influenced by my presence in the room. This was also achieved by collecting quantitative physical activity data for the week of observation plus an additional week with no observation, which is discussed in further detail below.

Ethnographic observations within the participating classrooms allow for temporal changes to be captured in field notes. Movement path diagrams are used at various times during the observation periods to identify areas of the classroom design that allow students to be physically active and those areas that promote sedentary behaviours.

While developed methods of physical activity observation exist, such as the System for Observing Play and Leisure Activity in Youth (SOPLAY) (McKenzie et al. 2000) and System for Observing Fitness Instruction Time (SOFIT) (McKenzie, Sallis and Nader 1992), they are objective measures and often used to collect quantitative data. This form of structured data collection was not required in this project, as accelerometers were used to collect this data. Instead, I used ethnographic methods to observe the students' physical activity behaviours, particularly focusing on interactions with the built environment. The observation allowed me to note where students were going when they were moving between various destination points such as water fountains, bathrooms or other resources within the classroom and school. The recording also included observations of what architectural elements students were interacting with when involved in various levels of physical activity behaviours. For example, if stairs were used during vigorous physical activity or as a seat during sedentary behaviour. While my observation focused on the physical activity behaviours of students, I also noted teachers actions in creating barriers or facilitators to student movement. These ethnographic observations were recorded using field notes, drawing, mapping and photography to accurately record observations and learning environments through thick description (Bryman 2004).

Field notes were both descriptive and reflective. Descriptive field notes document the environments, participants' activities and behaviours and summaries of conversations (Bogdan and Bilken 2007). Reflective field notes record the researcher's impressions, thoughts, assumptions and ideas (Bogdan and Bilken 2007). King (1984) recalls that during their own observation of classrooms, they would observe and analyse actions simultaneously as they occurred and record both in field notes. Similarly, I recorded both descriptive and reflective field notes concurrently throughout the research process before finally completing in-depth analysis after all data were collected. Shiflett (2008 quoted in Hays and Singh 2012) outlines similar methods of collecting observational and reflective field notes and then further reflecting on the activities observed later. These additional personal reflections, often referred to as 'memos' (Corbin and Strauss 2008), are usually written after field notes, as part of the initial stages of analysis and continue throughout and after the observation period. The purpose of memos is to explore the data, identify categories, provide comparisons and explore the relationships between the variables being researched (Corbin and Strauss 2008). During this project, the memos also included my thoughts on the effects of my presence and any personal bias identified within the observation. Ezzy (2002, 61) discusses the importance of simultaneously collecting and analysing data, as it 'builds on the strengths of qualitative methods as an inductive method for building theory and interpretations from the perspective of the people being studied'. Thus, the later stages of the research project can be influenced by initial analysis and lead to the beginnings of grounded theory. Ezzy (2002, 3) notes that 'qualitative research methods are particularly good at examining and developing theories that deal with the role of meanings and interpretations'. In this project, these meanings and interpretations were discovered through manual thematic analysis, which is discussed further below.

Ethnographic Observations of Teaching and Learning

To understand the complex issues that may influence the physical activity behaviours of students in the case study school, data were collected on the policy and management of teaching and learning in the school. These data were collected through observation and interviews at the participating school. This included recording the teaching style or pedagogy, including the incorporation of any physically active lessons. Class timetables and classroom organisation were also recorded to ascertain if students work in a single multifunctional room or whether they move around between specialised classrooms. The organisation of classrooms and timetables can provide context to the physical activity behaviours of students during class time. Donnelly and Lambourne (2011) discuss the possible effects of physical activity on academic achievement, but this falls outside the scope of this project, so no data were collected on specific educational outcomes.

Interviews

Semi-structured interviews were conducted with two participating teachers and three architects who have designed WA primary schools. The interview questions aim to ascertain the interviewees' opinions of the physical activity behaviours of children and how the design of the learning environments influences these behaviours. The teachers provide context to the observed behaviours of students and provide information not experienced during the observation period. The architects provide information on the current architectural practice to ascertain the design process of primary schools in WA. Together, the interviews with the teachers and architects portray the use and design of learning environments.

Smith (1995, 20) defines a semi-structured interview as one in which 'the investigator will have a set of questions on an interview schedule but the interview will be guided by the schedule rather than be dictated by it'. The main benefit of semi-structured over formal interviews or surveys is that the researcher can be flexible with questions (Smith 1995). For example, if the interviewee reveals an interesting or surprising answer, the researcher is able to enter into in-depth discussion and ask further questions that may not have been considered previously. Semi-structured interviews provide rich data that reveal 'participants' thoughts, feelings, intentions, and actions as well as context and structure', which may be hidden during other data collection methods (Charmaz 2008). Ogden and Cornwell (2010) discuss other factors contributing to the richness of data from semi-structured interviews, such as response length, personal insights and degree of analysis. Rowley (2012) states that six to eight interviews of one-hour duration are ideal for semi-structured interviews or until saturation is reached. In this project, I conducted a total of five interviews, with interviews with teachers lasting for roughly half an hour each and interviews with architects lasting for roughly one hour each. The lower number of interviews is because the interview data were not required as a critical source of original data but only used to provide context or further detail to the other findings.

The teachers of the three classes who were nominated by the case study school were invited to participate in a semi-structured interview after the observation period to ascertain their opinions of physical activity behaviours of children and how the design of the learning environments influences these behaviours. Two participating teachers agreed to undertake interviews, with the third teacher not participating due to staffing changes at the school. These interviews were scheduled after accelerometer data collection to allow for ethnographic observations to inform interview questions. The questions asked aimed to collect data on the teachers' current and past experiences within schools before discussing their understanding of barriers and facilitators to improving students' physical activity behaviours while lowering sedentary behaviour (see Appendix 10.3). The teachers were seen as a valuable source of information for this study, as they spend a considerable amount of time with their students and could provide information not experienced during my observation period.

WA architects who have designed completed primary schools were invited to participate in the project through semi-structured interviews to ascertain the opinions of architects on physical activity behaviours of children and how this forms (or does not form) part of their design process. Architects were selected for participation based on the level and history of their experience or their unique knowledge relevant to primary schools in Perth. For instance, the architect who designed the case study school was invited to participate as an interviewee due to their unique knowledge. Other architects invited to participate included those with a long history of designing primary schools (at least five schools) in Perth. Three architects were contacted via email and provided with informed consent forms (see Appendix 10.2), and all agreed to participate as interviewees. The questions asked aimed to collect data on current practice to ascertain methods of primary school design in WA and considerations of physical activity behaviours. Interviews opened with questions about the level of experience the architect had in primary school design before asking more in-depth questions about their design process and opinions in relation to students' physical activity behaviours (see Appendix 10.4). The architects were seen as a valuable source of information for the design, construction, occupation and evaluation of schools, which is not widely available in current literature.

All semi-structured interviews were audio-recorded and transcribed verbatim by the researcher before analysis. The first two interviews were transcribed prior to continuing with the remaining interviews because, as Ezzy (2002) discusses, this can provide valuable information, and it allows for initial reflection and analysis that can inform future interviews. Interviews were analysed using qualitative methods, rather than merely coding into quantitative categories, as the researcher can bring their own knowledge and therefore understand more complex issues (Smith 1995).

Thematic Analysis

The thematic analysis process used in this project can be broken down into five overlapping stages: compiling, disassembling, reassembling, interpreting and concluding, as described in the text *Qualitative Research from Start to Finish* (Yin 2010). In this project, the methods of compiling differed based on the data type and are described above; for example, interviews were transcribed, and field notes were handwritten. Disassembling often refers to the coding of the data in which key ideas are grouped by common codes, often with the assistance of digital software. However, in this project, traditional coding was not used and instead, the process that Yin (2010, 188) describes as 'disassembling data without coding' through the use of 'substantive notes' that categorise original field notes and qualitative data by concepts or ideas was used. The decision to disassemble the data manually was made due to the small sample size and because in thematic analysis, 'the importance of the theme is not dependent upon how often it appears or how much data is contained within the theme. Rather, the importance is related to whether it captures something important in relation to the overall research questions' (Castleberry and Nolen 2018, 812). The concepts uncovered must then be looked at in their specific contexts to identify patterns that arose in or across the data sets, which is the process Yin (2010) refers to as 'reassembling'. However, Castleberry and Nolen (2018) note that the disassembly and reassembly process must be done rigorously to ensure that the data are not arranged to purely suit the researchers own theories or bias. To ensure the process was rigorous, in this project, these stages of analysis were iterative, and the data were re-read multiple times to ensure the themes identified were illustrative of the data sets. The interpreting stage involved the researcher identifying connections between themes with reference to relevant published literature, before the concluding analysis phase presented these themes and their relationships to answer the overall research questions and demonstrate the spatial implications of the research.

Triangulation Analysis

The final stage of analysis was the manual triangulation informed by the social ecologic theoretical framework to develop grounded theories from the combined data sets. Corbin and Strauss (1990) define grounded theory as a theory that is established through rigorous data collection and analysis. This differs from traditional hypothesis testing research, as theory is instead built up from observations. This process begins with issues or phenomena that allow for data to be collected through ethnographic observations and theories developed throughout the process. Grounded theory is suited to this research project, as it was not currently known what architectural elements influence the physical activity behaviours of children. Therefore, ethnographic observation was used as the main method to generate data before inductively deriving theory. The theories developed describe the behaviour in social environments and provide statements about the associations between variables studied (Ezzy 2002).

Triangulation of all analysis allows connections to be made between the individual sets of data, thereby creating grounded theory. The central focus of triangulation in this project was finding connections between architectural analysis, observations and physical activity behaviours within the case study school and comparisons between the classrooms. The interviews with the teachers and the architect who designed the case study school provided context and further informed the observations. The interviews with the other architects inform an understanding of current design processes so theories for future change can be proposed. The focus on physical, social and organisational factors within learning environments is informed by the social ecologic model theoretical framework. The connections uncovered provided the significant findings of the project. Although the outcomes from the analysis of each data set are important, the outcomes from triangulation analysis are even more so because they provide clear outcomes for schools and architects to use for future design outcomes. For example, while current physical activity behaviours of students are important to unveil, the analysis through triangulation of the quantitative data with the qualitative observations and interviews findings provided grounded theories that can act as a catalyst for change.

Conclusion

The mixed-method approach using a case study framework was crucial to provide rich data that not only recorded the physical activity behaviours of children quantitatively but also paired that with qualitative methods to understand what students were doing and why, and how they were interacting with learning environments. Pawlowski et al. (2016, 12) discuss the importance of the mixed-method approach in their own research into the physical activity behaviours of children, stating that it 'created a greater credibility of results by offering complementary insights and understandings that neither the quantitative nor qualitative methods alone had the potential to achieve'. The mixed-methods data collection and analysis also suit the project's combination of architecture, health and education fields to ensure the findings are relevant to all disciplines. The single case study school allowed for an in-depth understanding to be developed through observation and architectural analysis, quantitative physical activity data and interviews with teachers and architects. Bryman (2004) discusses how the ethnographic observation recorded through thick description is particularly important to allow others to decide if the findings have potential relevance or comparability to other settings.

Analysis followed the mixed-methods approach with quantitative analysis, thematic analysis and triangulation to build grounded theory. As it was not previously known how the learning environments influence the physical activity behaviours of students, the data were collected before grounded theory was inductively derived. The theoretical framework for the project, the social ecologic model, complements the case study framework and mixed-method approach because it recognises that various physical, social and organisational factors within learning environments could influence students' physical activity behaviours. While the overall project remained focused on architectural design, through the mixed-method approach, I was able to understand and analyse learning environments through both a qualitative and a quantitative lens.

5. The Case of a Montessori School

In this chapter, we encounter a learning environment that is non-traditional in both its physical and pedagogical organisation, which allowed for the increased physical activity of students but did not always encourage it. The case study Montessori primary school in Perth, WA, provided an opportunity to observe architectural contributions to students' physical activity behaviours. The three participating classrooms spanned each of the three age groups of students with three- to five-year-olds in lower primary, six- to eight-year-olds in middle primary and eight- to 11-year-olds in upper primary. The contemporary school was specifically designed to suit the Montessori education system, where students were given freedom of movement within the classroom. The school acts as an interesting case study due to the non-traditional school architectural design and education and was a substantial test for the research methods. The learning environments act as a good case study to inform NGLEs, as the case study classrooms were quite different from traditional classrooms. They were not rectangular and did not have a 'front' with a fixed whiteboard, and the furniture was not arranged in rows. Each classroom had abundant natural light, views to the outside and light-coloured or natural materials.

This chapter outlines the results of the data collected at the case study school to provide a detailed picture of the school architectural design and the students' physical activity behaviours within it. First, I summarise the Montessori pedagogy with the incorporated movement and the design of learning environments within Montessori schools. Before discussing the specifics of the research findings and why they are important for future school design in the next chapter, it is critical that the reader understands the case study school in depth. This will be achieved through a thick description of the school, as was observed in 2018, paired with photos, drawings and diagrams of the school, starting with the overall campus and then a discussion of each nominated classroom in depth. The term 'classroom' is used in this chapter for ease of describing the different spaces analysed, and the term 'observed classroom' is used to differentiate the three participating classes from the rest of the school. The architectural analysis was informed by an interview with the architect who designed the case study school, and the interviews with the participating teachers provided context to the ethnographic observations. Following this, a summary of the quantitative physical activity data is presented with comparisons to previous studies of similar aged children. Last, the ethnographic observation is presented, which provides context and understandings of both the architectural analysis and quantitative physical activity data.

The results demonstrate that the physical learning environments at the case study school allowed students to be physically active; however, social and organisational factors often acted as barriers. The results and initial discussions are presented in this chapter, with further discussion in Chapters Six and Seven. While these results were from a small sample at a single case study school, the mixed-methods data and ethnographic observations allow for a deep understanding of the complexities within the single case and may hold value to inform the design of other non-traditional primary schools and design processes of any school.

Montessori Schools

Montessori schools are one of the most common alternative schooling types in Australia and are of particular interest due to the similarities between Montessori learning environments and NGLEs where students move throughout the classroom during the school day. The case study school selected for this research project is a Montessori school, and in this section, I outline the Montessori method, how it is used in Australia, how physical activity is incorporated into learning tasks and the architecture of selected Montessori schools.

In the early twentieth-century, Maria Montessori developed the Montessori method, which is a child-centred approach in which students are grouped in multi-age classes and given the ‘liberty’ to move around and choose the learning tasks they want to undertake (Montessori 1909). A vital element of the Montessori method is the notion of discipline, which is described as showing a child what to do rather than telling them. Children must not be offensive, irritating to or disturbing of others, violent or unsafe, but all other behaviours are permitted (Montessori 1909). Montessori (1909, 127) states:

> Our aim is to discipline for activity, for work, for good; not for immobility, not for passivity, not for obedience. A room in which all

> the children move about usefully, intelligently, and voluntarily, without committing any rough or rude act, would seem to me a classroom very well disciplined indeed.

The Montessori teacher's role is to observe the students and only intervene when behaviour needs correcting, or guidance is required to ensure students can work on tasks that are appropriately challenging (Hobbs 2008). Hobbs (2008, 13) states that children work independently on various tasks, so the teacher primarily provides lessons to students individually or in small groups. Students in a Montessori school undertake self-directed tasks that develop their independence, motivation, social and academic skills and imagination (Association Montessori Internationale 2021). Montessori tasks are sequenced to become more challenging as the student develops at their own pace and are displayed on open shelving to allow students to see the possible tasks (Hobbs 2008, 19).

Montessori schools in Australia must follow the same guidelines for providing a minimum of two hours of physical activity per week. However, movement is seen as an essential aspect of many Montessori learning tasks: 'movement is the key. It's through movement that we develop our brain' (Montessori Guide 2020, 4:28). Montessori (1946) believed that movement is a critical element for the development of a child, but their use of the word 'movement' differs slightly from purely physical activity. When Montessori (1946) uses the word 'movement', it includes movement of the whole body as well as movement of the hand, which includes any movement from walking to touching an object. In the chapter 'Muscular Education—Gymnastics', Montessori (1909) outlines various exercises that assist students in building key muscles required for daily duties, which range from fine minor skills developed by buttoning fabric to jumping and climbing stairs. However, much of the chapter focuses on using muscles in the mouth for speaking, so it is not strictly relevant to physical activity behaviours as defined in this project. More recently, the Association Montessori Internationale partnered with an organisation called Montessori Sport to share resources about child-centred sports practices to 'integrate Montessori principles within schools' sports programmes' (Association Montessori Internationale 2021).

Architectural Design of Montessori Schools

Montessori schools are often referred to as ‘prepared environments’, which include both inside and outside spaces organised with learning tasks appropriate for the ages of students (Association Montessori Internationale 2021). Montessori (1909) believed that the whole school learning environment and learning methods should be child centred. In describing traditional schools, Montessori stated, ‘the school is, for the child, a place of extreme desolation. Those immense buildings seem to be built for a host of adults. Everything is designed for adults, the windows, the doors, the long hallways, the bare, monotonous classrooms’ (Montessori quoted by Schalz 2015, 52). In contrast to a traditional school, a Montessori school has student-focused spaces with appropriately scaled furniture: ‘Montessori classrooms should be bright, warm, and inviting, filled with plants, animals, art, music, and books’ (Seldin and Epstein 2003, 237). The classroom has tables arranged so that there is sufficient floor space; thus, students can choose where they would like to work (Hobbs 2008). Lawrence and Stähli (2018) analysed the architectural design of Montessori schools and created a system of design principles for Montessori learning environments. The major design principles include elements such as interconnected zones with doors excluded where possible, varying floor and ceiling heights, spatial articulation and acoustics and a learning environment scale that suits children of all sizes. The minor design elements that are recommended by Lawrence and Stähli (2018) include open shelving, spaces for solitude, bathroom and kitchen facilities, natural light and access to outside space with a garden and space for movement.

Herman Hertzberger designed the first purpose-built Montessori school from 1960–1966 in Delft, Holland (Hertzberger 1991, 268). The design theory by Hertzberger (2008) is a spiral (or ‘snail’s shell’) to allow the school to have openness within the outer areas, which progressively changes to more private spaces within the classrooms. This translates to a school with a central public hall that leads into individual classrooms with multiple levels of privacy. Privacy is achieved through the L-shaped classroom and the floor level changes, which control sightlines. Hertzberger (2008) outlines the various physical activity behaviours appropriate for each space within the classroom. This begins with the space nearest to the entrance of the classroom, which is the lowest space, and it should be used for walking around while doing domestic or creative work. The next space is for stationary work (sitting and standing) such as lessons and sensory work. The final space, which is the most private, is for sedentary work that requires a high level of concentration (Hertzberger 2008). This suggests that Hertzberger (2008) believes there is a positive relationship between concentration levels and decreased physical activity, which may be due to distraction, which is discussed many times.

Articulation and acoustics are two key elements of learning environments that are consistently discussed with reference to Montessori schools. The importance of spatial articulation is made clear by Hertzberger (1969), as it allows for a variety of activities to occur at one time. Al, Sari and Kahya (2012) agree that articulation is needed within Montessori classrooms but also believe that the teacher should have full visibility within the classroom to monitor students' behaviour. Articulated space can be considered a series of interconnected spaces rather than a singular large space (Lawrence and Stähli 2018). Unarticulated classrooms are traditional rectangular rooms that allow full surveillance by the teacher and suit teacher-directed learning (Hertzberger 2008). Traditional classrooms tend to have acoustic environments that suit didactic learning; that is, rectangular classrooms with hard surfaces amplified sound so students can easily hear the teacher and the teacher can easily hear if students were misbehaving. Hertzberger (1969, 58) relates that if these types of traditional learning environments are used for non-didactic learning activities, it 'tends to create a rather chaotic situation in which the children become a disturbance to their neighbours. Children who have difficulty in concentrating, or those doing demanding work, are consequently at a considerable disadvantage'. Montessori and other non-traditional learning environments require more absorbent materials to control excess noise and ensure a comfortable space for various activities to occur simultaneously. Hertzberger (2008) argues that classroom articulation and acoustics go hand in hand to limit distractions through students' ability to control the activities to which they are exposed.

Learning Environments of the Case Study School

In this section, I paint a picture of the architectural design of the Montessori case study school as I observed it to share a deep understanding of the learning environment I experienced. I focus on the physical environment to provide context for the data collected and discuss relevant observations about behaviours and social aspects influenced by the physical design. I begin by outlining the whole school site before discussing each of the three classrooms individually, starting with lower primary and moving on to middle and upper primary. The description of the whole case study school starts with a discussion of the site itself and the construction materials used before moving on to the school entrance and central piazza, which acts as the heart of the school. The front facade and classroom wings are described, focusing on spatial articulation and visibility to create connections between classrooms and shared spaces because these are key factors of Montessori design, as identified by many authors, including Hertzberger (1969) and Lawrence and Stähli (2018). I then highlight the similarities and differences between each of the three observed classrooms.

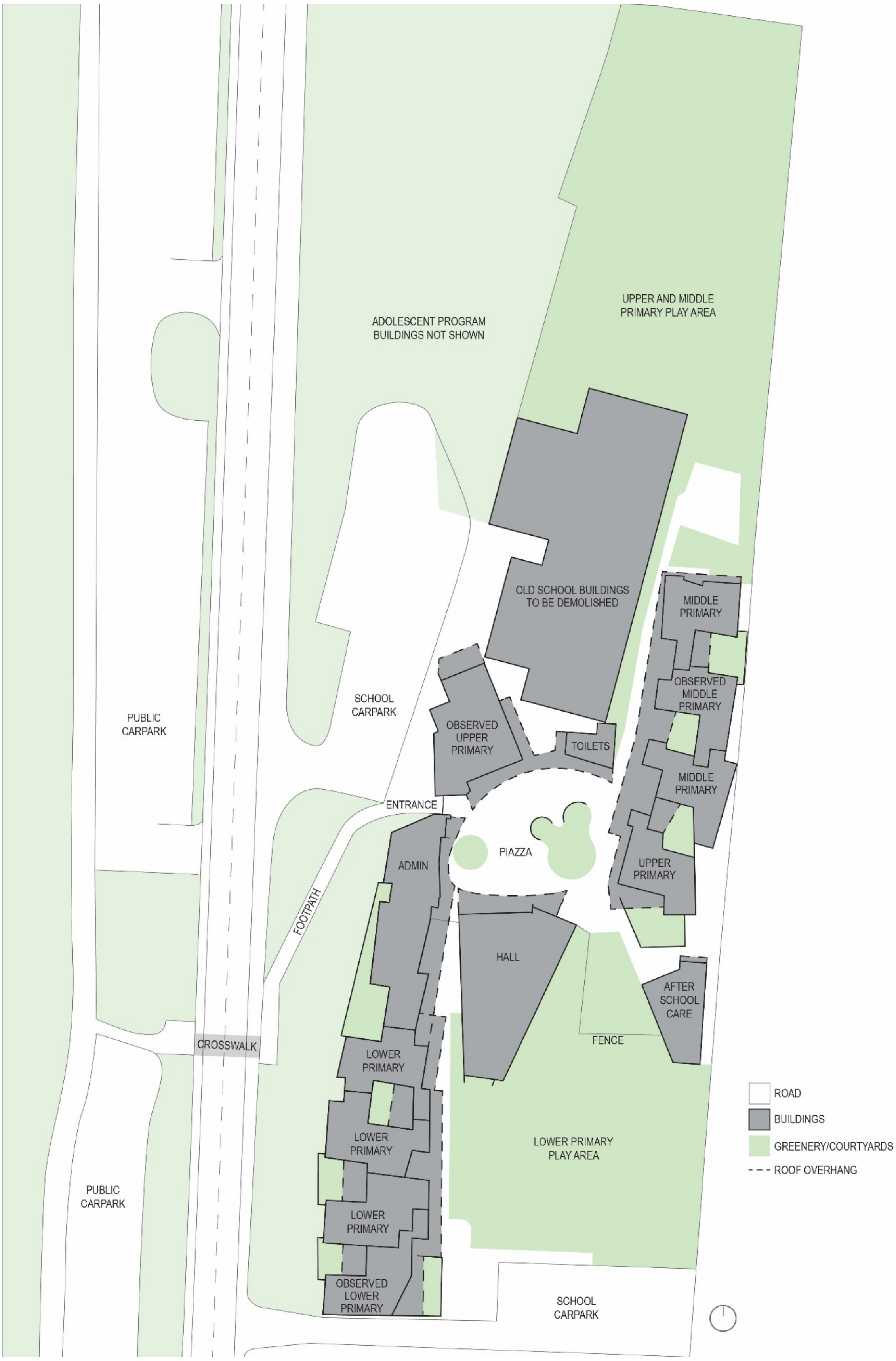


Figure 5.1 Case study school site plan diagram.

Whole School

The case study school was constructed relatively recently with master planning beginning in 2008 and built in stages over 10 years. In some ways, the case study school is contemporary with an openness and flexibility in learning due to the Montessori pedagogy; however, in other ways, the school seems quite traditional and rigid. The separation of classrooms into individual units has similarities to traditional schools, with classrooms in rows off the main corridor. However, in the case study school, the corridor is an outdoor one. This section provides a description of the whole school, discussing the site, the construction materials used, the school entrance and the central piazza.

Site

The case study school is a Montessori primary school located in the western metropolitan suburbs of Perth, on a 12,175 square metre site. The school has primarily single-storey buildings that sit low in the landscape and are unobtrusive to its surroundings. It is oriented around a main north-south axis through the centre, as can be seen in Figure 5.1. The administration and lower primary wing run along the western boundary, which is the portion of the school visible from the road. The hall, library and toilets are located centrally and the middle primary wing runs along the eastern boundary. The school has a central paved piazza, a play area to the north for the middle and upper primary students and a play area to the south for the lower primary students. The original school building remains onsite and is only partly used, with a small portion of it acting as the library. It is planned to be demolished to make way for the final stage of construction, which includes a purpose-built upper primary wing. The original school building separates the new buildings from the northern play area and does not flow within the overall master plan.

The west facade of the school is bordered by a road with two lanes separating the school from a nature reserve. The road is quite busy, so there is a pedestrian crossing that is controlled by a crossing guard in the mornings and afternoons. The crossing connects the school to a footpath and two public car parks, which were used by most parents, as the schools' two car parks were for staff parking. The southern car park is adjacent to the lower primary play area, but due to level changes and vegetation, the cars parked were only partially visible from inside the school (see Figure 5.2). Some students rode bikes or scooters to school with their parents walking beside them. Some families may have travelled from the nearest suburban area to the north (at least 550 m or a seven-minute walk), from the train station to the north (850 m or a 10-minute walk) or over the overpass to the south (650 m or an eight-minute walk).

Figure 5.2 Case study school view to southern car park.

Materials

The school has predominantly white painted fibre cement sheet walls with some feature walls constructed from light pink rammed earth (see Figure 5.3). Grey concrete is also used as a feature on some buildings and acts as both the column and beam supporting structure as well as gutters and downpipes. There is an abundance of clear glass windows that enables views into and out of rooms with deep verandahs or overhangs shielding the glass from the hot summer sun (see Figure 5.4). Exterior floor surfaces are square concrete pavers in grey, light pink and beige. All other surfaces are primarily painted white, with the ceiling of some verandahs painted light yellow and some elements such as bench seats in natural timber.

Entrance

The school's front facade faces west and does not resemble a traditional school with a monumental facade. The only indications of the building function are the crosswalk over the road and a small sign on the edge of the western car park close to the entrance. The main entrance is located centrally on the site. The entrance is simple and understated with no signage or grand architectural gestures and has a high double gate roughly 2.5 metres wide with a safety latch at the top for parents and older students to open. Only one of the gates was used during the observation period, so it often became a bottleneck in the morning and afternoon, but many people would hold the gate open for those walking close behind them. There is no roof cover over the gate and, therefore, no shelter from the weather, which could be unpleasant during rain.

Figure 5.3 Case study school rammed earth walls at the entrance.

Figure 5.4 Case study school central piazza collage.

Heart of the School

The central piazza is located just inside the entrance gate and is roughly circular in plan and open to the sky. Each building has roughly two to three metres of verandah extending out over the piazza for shelter and shade, which provides a sheltered path from the front gate to most rooms with minimal gaps. Bougainvillea plants grow up climbing wires and spread over trellises extending out from the verandah edge. The piazza is primarily paved in wide stripes of alternating light pink and grey-coloured concrete pavers. There is a single deciduous tree outside the administration office entrance. There is also a cluster of landscaping central-east within the piazza, which includes three deciduous trees, small shrubs, small circular grass areas, a grass-covered mound and small curved brick walls at low seat height. A statue of Maria Montessori reading in a seated position is placed on the wall facing the main entrance, and a statue of a small child standing is placed nearby (see Figure 5.5). The deciduous trees provide some shade in summer and allow sun in winter. Overall, the piazza was a very inviting space to occupy and suited the community nature of the Montessori school, which encouraged parents and children to linger for conversations.

Figure 5.5 Case study school central piazza looking southeast with a sculpture of Maria Montessori.

Around the piazza from the gate, the upper primary class is to the north-west, the shared toilets are to the north with the old buildings behind, and a block of four middle primary classrooms is to the north-east. A childcare centre is set back from the piazza against the east boundary fence, and the multipurpose hall is to the south. The block of four lower primary classrooms is to the south-west, and the administration building is to the west of the piazza. Most facades facing the piazza have large, glazed areas except for the shared toilets and the southern-most middle primary classroom (which was used as an upper primary classroom during the observation period).

Front Facade

The western facade of the school is quite solid to control solar heat gain during the afternoon and act as thermal mass to regulate the temperature within the rooms. The primarily solid western facade also assists with controlling the prevailing winds from the south-west and minimising traffic noise. The three western courtyards and part of the administration building have rammed earth walls along the facade at varying heights, which breaks up and adds interest to the building. The western windows have an overhang that blocks direct sunlight during most school hours. The architect of the school discusses their intention that all classrooms would have access to northern light to provide adequate daylighting and warm rooms during winter days (source redacted); however, the upper primary classroom has a temporary shelter to the north, which blocks this direct sunlight. The temporary structure was added by the school after the architect handed over the building, and the architect viewed it as negatively affecting the design (interview with architect A, 20 September 2018).

Classroom Wings

The facades of both classroom wings are quite solid, facing towards the main walkways, which restricts views and therefore limits the feeling of connection between the classrooms and the rest of the school. The two classrooms' wings each have four classrooms and four courtyards, and the administration building also has a dedicated courtyard for staff (see Figure 5.6). The lower primary wing of the school is connected to the administration building but separated from the rest of the school site by a metal security fence that is roughly 1.5 metres high. All four lower primary classroom entrances lead off the main north-south walkway to the east of the classrooms, which is made of beige-coloured concrete paving. The east wall of the classrooms is primarily solid and is painted with a large bright floral mural. The only cut-outs in the mural walls are small highlight windows to provide some natural light into the classrooms' storerooms.

Articulation in facades create spaces that can be used rather than just spaces for walking past. The east facade of the lower primary is somewhat articulated at each classroom entrance, but this seems to be more to shelter from weather than to create spaces for use. The lower primary classroom entrance doors were closed for most of the day except during recess or physical education. The doors are solid with clear transparent glass louvres in the top half so teachers can see out the door, but children cannot. This creates a further disconnect between the class and the rest of the school. The middle primary wing is more open and articulated due to glass entrance doors and the placement of some courtyards along the western facades (see Figure 5.6). However, as these courtyards were viewed as private spaces for the students of each classroom, they do not provide a space where other school users would feel comfortable lingering.

Figure 5.6 Case study school plan circulation diagram.

Classroom Connections

The classrooms each have large windows to allow natural light and views to the plants in courtyards, but the classrooms are quite inward focused, with varying degrees of visual connection to the rest of the school due to limited views from most classrooms. The architect pointed out that all lower primary classrooms are visually connected to one another, with sightlines available for the length of all four classrooms (interview with architect A, 20 September 2018). However, due to changing light levels and reflection on the glass, these sightlines are not as clear as intended, and the students did not seem to look into other classrooms. They did, however, look into the adjacent courtyard if that was being used by students when noise or movement caught their attention.

The middle primary wing is slightly more open, with glass entrance doors and lower windows bordering the main walkway, but the overall connection to the rest of the school is limited. This also differs, as each individual classroom is designed differently. Generally, the main connection of each classroom is to its neighbouring classroom. For example, the southern-most lower primary classroom (the observed classroom) has a full view into the courtyard of its neighbouring classroom. While this design was similar across all classrooms, the use of the classrooms did not always allow for this visual connection. For example, the northern-most middle primary classroom was designed with views into its neighbouring classroom (the observed classroom) from the courtyard, but the observed classroom has semi-opaque blinds, which block views while allowing some diffuse natural light. The west facades of the middle primary classrooms are quite solid, with high windows that only allow a view of children's heads as they walk past on the path. The front doors are clear transparent glass, which enabled views, but the doors are set back into the classrooms so that there was a roof above the entrance for shelter. The relatively solid walls on the west facades limit the feeling of connectivity between the classrooms and the rest of the school. Although the walls are relatively solid, the building shape on the west facade is heavily articulated since three of the four courtyards were on the western side. The northern-most classroom has its courtyard to the south-east of the room and is quite isolated.

In contrast to the lower and middle primary classrooms, the upper primary classroom was originally designed as a library for the school but has been adapted to work as a classroom while waiting for the final stage of construction to be completed. Therefore, the design was quite different to the other classrooms. It is visually open to the rest of the school due to the majority of the southern facade featuring glazing, which gives a sense of connection to the piazza. The upper primary classroom itself is discussed in further detail in the following section.

Play Spaces

The case study school has two separate play areas for the young and older students, which I will briefly describe. However, they are not a focus of the research. The play area for the lower primary students is located in the south-east of the site and is primarily grass with a paved circular path running through it, three large deciduous trees to the west and some smaller trees to the south (see Figure 5.7). There are three main playgrounds in the lower primary play area, which are each covered in shade sails. To the north is a sandpit with play equipment. In the south-west is some fallen logs for climbing and two swings above a sandpit. To the west is two sandpits, and one has limestone and timber arranged for climbing. There is also a play area to the south-east without shade sails, which includes large rough boulders scattered around small trees. Three raised large doughnut-shaped objects that are covered in artificial grass are placed along the south. The play area for the middle and upper primary students is located in the north-east of the school site. It is primarily grassed with a paved court for ball sports and two small sandpits with play equipment such as climbing frames. There were numerous mature trees providing shade and views to bushland to the north.

Figure 5.7 Case study school view to the lower primary play area.

Shared Spaces

The shared spaces within the school, such as the main piazza, seem underutilised during school hours, which could be due to nearly all classrooms having (and preferring to use) their own designated courtyards. The upper primary observed classroom is the only class without a designated courtyard since the room was designed as a library. The students instead used the main piazza daily for morning tea and lunch and infrequently for learning tasks if the weather permitted. However, if they were in their purpose-built classroom, then they would have their own designated courtyard; therefore, the piazza would primarily be used only before and after school hours. During the observation periods, the two play areas were only used during physical education and recess times (and were not used during class times). The play spaces feel quite disconnected from the classrooms, which is heightened by the placement of the two play areas at opposite ends of the school. The southern play area has some visual connection into the piazza, but views are predominantly blocked by the large school hall building. The northern play area is separated from the central piazza by the old school building, which was very large. Once the old school building is demolished and the new upper primary and special education wing is constructed, the architect believes it will create more connection to the northern playground (interview with architect A, 20 September 2018). This is because the new buildings will be much smaller than the old ones, with a secondary piazza that partially opens up to the northern playground. During my observation period, a teacher commented to me that the north playground was not big enough for the number of students and should be redesigned. They also said that the school fence was not located on the external border of the property, so the playground could be further extended. The old school buildings are also very large and take up space that could be allocated for play.

Bathroom facilities are shared by the students and school community. The lower primary classrooms have their own bathrooms that join and were shared by two classrooms. The middle and upper primary classrooms do not have dedicated bathrooms, and the students used the shared bathrooms located on the north side of the main piazza. The shared bathrooms were also used by parents or other visitors to the school. Teachers and other staff have access to dedicated bathrooms within the administration building.

Observed Classroom Comparisons

In this section, I describe the three primary learning environments that I observed with a focus on physical aspects and some discussion of use. The discussion begins with a description of the location, layout, openings, materials and facilities, before discussing the furniture and connections to nature.

Classroom Locations and Layout

The observed lower primary classroom was the southern-most classroom in the lower primary wing (see Figure 5.8). It is a roughly L-shaped room with a private courtyard on the eastern side (see Figure 5.9). The classroom entrance is on the eastern facade, with the kitchen and bathrooms located on the northern-most side and the main learning activities arranged in the southern part of the classroom (see Figure 5.10).

Figure 5.8 Lower primary observed classroom location diagram.

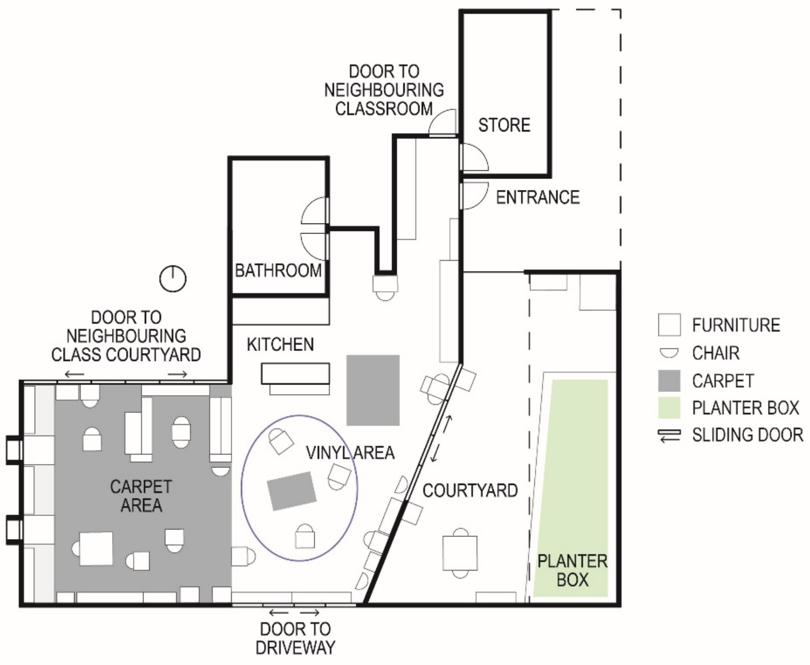


Figure 5.9 Lower primary observed classroom floor plan diagram.

Figure 5.10 Lower primary observed classroom looking southwest.

The middle primary wing is located to the north-east of the central piazza and backs onto the east fence, separating the school from the public transport routes to the east. The observed middle primary classroom is the upper centre classroom in the middle primary wing (see Figure 5.8). It is a roughly L-shaped room with a semi-enclosed courtyard on the south-west side (see Figure 5.11).

The observed upper primary classroom is on the north side of the main piazza (see Figure 5.8). It is a roughly L-shaped classroom with an operable wall that folds to one side to separate the room into two spaces (see Figure 5.12). The architect discussed that the larger southern room was intended as the main library with a reading deck to the west, and the northern room was intended as a staff training room (interview with architect A, 20 September 2018).

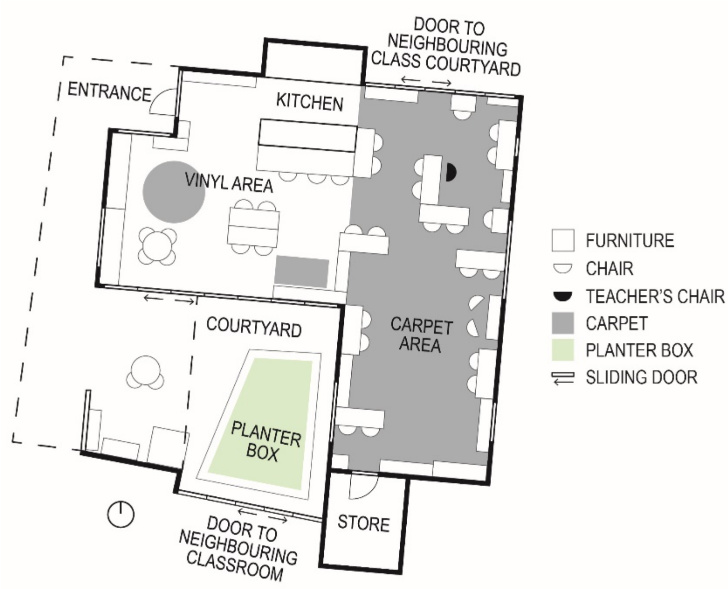


Figure 5.11 Middle primary observed classroom floor plan diagram.

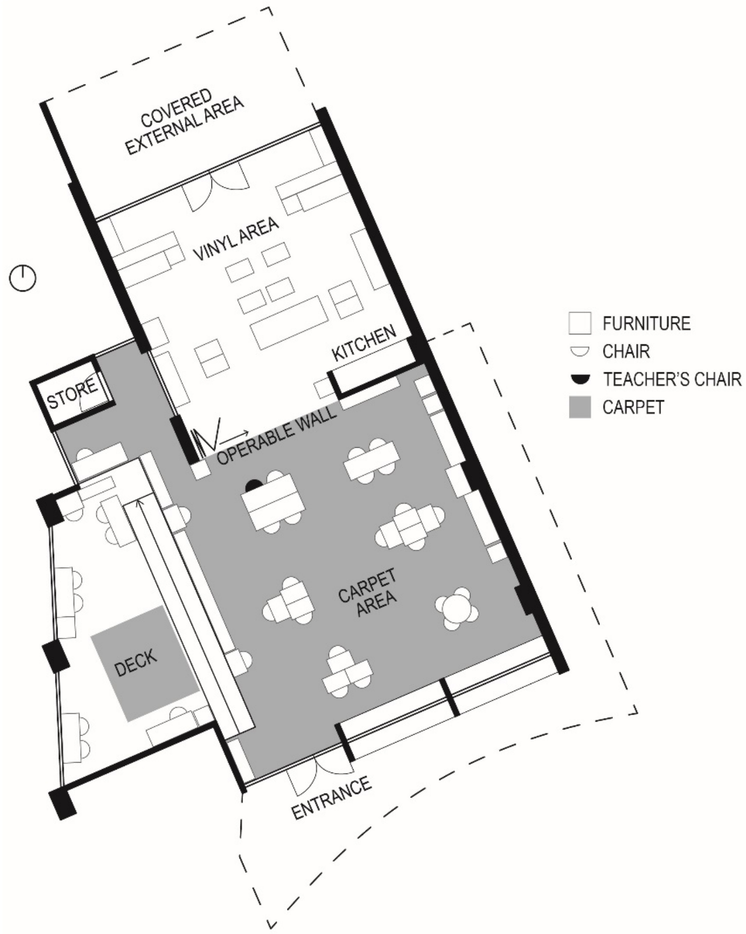


Figure 5.12 Upper primary observed classroom floor plan diagram.

Classroom Areas

Comparisons between each of the classrooms demonstrates that the three observed classrooms are primarily similar with some differences in the upper primary classroom. As can be seen in Table 5.1, the estimated internal floor area in the lower and middle primary observed classrooms are similar with a slightly different ratio allocated to carpet and vinyl flooring. The upper primary classroom is significantly larger due to its original design intention as a library. The calculations of internal and total floor area per student were calculated using the maximum number of students in attendance during the observation period, which was 22, 18 and 21 for lower, middle and upper primary, respectively. However, student attendance fluctuates throughout the day, which was particularly apparent in the observed upper primary classroom where students moved between the two upper primary classrooms and some students attended the adolescent program in the north of the school site. The lower primary classroom also had fluctuating attendance rates due to younger students attending school part time. The courtyard area in the lower primary classroom is larger than the middle primary courtyard, and although the upper primary did not have a designated courtyard, the piazza is significantly larger than all courtyards.

Table 5.1 Observed classroom areas.

	Classroom Areas (m^2)*		
	Lower	**Middle**	**Upper**
Glass window and door area (excluding skylight windows)	34	31	35
Carpet floor area	41	54	76
Vinyl and wood floor area	58	46	94
Total internal floor area	**99**	**100**	**170**
Designated courtyard floor area	47	37	0
Internal floor area per student	4.5	5.6	8.1
Total floor area, including courtyard	**146**	**137**	**170**
Total floor area per student	6.6	7.6	8.1

* all amounts were estimates based on manual measurements and rounded to nearest whole number or decimal.

Openings for Lighting and Ventilation

The observed classrooms all have windows and external doors with silver metal frames and clear glass facing all cardinal directions. Most sliding doors and operable windows do not have flyscreens, except for the sliding doors in the lower and middle primary classrooms, which open onto the courtyard of the neighbouring class or the access road to the south. These flyscreens seemed to be used to ensure students stayed within their designated classroom rather than for protection from insects because the sliding doors to the courtyards do not have flyscreens. In addition to the flyscreens, the middle primary classroom also has semi-opaque blinds that covered the northern doors and windows for the duration of the observation period. The blinds allowed some diffuse light to enter but created a visual disconnection between the two classes.

All three observed classrooms have non-operable windows. The lower primary classroom has two box windows in the west wall that allowed sunlight to enter the class and views out to the horizon (see Figure 5.13). The middle primary classroom has non-operable windows along the eastern wall and one on the western wall of the carpet area, which led to the south-east part of the classroom having no natural ventilation and being darker than the rest of the class. Uniquely, the upper primary classroom has large saw-tooth roofs with windows facing south to allow daylight to enter deep into the south room (see Figure 5.14). The northern room of the upper primary classroom was described by the architect as the 'warmer, sunnier' space (interview with architect A, 20 September 2018); however, in reality, this room is quite dark due to its use and alterations by the school (see Figure 5.15 and Figure 5.16). The school has added a temporary shelter built outside the northern wall of the classroom, which blocks all direct light from entering the north facade. All three observed classrooms have varying ceiling heights with many artificial lights installed that were used on most observation days. Each classroom also has ceiling fans and air-conditioning installed.

Figure 5.13 Lower primary observed classroom looking west.

Figure 5.14 Upper primary observed classroom southern room.

Figure 5.15 Upper primary observed classroom northern room.

Figure 5.16 Upper primary observed classroom view to north from deck.

Materials

Each of the observed classrooms has light, neutral-coloured materials throughout. All feature white painted plasterboard walls and ceilings with no student work or learning resources displayed on the walls or hanging from the ceilings. Uniquely, in the upper primary classroom, three large grey concrete beams spanned over the south room (one was above the kitchenette and operable wall), which also act as gutters for the roof (see Figure 5.17). The water drains down external channels in the columns in the east wall. The east wall of the upper primary classroom has light pink rammed earth between the concrete columns/channels. All three classrooms have one zone with beige carpet tile flooring and another with light grey vinyl flooring. The vinyl areas were often used for messy tasks such as art or cooking, and the lower and middle primary classrooms added rugs to the vinyl areas (see Figure 5.18). Uniquely, the lower primary classroom has a large oval blue vinyl sticker on the vinyl floor and a built-in timber structure along the west windows. The upper primary classroom also has a raised timber covered deck to the west (see Figure 5.19).

Figure 5.17 Upper primary observed classroom external gutters.

Figure 5.18 Middle primary observed classroom looking west.

Figure 5.19 Upper primary observed classroom deck.

Facilities

The three observed classrooms have kitchen facilities with benches at a height appropriate for most students in the class. The lower and middle primary classrooms each have a full-sized galley kitchen with a full bench and overhead cupboards, an island bench, two sinks, an oven, a stovetop and a fridge (see Figure 5.20, Figure 5.21 and Figure 5.22). The lower and middle primary classrooms also have a step stool to help shorter students use the kitchen facilities. The upper primary classroom has unique facilities as the kitchenette in the north room is quite small compared to the other classrooms due to its intended use as a library space.

Figure 5.20 Lower primary observed classroom kitchen.

Figure 5.21 Middle primary observed classroom kitchen.

Figure 5.22 Middle primary observed classroom looking north.

The lower primary classroom has a private bathroom that is shared with the neighbouring classroom to the north. This ensures lower primary students do not need to leave the classroom to go to the bathroom, which could improve students' safety, but also limits physical activity since students do not travel far. The middle and upper primary classrooms do not have access to a private bathroom and shared the bathrooms at the north of the piazza.

Furniture

All of the observed classrooms have similar furniture, mostly in light colours or timber. Each class has open shelves spread around the classroom, which display the learning resources, and the height of the shelves differs to suit the height of students in each class. Each class has an open cupboard where students can store their backpacks. The lower primary classroom has shelves placed along all available walls and some shelves that are placed perpendicular to the walls to create smaller articulated spaces. There is also a mid-height shelf along the back of the lower primary island bench, which stopped students from using the kitchen from both sides. The middle primary classroom has fewer shelves than the lower and upper primary classrooms and is quite open and uncluttered. On the south-east of the vinyl area in the middle primary classroom, there are two timber shelves arranged in an L-shape with a rectangular dark blue rug where students sometimes sat on the floor to work (see Figure 5.23). This configuration of the shelves and rug help to create articulated space and separate the vinyl area from the carpet area.

Figure 5.23 Middle primary observed classroom shelving.

The middle and upper primary classrooms have the same light blue or grey plastic chairs (see Figure 5.24), which are very similar to what can be found in many Australian schools, including traditional government schools. In contrast, the lower primary classroom predominantly has lightweight timber chairs, two wicker chairs on the vinyl area and a small leather tub armchair placed on the edge of the carpet area with a box of books for reading in front of it. The middle primary classroom also has two armchairs for reading (see Figure 5.25).

Figure 5.24 Middle primary observed classroom furniture.

Figure 5.25 Middle primary observed classroom looking south.

The tables within each classroom differed in type and arrangement. In the lower primary classroom, there are 13 single tables made of lightweight timber scattered around the room, as well as one larger square table able to fit up to four students and a rectangular timber table that are placed in the southern portion of the carpet area. The lower primary classroom also has a dark timber structure that runs along the length of the west wall and provides window seats under the two western windows (see Figure 5.26 and Figure 5.27). The architect described it as a playful addition that enabled various interactions, as it could be used as a low seat, high window seat, a step to stand or lay on, or students could ‘hide underneath’ (interview with architect A, 20 September 2018). The middle primary classroom has 11 rectangular tables for students to use in pairs and two small single tables; all the tables have black metal frames with beige laminate tops. On the carpet area, these tables are primarily placed against the walls to create an open area on the carpet where students could gather as a whole class (see Figure 5.25). The middle primary classroom also has a large wooden table at the west end of the classroom and two large tables with solid sides and wheels, which are pushed up against the back of the kitchen island bench (see Figure 5.28). The upper primary classroom has a variety of different tables; in the southern part of the classroom there is three large rectangular tables and one large round table that remained in place during the observation period, as well as 13 individual tables that were frequently moved around by the teacher and students. On the upper primary deck, there are four large desks with computers and in the northern part of the classroom, there are eight small individual tables, and one very large table. In the upper primary classroom, most of the tables are grouped towards the centre of the spaces rather than pushed against the walls.

Figure 5.26 Lower primary observed classroom window seat.

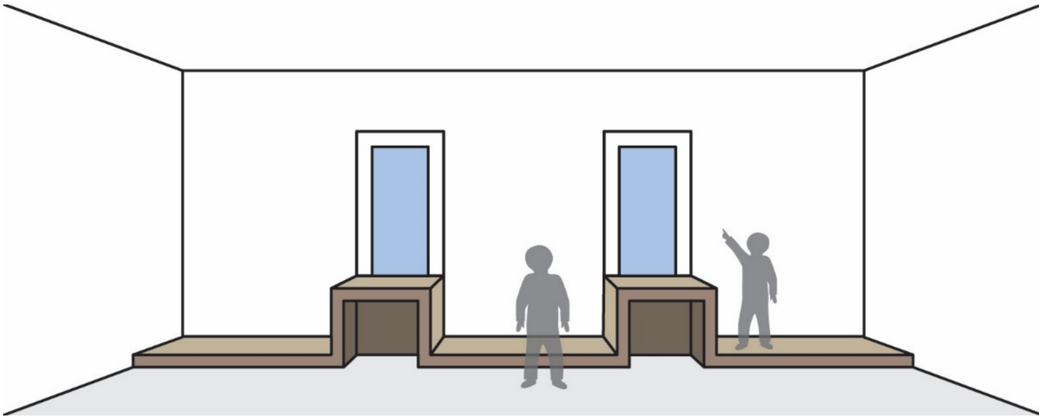


Figure 5.27 Drawing of lower primary observed classroom window seat.

Figure 5.28 Middle primary observed classroom furniture.

The middle and upper primary classrooms also have portable whiteboards and blackboards. The middle primary classroom has three small A-frame boards that were moved around the room as needed. The upper primary classroom has two large whiteboards on wheels, which were infrequently used, and a small A-frame board that was used daily as the teacher clipped a piece of paper with maths problems.

Connections to Nature

All of the observed classrooms have views of nature from the windows and nature brought inside through potted plants. The lower primary classroom has significantly more indoor plants, including some larger plants that all looked healthy. The middle primary classroom has some potted plants placed on top of shelves; however, they were relatively small and did not look very healthy. The upper primary classroom has some small potted plants placed on top of shelves. As previously mentioned, the lower and middle primary classrooms each have a designated private courtyard, and the upper primary classroom has a small, covered area to the north where two rabbits were housed.

The lower primary courtyard has half-height rammed earth walls on all sides except for a small section on the north side, which has a metal fence that enables views to the classroom entrance and some views out to the school (see Figure 5.29). The south wall has a full-height timber lattice fixed to it and a timber blind to block strong winds. The roof covers the paved areas of the courtyard with a rectangular opening to the north. Due to being primarily enclosed, the courtyard feels like an external room. A raised timber planter box is on the east side of the lower primary courtyard is filled with lush plants, which seem to be primarily edible herbs. There are also potted plants around the courtyard's perimeter, a small water tank and a trough sink in the north-east corner. There is a blue painted shelf along the south wall, a large square table with two chairs, and a small timber table next to the sliding door. There is an art easel for painting and two racks for drying artwork and wet cloths. The arrangement of furniture in the courtyard provides specific cues to students as to the activities allowed to be undertaken in the courtyard.

Figure 5.29 Lower primary observed classroom courtyard.

The courtyard of the middle primary classroom is semi-enclosed, with a roof covering the paved area. The courtyard is accessed through a double glass sliding door in the south wall, and there are three large, fixed window panels, making this wall primarily transparent (see Figure 5.30). The other main wall of the courtyard is full-height glass with views into and out of the neighbouring class. The courtyard opens directly onto the main access path. The opening to the path is only partially closed with a small half-height wall with a set of shelves pushed up against the courtyard side. The courtyard feels very open and not as private as the other courtyards in the school. The courtyard has a raised timber planter box on the east side with some trees and plants, but they are quite sparse. There are also some plants in pots scattered around the courtyard on the floor and shelves, but the plants are not very lush, so they did not provide an especially pleasant feeling. There is a small water tank in the south next to a wall-mounted trough sink.

Figure 5.30 Middle primary observed classroom view to courtyard.

Student Physical Activity

This section presents the results of the participating students' physical activity behaviour collected through accelerometer (ActiGraph GT3X+) devices. I begin by outlining the participation and attendance of the participating students before summarising the results from all participating students to provide an overall picture of the physical activity behaviours. I then outline the results from the whole day, class time and recess time with comparison and discussion of each of the three classrooms.

Participation

The case study school principal nominated three classes of different aged students, and all three classroom teachers provided participatory consent. A total of 37 students (22 males, 15 females) participated in the study, which spanned three classrooms: lower (n = 11), middle (n = 17) and upper (n = 9) primary (see Table 5.2). Due to a technical error with data downloading, one upper primary student's data were excluded from analysis and were not included in the totals above or in any further discussion. Student participation rates were 61% total with 50%, 94% and 48% for the lower, middle and upper primary classes, respectively, which is comparable to two other large Australian studies, which achieved participation rates of 56.8% (McCarthy et al. 2021) and 74.1% (Martin et al. 2013). The lower rates in the lower and upper primary classes may mean that the findings were not a true representation of the whole class. The higher number of participants in the middle primary classroom was due to the teacher's dedication to the project by encouraging all students to participate and ensuring all parents were aware of the project and given a copy of the consent form. This demonstrates the importance of teachers' involvement in reminding participants to return consent forms. Most (30) participating students attended school full time from 8:30 a.m. to 3 p.m. daily (6.5 hours), with four lower primary students leaving at 12:30 p.m. on Fridays and three lower primary students leaving at 1 p.m. Mondays to Thursdays and 12:30 p.m. on Fridays.

Table 5.2 Participant totals, participation rates and sex divisions.

Participants	**Total**	**Participation Rates**	**Sex**	
			Male	**Female**
Lower Primary	11	50%	7 (63.6%)	4 (36.4%)
Middle Primary	17	94%	10 (58.8%)	7 (41.2%)
Upper Primary	9	48%	5 (55.6%)	4 (44.4%)
Total	37	61%	22 (59.5%)	15 (40.5%)

Accelerometer Wear

Participating students were asked to wear an accelerometer (ActiGraph GT3X+) device around their waist above their right hip for 10 school days, and most participating students were quite enthusiastic to wear the accelerometer device each day. I observed some students fidget with the accelerometer or move the accelerometer from above their right hip, often to sit in the centre of their body, which can lower the accuracy of data collection.

Accelerometer non-wear time occurred due to both absenteeism and student choice. Across all classes, 13 participating students were absent for a total of 29 days. Students were often late; generally arriving between 8:30 a.m. and 9:00 a.m., and some lower primary students only attend for half the day. All participating upper primary students chose to wear the accelerometer device on the days they attended. One participating middle primary student chose not to wear the accelerometer device on 2.5 days they attended, as they thought the belt was uncomfortable. Four participating lower primary students chose not to wear the accelerometer device on a total of 15 days they attended, plus one lower primary student chose not to participate despite parental consent. The lower primary students did not give a reason why they chose not to wear the accelerometer device, but I witnessed some students choose not to wear the devices after seeing other students do the same. I also witnessed the same students ask to put the accelerometer back on after seeing other students put it on. This demonstrates that students of all ages were able to make their own decisions but were also influenced by the decisions of their peers.

Student Attendance

The total student numbers in attendance in each observed class were recorded; however, the number of students present in the classroom during any one time fluctuates significantly due to a number of reasons. In the lower primary class, some of the younger students were enrolled part time, so they only attend until 1 p.m. The highest number of lower primary students recorded was 22, and the lowest was 10, but on average, there were 18 students in the mornings and 12 in the afternoons. In the middle primary class, some students attend other classes in small groups for specialist learning such as music or drama, with an average of 16 students attending each day. In the upper primary class, the students frequently move between the two upper primary classrooms and also attend classes in the hall. The older upper primary students attend a specialist program in the buildings on the north of the campus and thus spend a great deal of time away from the classroom. There was an average of 19 upper primary students attending each day, but usually, this number was only present during the mornings.

Physical Activity Results of All Participating Students

The accelerometer data for all participating students provide an overall picture of the physical activity and sedentary behaviours of the participating students. To reiterate from Chapter Three, sedentary behaviour is sitting or lying still, and a sedentary bout is a period of constant stillness that lasts for at least 10 minutes (Chinapaw et al. 2014). Participating students wore the accelerometer for an average of 5:55 hours per day at school and completed an average of 9,015 steps in that time (see Table

5.3). There were no statistically significant differences noted in students' recorded physical activity behaviours when comparing males and females or comparing days with or without direct observation (see Appendices 10.5 and 10.6). When comparing morning and afternoon classes, there were no significant differences between mean percentages of time spent in sedentary or light behaviour or mean steps per minute; however, there was a significant difference in students' mean percentage of time spent in MVPA, with more MVPA during afternoons (see Appendix 10.6). This increase in the mean percentage of time spent in MVPA could be due to the flexibility in the timetable, which means analysis could include some recess time into the afternoon classes. As the results in morning and afternoon are predominantly similar, they are not discussed separately in detail. There were statistically significant differences in all tests when comparing class time and recess time, which demonstrates students were less sedentary and more active during recess. A summary of the results is presented below.

Students spend close to half of their day (47.7% or 2:49 hours) in sedentary behaviours, less than 8% (28 minutes) in MVPA, and the rest (44.7% or 2:38 hours) in light activity (see Figure 5.31). There were no Australian recommendations for the amount of time students should spend in MVPA during school hours; however, the current recommendation was that students achieve a minimum of 60 minutes of MVPA each day (Australian Government Department of Health 2014). As these students were not meeting the daily recommended MVPA during school time, they should be making up this gap outside school hours. This research demonstrates that, on average, these students will need to achieve an extra 32 minutes of MVPA each day before or after school. It was important that parents be aware of this information, so they can make informed decisions about their children's physical activity outside school time. The US and Canada recommend that students accumulate at least 30 minutes of MVPA each school day (McCarthy et al. 2021), which was not being met by the participating students. The sedentary bouts recorded by participating students in the case study school was a mean of 16 minutes and a mean maximum of 24 minutes, which demonstrates that, on average, these students were not sitting for prolonged periods. These were considered short bouts of sedentary behaviour by Diaz et al. (2019), as it was fewer than 29 minutes.

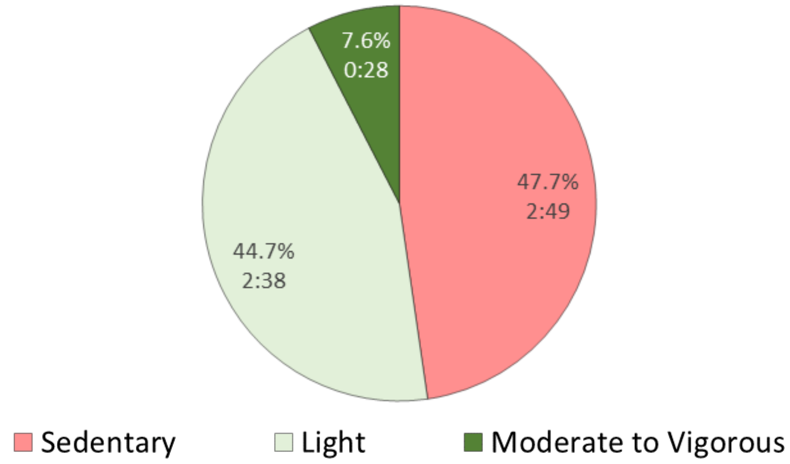


Figure 5.31 Mean percentage and time per whole school day spent in physical activity behaviours by all participating students.

Table 5.3 Physical activity behaviours per whole school day.

	All Students	**Males**	**Females**
Mean (SD) time wearing accelerometer per school day	5:55 hours (1:01)	5:47 hours (1:09)	6:06 hours (0:48)
Mean (SD) percentage time in sedentary behaviours	47.7% (8.0)	47.1% (7.8)	48.6% (8.4)
Mean (SD) percentage time in light behaviours	44.7% (6.9)	44.9% (6.3)	44.5% (8.0)
Mean (SD) percentage time in MVPA	7.6% (2.6)	8% (2.6)	7% (2.6)
Mean (SD) sedentary bout (mean time sitting before standing)	16 minutes (6)	16 minutes (5)	16 minutes (7)
Mean (SD) maximum sedentary bout (mean maximum time sitting before standing)	24 minutes (12)	25 minutes (11)	23 minutes (14)
Mean (SD) step count per school day	9,015 steps (2177)	9,416 steps (2328)	8,822 steps (1901)
Mean (SD) steps per minute	25 steps (3.9)	26 steps (4.0)	24 steps (3.3)

Understanding the opinions of parents/guardians in relation to their children's physical activity behaviours can provide important information. Most parents/guardians (87%, n = 33) chose to answer the two optional questions asked on the consent forms. As can be seen in Table 5.4, most parents/guardians who answered the questions (72.7%, n = 24) believe their children were regularly meeting the physical activity guidelines of at least 60 minutes of MVPA per day. All parents/guardians who answered the questions (100%, n = 33) believe their children were meeting sedentary behaviour guidelines with no more than two hours of sedentary-based screen time for entertainment. Due to the question's phrasing to include the whole day, it is not clear how much physical activity or sedentary behaviour parents believe their children were accumulating during school time. On reflection, the question should have been phrased to ask parents only about their opinions of their child's physical activity during school time only. This was important to know because if parents believe their children were meeting physical activity guidelines during school time, then they may not encourage their children to continue MVPA outside school hours. As previously discussed, the accelerometer data show that students were not meeting recommended levels of MVPA during school hours. The upper primary teacher believes that the whole school community were 'a conscious body of people who think about health' (interview with upper primary teacher, 30 November 2018), so families work with the school to encourage kids to be healthy both with physical activity and healthy eating.

Table 5.4 Results from parent/guardian questions.

Question 1: How much moderate to vigorous physical activity (e.g., fast walking, running, active play) does your child regularly accumulate per day?		
Answer	**Number**	**Percentage**
0 to 30 minutes	0	0%
30 to 60 minutes	9	27.3%
1 to 2 hours	14	42.4%
more than 2 hours	10	30.3%
Question 2: How much time per day does your child regularly spend sitting or lying using electronic media for entertainment (e.g., TV, computer, tablet, phone)?		
Answer	**Number**	**Percentage**
0 to 30 minutes	16	48.5%
30 to 60 minutes	13	39.4%
1 to 2 hours	4	12.1%
more than 2 hours	0	0%

Comparing Classes Physical Activity during the School Day

Across the whole school day, comparisons have been made between the physical activity behaviours of the participating students in each of the three observed classes. These comparisons (as shown in Figure 5.32) demonstrate that lower primary students spend nearly half of their school day in light physical activity (49.2%), which was a higher percentage than both the middle (44.3%) and upper (40.0%) primary students. The lower primary students were spending only 6.4% of their school day in MVPA or an average of 19 minutes, whereas the middle and upper primary students spend 8.0% (30 minutes) and 8.2% (32 minutes), respectively. On average, lower primary students require an additional 41 minutes of MVPA each day, middle primary requires an additional 30 minutes, and upper primary requires an additional 28 minutes to meet the Australian guidelines. The middle and upper primary students were meeting the minimum 30 minutes of MVPA recommended by the US and Canada (McCarthy et al. 2021); however, the lower primary participating students were not. McCarthy et al. (2021) highlight the importance of not just understanding the mean MVPA across participating student groups but also understanding the percentage of students who were meeting the minimum requirements. As can be seen in Table 5.5, only two (18%), 10 (59%), and six (67%) lower, middle and upper primary students, respectively, were gaining at least 30 minutes of MVPA per school day. A recent Australian study by McCarthy et al. (2021) found that 61% of students were meeting the minimum recommended amount of MVPA (30 minutes) during school time.

As was reflected in the mean total time wearing accelerometer per day, some lower primary students did not attend classes for the full day, which limits the comparability of the results. Of the participating lower primary students, three left school at 1 p.m. on Mondays to Thursdays, and seven left at 12:30 p.m. on Fridays. As fitness/sport was usually observed to be conducted in the afternoons, this may somewhat explain the lower time spent in MVPA per day. Even so, the low level of MVPA was surprising, as the lower primary data were collected in late October when the weather was predominantly sunny and allowed for more outdoor activities. The middle and upper primary data were collected in August and September when the weather was sometimes cold and raining, which affected some recess, fitness and sports. The average maximum temperature on data collection days was 21.0°C for lower primary, 18.0°C for middle primary and 18.7°C for upper primary. Average rainfall was 1.4 mm across five lower primary data collection days, 2.0 mm across seven middle primary data collection days and 3.2 mm across five upper primary data collection days.

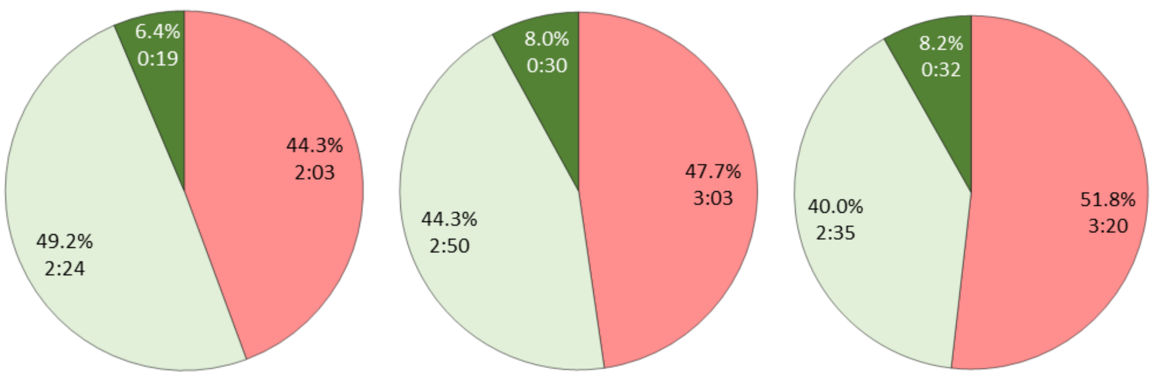
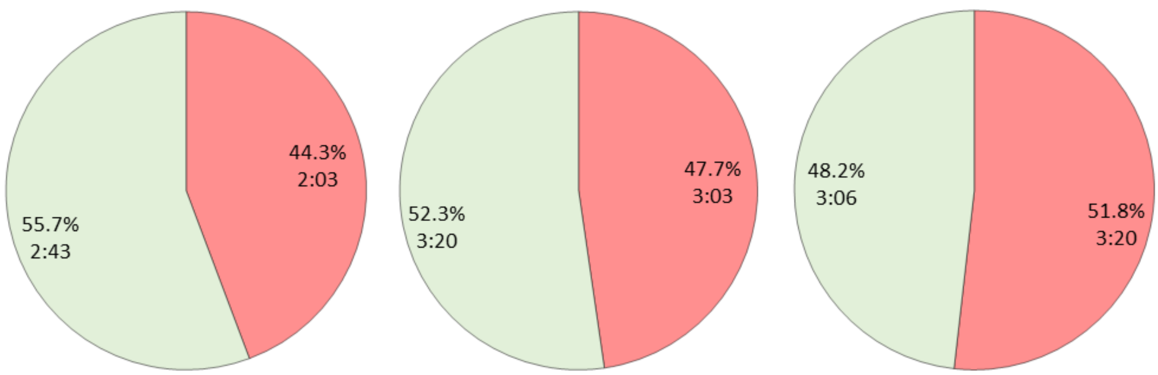


Figure 5.32 Mean percentage and time per whole school day spent in physical activity behaviours: comparison of lower (left), middle (centre), and upper (right) primary students.

Table 5.5 Physical activity behaviours per whole school day: comparison of lower, middle and upper primary students.

	Lower Primary	**Middle Primary**	**Upper Primary**
Mean (SD) time wearing accelerometer per school day	4:46 hours (1:17)	6:23 hours (0:10)	6:27 hours (0:01)
Mean (SD) sedentary bout (mean time sitting before standing)	21 minutes (10)	14 minutes (2)	14 minutes (1)
Mean (SD) maximum sedentary bout (mean maximum time sitting before standing)	35 minutes (17)	19 minutes (7)	22 minutes (4)
Mean (SD) daily step count	7,277 steps (2842)	9,518 steps (1257)	10,118 steps (1352)
Mean (SD) steps per minute	25 steps (5)	25 steps (3)	26 steps (3)
Percentage of students achieving at least 30 minutes MVPA per school day	18% (n=2)	59% (n=10)	67% (n=6)

Many studies have reported that students' MVPA declines as they age (see for instance McCarthy et al. 2021); however, this is not the case in the case study school (see Figure 5.32). Across the whole school day, a mean of 6.4%, 8.0% and 8.2% was spent in mean MVPA by the lower, middle and upper primary students, respectively. By combining light physical activity and MVPA into a single 'active' category, then a decline of total physically active behaviours and an increase in sedentary behaviour is seen as students age (see Figure 5.33). This is consistent with previous studies on the decline of total physical activity as children's age increases (see for instance Farooq et al. 2018). However, the decline is minor, with no statistically significant differences between sedentary or MVPA behaviour by participating students. The only statistically significant difference is that the lower primary students recorded significantly higher light physical activity when compared to the upper primary (see Appendix 10.6).



■ Sedentary ■ Active

Figure 5.33 Mean percentage and time per whole school day spent in sedentary and active behaviours: comparison of lower (left), middle (centre) and upper (right) primary students.

Comparisons of mean and mean maximum sedentary bouts in the three observed classes demonstrate differences in students' behaviour, but this data type can be skewed by individuals who were highly sedentary. As previously stated, a sedentary bout was at least 10 minutes of constant stillness (Chinapaw et al. 2014). As shown in Table 5.5, the mean sedentary bouts during the whole school day were 21 minutes for lower primary students and 14 minutes for both middle and upper primary students. The mean maximum sedentary bout was significantly higher by the lower primary students (35 minutes), when compared to the middle primary students (19 minutes) and upper primary students (22 minutes). According to Diaz et al. (2019), the lower primary students mean maximum was a moderate sedentary bout (between 30 and 59 minutes), whereas the middle and upper primary students mean maximum was a short bout (fewer than 29 minutes). However, it is important to note that the mean maximum was the longest bout of sedentary behaviour by each student across the whole data collection period, so it does not necessarily reflect habitual behaviour. So, if each student remained still for one long sedentary bout each fortnight, then the mean maximum would be high. For example, during assembly on Fridays, students were generally expected to remain seated for the entire event, which ran for an average of 54 minutes on observation days; however, students were generally less sedentary during other class times, as will be discussed below. The maximum length of sedentary bouts recorded at the case study school was 55, 31 and 25 minutes for lower, middle and upper primary students, respectively. So, for lower primary students, although the percentage and total time spent in sedentary behaviour was less, the bouts of sedentary behaviour were longer than the middle and upper primary. It should also be noted that two students did not record any sedentary bouts during the data collection period demonstrating that they moved at least once every 10 minutes, which was not reflected in the analysis of sedentary bouts.

Comparing Classes Physical Activity during Class Time

Comparisons have been made between the physical activity behaviours of the participating students in each classroom during class time (as shown in Figure 5.34 and Table 5.6). Class time excludes recess time but includes formal fitness and sports. Classes were scheduled 8:30 a.m. to 12:30 p.m. and 1 p.m. to 3 p.m. Monday to Thursday and 8:30 a.m. to 1 p.m. and 1:30 p.m. to 3 p.m. on Fridays; however, there was no school siren, so these times were flexible. During observation periods, I recorded specific class times for further accuracy. During class time, the lower primary students recorded higher levels of light activity and lower levels of sedentary behaviour than the middle and upper primary students. All three classes recorded similar levels of MVPA during class time (between 5.5% and 5.7%). The proportion of class time spent in MVPA is low compared to results from another study based in Perth, WA, primary schools by Martin et al. (2013). They reported that mean class time MVPA was 11% for girls and 12% for boys, but this average was highly varied across individual schools, ranging from 1% to 28% of class time (Martin et al. 2013).

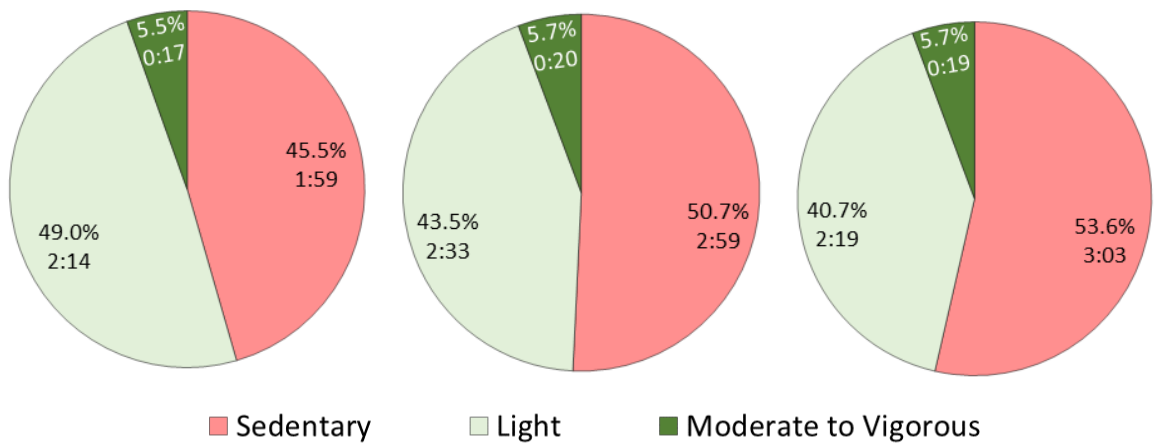


Figure 5.34 Mean percentage and time per class time per day spent in physical activity behaviours: comparison of lower (left), middle (centre) and upper (right) primary students.

Table 5.6 Physical activity behaviours per class time per day: comparison of lower, middle and upper primary students.

	Lower Primary	**Middle Primary**	**Upper Primary**
Mean (SD) time wearing accelerometer per day	4:38 hours (1:02)	5:52 hours (0:10)	5:41 hours (0:07)
Mean (SD) sedentary bout (mean time sitting before standing)	19 minutes (6)	14 minutes (2)	13 minutes (1)
Mean (SD) maximum sedentary bout (mean maximum time sitting before standing)	34 minutes (15)	19 minutes (6)	19 minutes (5)
Mean (SD) daily step count	6,690 steps (2357)	7,596 steps (1000)	7,975 steps (968)
Mean (SD) steps per minute	24 steps (5)	22 steps (3)	23 steps (3)

The mean daily step counts of the participating students are different to the findings from a study by Clemes et al. (2016), which studied the intervention of sit-to-stand desks in Australian and UK primary school classrooms during class time. Clemes et al. (2016) reported that Australian students' mean daily step counts during class time were between 3,209 and 3,356, even with sit-to-stand desks installed. These results are much lower than the mean daily step counts of the participating students in this study.

The sedentary behaviours of the participating students are also different to the findings from Clemes et al. (2016). The study found that Australian students in traditional classrooms were sedentary for between 64.8% and 70.8% of class time, which decreased to 58.5% with sit-to-stand desks installed (Clemes et al. 2016). The case study students spent a mean of 49.9% class time in sedentary behaviour, which was lower than both the baseline and follow-up post-intervention in the Clemes et al. (2016) study. Although these comparisons of sedentary behaviour are helpful to understand how the case study compares to others in Australia, the participating students in the case study school were still sedentary for close to, or slightly more than, half of their class time. Other comparisons between the two studies are limited because the Clemes et al. (2016) study did not report on the intensity of physical activity behaviours due to the type of accelerometer (activPAL) used. They did also report the proportion of time spent standing and walking, in other words, non-sedentary time, which is the inverse of the earlier comparison. A more recent classroom intervention study by Clemes et al. (2020) used both the activPAL and the ActiGraph accelerometers, which provided information on the intensity of physical activity behaviours of students in the UK; however, comparisons cannot be drawn because results summarised physical activity behaviours during all waking hours rather than during class time only.

Comparing Classes Physical Activity during Recess

Comparisons have been made between the physical activity behaviours of the participating students in each class during recess. Recess time includes only the 30 minutes spent in the play area after lunch each day, which was scheduled 12:30 p.m. to 1 p.m. Monday to Thursday and 1 p.m. to 1:30 p.m. on Fridays. During the observation period, specific times were noted for further accuracy, but inaccuracy was possible during non-observation days due to the flexibility in the school timetable. During recess time, all three classes recorded quite different physical activity behaviours (as shown in Figure 5.35). Middle and upper primary students recorded similar levels of MVPA, but differing levels of light and sedentary behaviours. Lower primary students recorded the lowest levels of MVPA and highest levels of light activity. The middle primary class did not have any inside recess during observation. There were no sedentary bouts recorded during recess, so although students spent on average between 13.4% and 26.6% of recess time in sedentary behaviours, the bouts of sitting or lying were very short (fewer than 10 minutes). Although expected, the mean steps per minute during recess were significantly higher than class time, with an increase of 22, 40, and 33 steps by lower, middle and upper primary students, respectively.

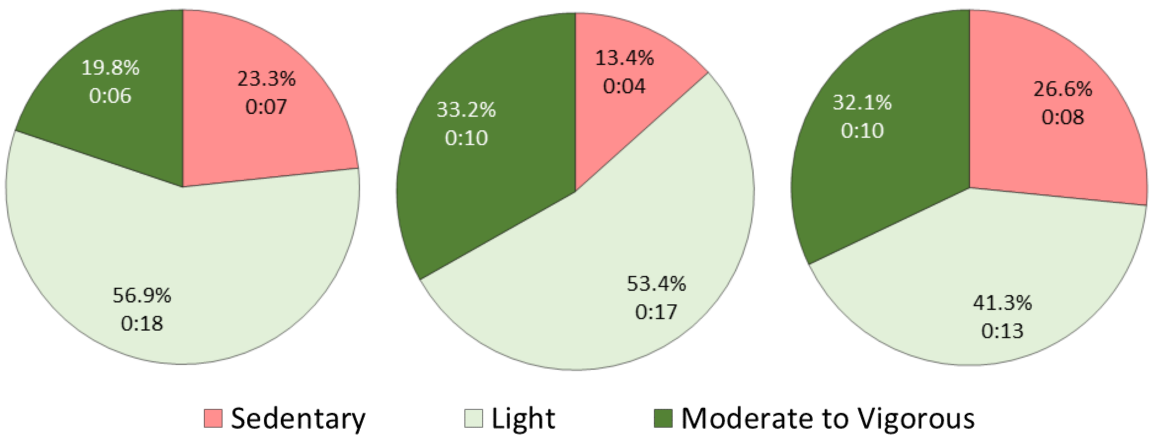


Figure 5.35 Mean percentage and time per recess time per day spent in physical activity behaviours: comparison of lower (left), middle (centre), and upper (right) primary students.

Table 5.7 Physical activity behaviours per recess time per day: comparison of lower, middle and upper primary students.

	Lower Primary	Middle Primary	Upper Primary
Mean (SD) daily step count	1,447 steps (371)	1,917 steps (412)	1,703 steps (477)
Mean (SD) steps per minute	46 steps (11)	62 steps (13)	56 steps (16)
Percentage of students achieving at least 40% MVPA per school day	9% (n=1)	55% (n=6)	33% (n=3)

The proportion of recess time spent in MVPA is low when compared to results from another study based in Perth, WA, primary schools by Martin et al. (2013). They reported that mean recess time spent in MVPA was 27.4 minutes or 45.7% of the average 60 minutes recess time; however, this average varied significantly across individual schools (Martin et al. 2013). The average time spent in recess is considerably less at the case study school, with 30 minutes per day in recess, which is half of the average reported by Martin et al. (2013); this is likely because the students in case study school have both morning tea and lunch inside, so recess is strictly playtime. However, the proportion of time spend in MVPA during that recess time is lower than the averages reported by Martin et al. (2013), especially for lower primary participating students.

There is no current consensus for the proportion of recess time that should be spent in MVPA, with Stratton and Mullan (2005) recommending 50% of recess time, and Ridgers, Stratton and Fairclough (2005) suggesting 40% of recess time spent in MVPA is a more 'achievable' goal. As can be seen in Table 5.7, only one (9%), six (55%), and three (33%) lower, middle and upper primary students, respectively, were spending over 40% of recess time in mean MVPA per school day. In a recent Australian study, McCarthy et al. (2021, 3) found that only '3.8% of students met break time guidelines, spending at least 40% of break time in MVPA'. In comparison to the Australian study, a much higher proportion of total participants (32% n = 10) in the case study school were meeting the 40% threshold; however, only 10% (n = 3) met the higher threshold of 50% of recess time spent in MVPA.

Recess was affected by weather conditions, and during periods of rain, recess was held inside classrooms with students provided with predominantly sedentary activities such as chess, drawing or games such as board games. During the observation period, the upper primary had two days of inside recess, and the lower primary only had one day where inside recess games were briefly brought out, but the rain cleared shortly after, so the students went back outside to play.

Observations in Classrooms

In this section, I discuss the key qualitative observations of student movement made in the case study school with a focus on the influence of the physical learning environment. I conducted ethnographic observations of each nominated classroom for five school days. I observed numerous physical factors that influence student movement, including the acoustic design and the furniture arrangements encouraging light physical activity. I also observed numerous social and organisational factors such as the classroom schedule, the teachers' control of MVPA and sedentary behaviour within classrooms and the students' choice of furniture or work area. In this section, I highlight the similarities and differences observed between the three classrooms.

Observations of Movement and Classroom Schedule

In the observed classrooms, the students arrive and greet their teacher each morning. In the observed lower primary class, the teacher opened the door at around 8:30 a.m. and greeted children by shaking their hand and saying ‘good morning, [name]’. Once all the children waiting were greeted, the teacher would often close the door to begin assisting students with their work. Students arriving late would knock on the door and wait to be greeted by the teacher. As students entered, they put their bags in the allocated cupboard and then enter the classroom proper. This differed from the middle and upper classes, where students placed their bags in the allocated cupboard first before going to shake hands with the teacher. Across all three classes, some students would put their accelerometer on straight away, and others would wander around first and then either remember their accelerometer or be asked if they wanted to wear it for the day. Some students would go straight to retrieve their first task of the day, but many students would wander around the class first. By 8:45 a.m., most students had started their first task; however, some students frequently arrived late, closer to 9 a.m.

The classroom schedules in the case study school follow a rough timetable but are flexible and change to accommodate daily changes. Discussion of the Montessori method often states that the classroom does not have a timetable, and students are able to complete tasks as they see fit throughout the day (Lawrence and Stähli 2018). This was not the case within the case study school and does not seem to be what was intended by Montessori. Montessori (1909) writes about the day’s schedule and describes the types of activities that should occur each hour. For example, Montessori (1909, 154) states, ‘the first hour (9–10) was for entrance, greeting, cleaning, and conversation’. The basic timetable followed by the case study school was learning from 8:30 a.m. to 12 p.m., including a short break for morning tea; lunch from 12 p.m. to 12:30 p.m.; recess from 12:30 p.m. to 1 p.m.; and learning from 1 p.m. to 3 p.m. This schedule alters on Fridays because the whole school meets in the hall for assemblies, and then each class shares morning tea. Lunch and recess on Fridays were then generally pushed back by half an hour. The final half an hour of each school day was predominantly spent cleaning up the classroom.

Each class also had other daily or weekly schedules that influence students’ movement, with each class undertaking drama, music, Italian, fitness and sport at specific times each week. Both the middle and upper primary classes start the day with maths each morning. At the end of the day, while waiting for parents to collect the students, the lower and middle primary teachers generally read a book to the students, and the upper primary students are allowed to do quiet tasks such as reading or drawings on their own. The timetable is quite flexible as there is no schoolwide siren system, so the schedule can vary from classroom to classroom and day to day. During observation days, the schedule varied by up to 18 minutes. To replace the siren, each classroom had their own system. For example, the observed middle and lower primary classrooms use a traditional metal bell, and the upper primary classroom had a 'singing bowl'. These bells and bowl were used to signal timetable changes and also to draw students' attention to issue instructions.

Observations of Acoustic Design Influence on Students' Physical Activity Behaviours

The acoustic design of the case study classrooms was observed as influencing the physical activity behaviours of students. Many materials in all observed classrooms were quite hard, including plasterboard, glass, vinyl, timber and laminate, which reflect sound around the room, and therefore, classrooms can become noisy quite quickly. This provides a challenge for the Montessori method and affects the behaviour of students. As students are often working on different tasks simultaneously, some students require a quiet environment to concentrate, whereas others require collaboration with peers or physical movement around the classroom. This means that students who are talking or moving are often asked to be quiet or remain still to keep the acoustic levels to a minimum. In the lower primary classroom, Italian lessons are taught outside in the courtyard in small groups that seemed to be grouped by age. The Italian lessons are quite noisy, with students singing and talking, so the courtyard provided some acoustic separation from the rest of the students to minimise disruption. However, when Italian lessons are taught in either the observed lower primary courtyard or the neighbouring courtyard, the movement and noise catch the students' attention, even with the sliding doors closed.

In the middle primary classroom, I observed the classroom bell rung frequently by students who then asked their peers to quieten down if they were being disturbed by too much noise. On one occasion, I observed a middle primary student ask everyone to be quiet, adding 'especially those on the echo-y area' and pointed to the vinyl area next to the kitchen. This demonstrates an awareness by students of the effect of the acoustic design of the classroom on sound levels and the influence noise can have on student learning. In the middle primary classroom, there was a large round beige rug on the floor in front of the cupboard where students store their backpacks, which helped absorb noise from this high traffic area. Acoustic problems were also noticeable in the upper primary observed classroom, as the elevated timber computer area was a framed timber box and amplified sound like a drum, so footsteps and dragging chairs could be quite loud. A large rug was placed on the deck, but it did not cover the whole deck and was only partly successful at absorbing noise. These acoustic issues could be overcome with the addition of softer materials such as carpets, fabrics or acoustic panels, potentially on the ceiling.

Observations of Limited MVPA in Classrooms

During my time observing each classroom for five days, I noticed that students moved around the classroom and school frequently, but it was highly controlled by the teacher. Students were generally able to move freely around the classroom if they were completing a task and were often quite active between tasks, so they would frequently run, skip or walk around the classroom. However, if students were running, they would be very quickly asked by all teachers to slow down. The teachers influenced the movement of students through general classroom rules and specific instructions issued throughout the day. This was observed through numerous examples within each classroom. In all observed classrooms, students were permitted to walk around the classroom if it was part of the task they were completing, for example, if they were walking around collecting materials before sitting down to complete the task. In the upper primary classroom, when students ran through the front door, the teacher would ask them to go back out and come in the back door calmly and quietly, which made students aware of their behaviour and gave them time to calm down before re-entering the classroom. The upper primary teacher discussed how they arrange tables to block any straight paths, so students must 'zig-zag' through the class to stop running and prevent injuries (interview with upper primary teacher, 30 November 2018). This demonstrates the teachers' environmental competence to use the classroom furniture to their benefit. In the middle primary classroom, I observed one student trip over from running, and I noticed that students who were generally well behaved were often not told off for short bursts of running inside the classroom. Students would frequently stand or walk around to observe other students working while they were between tasks. I noticed that students who knew where they were going tended to move much more quickly, whereas if they were trying to decide on a task, they moved very slowly around the room. In the lower primary class, the teacher would sometimes recommend that students sit in the 'observation chair' if they wanted to observe other students, which limited physical activity. This was also often used as what I would describe as a 'naughty spot' where students were told to sit and observe the good behaviour of other students.

Observations of Sedentary Behaviour in Classrooms

The teachers also controlled students' sedentary behaviour during class time through direct instructions. During sedentary-based tasks, students who fidgeted in their seats, knelt on chairs or stood at tables were often asked to 'sit properly' (in other words, sit still facing the table), regardless of the student's attention to their task. In some instances, the teachers would physically move the chairs of students sitting 'incorrectly' to be straight to the table. Students who were sitting 'properly' but not working on their task (generally talking with others) were often not spoken to by the teacher. This was most prevalent in the middle and upper primary classes as the lower primary classroom had primarily single desks, so tasks at a table were completed individually; therefore, there was minimal chatting at tables. The control of students' sitting posture by teachers was an unexpected observation. I observed that the acceptable behaviour was generally dependant on the task being completed. For example, during art lessons, students were permitted to stand at tables, but if they were completing maths tasks, then they were expected to be sitting 'properly'. This control of sedentary behaviour could limit the smaller movements by students, which could increase sedentary bouts.

Most learning tasks directed students to be sitting on a chair or the floor; however, many of these tasks could also be completed at a standing table if different height tables were available. After the observation period, the upper primary class installed some standing height tables. Lower primary tables may not need to be any higher for young students to stand; however, they may need to be heavier, so they do not move when leaned on. In the middle primary class, I observed some students standing and kneeling at tables for short periods; however, the comfort of the student seemed to depend on both the height of the student and the task being undertaken.

For example, on one occasion, a taller student was kneeling at a table when packing away stationery, but another shorter student then began to help while remaining standing at the table. On another occasion, a student seemed to change from standing to kneeling when they started writing, which suggests certain tasks require more height-appropriate tables. A teacher also gave this particular student a chair when they noticed them kneeling at the table.

Many learning tasks that I observed in the observed classrooms were quite sedentary, although most were completed quite quickly by students. For example, most mornings, the students in the upper primary classroom sat on chairs at tables to complete maths exercises where they remained seated until they completed the task, which ranged from 15 to 30 minutes. Most tasks across all classes take no more than 30 minutes to complete, so sedentary behaviour generally did not last for extended periods. Some tasks for younger students only take 10 minutes, but it seems dependent on how long a student wants to take. Some rush through the task if they want to finish quickly and may skip steps of the task to make it quicker to complete. Although most tasks were quite quick, one student in the lower primary class was observed doing the same task for the whole day and then needing to complete it the following day. The task was a purely sedentary task for maths, and it seemed that the teacher instructed them to continue working on it. The student seemed unmotivated to complete the task and would often drop objects on the floor and then stand up to pick them up. The student was also distracting other students by talking to them, and the teacher asked them to keep working many times.

Observations of Light Physical Activity in Classrooms

Although many tasks were sedentary based and students were expected to remain seated while completing, the students were expected to move around the classroom to collect the resources (such as books or stationery) they needed when they needed them. The placement of resources such as stationery, books, materials and student drawers at different places around the perimeter of the classrooms ensured that students were active during tasks and between tasks. The upper primary teacher said ‘the classroom was designed, the tables were specifically in certain places so that the children have the freedom to choose where they’re sitting and who they sit with as long as they were being productive’ (interview with upper primary teacher, 30 November 2018). They also stated that ‘the kids in this age group like to run so the tables were strategically put in a place which would block the motion of running' (interview with upper primary teacher, 30 November 2018). So, the students were expected to walk through the class to avoid accidents and should only be moving around the classroom 'for a direct purpose'—in other words, to obtain their resources.

The upper primary students were given significant freedom to move around the school campus. They were allowed to move freely between their class and the other upper primary classroom on the east side of the piazza. Some lessons were scheduled with students from both upper primary classes. If this were the case, a student from the classroom where the lesson was scheduled would be asked to walk across to the other class to collect certain students. Students generally use the front door and cross the middle of the piazza, but if it were raining, the students would follow the verandah around the edge of the piazza. The upper primary students used the main piazza for morning tea and lunch when the weather was nice. Some upper primary students from the other classroom also used the piazza for morning tea and lunch even though they had access to a private courtyard. This choice seemed to be based on friendship groups. The piazza was also used during learning activities. One group of students used the piazza when working on their laptops but sat directly outside the classroom on the bench. Some students also took their books outside to read in the sunshine. The upper primary students did not ask the teacher's permission before going to the bathroom, but they would ask permission before visiting the library. To visit the library, students would use the back door. When the students would travel through the school as a whole group for fitness or sport, the teacher asks them to line up in single file along the south wall of the bathroom. They did not leave for the north playground until all students were lined up and quiet.

Many learning tasks specifically included light physical activity. For example, in the lower primary class, some tasks for younger students involved walking numerous objects from a shelf and to their mat multiple times as students were told to carefully carry one object at a time. The student would then complete the task. When instructed by the teacher, the task would sometimes also involve carrying the objects to a second mat on the other side of the room. However, the physical activity was generally not essential to completing the task, and I did not observe any students replicate the additional physical activity unless specifically instructed by the teacher at the time. In other words, when students repeated the task, they only used one mat and therefore limited their incidental physical activity. When the task was completed, students would then carry the objects back to the shelf one at a time. They would sometimes try to carry more than one object at a time, but if the teacher noticed, they would ask the student to go back and just carry one.

In the observed lower primary classroom, the students use the large oval vinyl sticker on the floor as a meditative practice by slowly walking around it. This was generally used after recess, where students were given a choice to either sit quietly on the red carpet or walk heel to toe around the oval line. Usually, half the students chose to walk, and the other half chose to sit still. Some lower primary students also walked around the oval during the day throughout class time. Often, if one student started, another will quite quickly join in; however, if the teacher saw more than one student at a time walking around the oval during class time, they would ask the additional students to find another task.

Observations of Students Choice of Furniture and Work Area

The lower primary students have a range of furniture options and choice of work areas, but many are dictated by the type of task being undertaken. Nearly all (except one) lower primary tables are single tables, so most tasks are completed individually; however, some tasks that can be done on the floor mats are undertaken in pairs or small groups. The single tables are lightweight timber, so when students stand up and lean on them, they move; however, I did not observe any students move the tables purposefully. In the lower primary classroom, the students tended to gravitate towards the carpeted area in the mornings; however, some tasks that could be messy, such as pouring lentils or spreading vegemite, were required to be completed on the vinyl area. Usually, when a lower primary student selected a new task, they would pick up the task of the tray, which holds the necessary items, and then take it to an empty table. Most students tended to choose the closest available table, which limited physical activity. However, if the chosen task required a mat (small rectangular carpet roughly 0.5 x 1 m), then they would put the task down and obtain a mat from the box by the front door and return to place the mat in their chosen location. Most lower primary students chose to place their mat onto the carpeted area, but this area would fill up very quickly, and sometimes, the teacher asked students to move their mat to ensure they had enough space to walk around. If the carpeted area was full, then students placed their mat inside the oval line on the vinyl area. I did not observe any students placing their mat near the red carpet or the kitchen. The preference to work on the carpeted area could be due to the carpet itself being more comfortable to sit on or the overall feel of that area. The ceiling was lower over the carpet area, and due to the use of shelves and pot plants to create articulation, the scale of the spaces could feel more comfortable for the students. When they work on the vinyl area, which is very open, with tall ceilings, the students may feel more exposed (see Figure 5.36). The lower primary classroom also had the timber structure along the west wall, and while the window seats were rarely sat on, some students did gravitate towards this space when they were in between tasks.

Figure 5.36 Lower primary observed classroom view to the entrance.

Most tasks in the lower primary classroom require students to be sitting on a chair, at a table or on the floor. However, some tasks did encourage walking, such as gardening outside or the tasks with blocks where students carry one piece at a time to their mat and back again. I also observed some tasks that required standing, which included cooking, language at the long table next to table nine, bells on the step in the northwest corner and painting outside. The lower primary courtyard space could be used during the whole year, but it may be unpleasant with strong wind or heavy rain. The lower primary students frequently use their courtyard when weather permitted, but only specific tasks were to be completed outside, so some students used the courtyard more than others. On one occasion, the teacher asked a student to come back inside and said, ‘you can’t go outside for the rest of the day until you have had more lessons out there’, which suggests that the youngest students (aged three) who have not learned to complete the tasks outside correctly should not be using the space. The four-year-old students tend to complete the most outdoor tasks, and the oldest students (aged five) did not seem interested in doing the tasks in the courtyard. Students were generally not allowed to carry an ‘inside’ task into the courtyard; however, on one occasion, a lower primary student asked a teacher if they could take their task outside, and the teacher opened the door for them to go outside and sit at the table. So, there is some flexibility in the use of the outdoor space with teacher permission, but this is infrequent. Lower primary students seem to forget there were tasks to undertake outside until one student goes out and usually others follow shortly after. For example, on one occasion, a student went into the courtyard, and within 10 minutes, an additional four students also went outside; however, the assistant teacher asked them to come inside as they were told they were being silly. Two students remained outside busily completing various tasks, and after 10 minutes, a third student joined them outside.

The middle primary classroom offers little choice of furniture, but students were able to choose the area of the classroom to work in. The furniture was primarily single or double tables with chairs quite similar to what is used in traditional classrooms. In the middle primary classroom, most tasks that involve writing were completed at the double tables on the carpet area. Due to higher student numbers, some students also sat at the tables on the vinyl area, but usually only if all the double tables on the carpet area were full. Middle primary students generally did not choose to use the single tables, but students who were being disruptive were asked by the teacher to sit at the single tables. During lunchtime, the middle primary students chose to fill up the tables on the vinyl area first before spreading onto the tables on the carpet area. Messy tasks such as art were always undertaken at the tables on the vinyl, but I did observe one student take painting onto a table on the carpet before being asked by the teacher to move onto the vinyl. This suggests that students’ environmental competence was quite good but still required some guidance from their teachers.

The large tables pushed against the back of the middle primary kitchen bench were infrequently used for learning tasks, but the tables were often covered with piles of student work such as art, so the students would sometimes stand at the tables to look through the work to collect their own. A large fish tank was placed on one of the tables, which made the tables seem quite permanent and created a stepped height kitchen island bench. However, the lower tables were not used during cooking and instead acted to block a larger number of students cooking as only the 'internal' sides of the kitchen benches were used during cooking. The kitchen benches were too high for shorter students who needed a step stool, but they would have been able to use the lower tables if these were made available.

Middle primary students completed some tasks, such as reading on the carpeted floor, but this was fairly infrequent during my observation. Although the middle primary students altered very few things in the classroom, I believe this was due to the weight of the tables and the classroom rules. However, I did observe one student chose a book during a silent reading session and then spin the armchair around so they were facing the small bookshelf with their back to the classroom. During the observation period, the middle primary courtyard was infrequently used for learning tasks and was mostly used as a thoroughfare for students moving between the classroom and spaces to the south, such as the admin area. It was once used by three students to read quietly, once by two students for the outdoor sink, once for multiple students collecting plants for art, and some students infrequently sat on the edge of the planter box; however, the courtyard table and chairs were not used during the observation period.

The upper primary had a mix of tables for both individuals and pairs, but nearly all were grouped together for collaborative learning, and students were able to move some of the furniture. The southern room of the upper primary classroom looks very similar to a traditional classroom at first glance due to the tables being clustered in small groups, and the furniture was relatively standard for Australian schools. However, when the students were occupying the room, the Montessori pedagogy became clear as students worked independently and managed their own time in between scheduled classes.

In the upper primary classroom, all students generally start the day with maths, where they tend to sit at the tables on the carpet area. They would move the single tables to suit their preferences to allow them to either sit with friends or more easily see one of the whiteboards or blackboards. These students seemed to be grouped with others of the same age and often with the same sex. I believe grouping by age was due to the tasks differing, and therefore students can only collaborate with those completing the same task. This choice of location at the tables on the carpet was similar for all book-based learning tasks in the upper primary classroom, which seems to be the most comfortable for writing. However, for other learning tasks such as research, upper primary students tended to work individually and chose to sit at the tables on the deck where the computers were located. A ramp led up to the deck, but there was no railing, so users could step straight up (or down) to the deck from the ramp. However, furniture had been placed along the deck to prevent students from stepping up or down the side of the ramp. Art was usually conducted in the northern room with the vinyl floor and was often a scheduled class with all students at the same time. Very few upper primary students choose to complete tasks on the floor, although some students did sit on the floor during reading time. The students in the case study classrooms were able to choose the furniture they used and interacted with and often chose their location to work based on the task they were completing.

Observations of Teachers' Movement in the Classrooms

The teachers' physical activity behaviours in the classroom were noted during observations only in relation to its observed effects on students' movement. The lower primary teacher was quite active and rarely sedentary for long, as they did not have a dedicated seat in the classroom. They moved around the classroom as needed to assist students. In contrast, the middle and upper primary teachers were quite sedentary—they both had a seat in the classroom where they sat daily, and students would come to them for lessons and any assistance. The middle primary teacher sat on the northern part of the carpet area with their back to the wall where they could observe the whole classroom. The upper primary teacher sat at one of the large rectangular tables on the northern edge of the south room, close to the operable wall. The teacher faced south where they could observe the whole carpet area and timber deck—the areas most frequently used by students. The teacher could also see through the south facade glazing to observe students using the piazza. While the teacher could not directly see the north room since it was behind them, they were very close to hear any noises and could easily turn around to observe students. All assistant teachers were quite active, as they moved around the room to help students who needed it, as well as to complete administrative tasks. While some sources (see for instance Biddle and Mutrie 2007) suggest that students' physical activity is influenced by the teacher's physical activity behaviours, current research has not yet identified a clear link (Martin 2010). In the observed classrooms, the inactivity of the teacher provided additional opportunities for students to be active. For example, in the upper and middle primary classrooms, if students wanted assistance with their work, they would take their work over to the teacher to ask a question. There was only one student I observed in the upper primary class who yelled out to the teacher to ask a question rather than walking over. In contrast, the students in the lower primary classroom would often remain sedentary, as the teachers were more active in the classroom and would often come to them to provide assistance.

Observations of the Effects of Climate on Students' Physical Activity

The climate affected students' physical activity behaviours as play areas were not used during wet weather. During my observation period, all students took part in organised fitness and sports activities at least once per week. This was dependant on weather, as organised fitness and sports was undertaken outside where there was no shelter from the rain. Recess after lunch was predominantly conducted outside in the playgrounds, but when it was raining, the students remained in their classrooms. Interior recess was predominantly sedentary with games such as chess, board games, sketching or the use of digital devices. This occurred on numerous occasions during observation of the upper primary classroom, and students could move between the two upper primary classrooms.

The climate also influenced students' behaviour, and I observed students' awareness of the weather outside the classroom. Teachers mentioned that students were affected by both wind and the full moon. The students seem to be more restless, move more and concentrate less on windy days—even when the class was not opened up, and there was no natural ventilation. It was clear during observations that students were aware of the weather. For example, the middle primary students would ask their teacher if the UV rating was low enough during cloudy days not to have to wear hats during recess. Middle and lower primary students were directed to put sunscreen on their faces before lunch to be ready for recess. Some lower primary students would specifically look out the window and comment on the weather they could see. Lower primary students frequently stood to look out all windows. I noticed that they would stand on the timber step to look out the west windows due to the height of the windows. The timber window seats were quite high for most students—on an average height student, it was above hip height when standing on the timber step and even higher when standing on the ground.

Some students seemed more aware of and altered the physical classroom environment, and some students were aware of the effect of climate on their personal comfort. For example, the teachers would frequently open the doors or windows for ventilation, but I did not observe any students across the three classrooms doing the same. However, I did observe both middle and lower primary students closing doors to block cool breezes. This may suggest that the students were more aware of cool temperatures. On numerous occasions, the upper primary students commented they were cold and on particularly cold days would stand under the reverse cycle air conditioner near the teachers' table. The teacher suggested that these students run laps around the piazza to warm up, which some chose to do. Similarly, two middle primary students asked the teacher if they could run laps around the piazza during cold weather, but were not allowed to; one then commented it was because they loved running. On another day, a middle primary student asked if they could eat their lunch in the sun because they were cold, but again, they were not allowed, so they sat at the single table by the north windows, which was in near full sun. Many researchers emphasise the importance of indoor air quality and temperature control for health and learning (see for instance Barrett, Davies et al. 2015).

Observations of Student Physical Activity Outside Class Hours

Students' physical activity behaviours before and after school were influenced by school rules. All students were escorted into the school by their parents. Some upper primary students left their parents straight away at the road crossing or front gate and either played in the piazza or went to class. Middle and lower primary students were escorted to their classroom door by their parents, who waited for their child to enter the class before leaving. Some parents who had multiple children in different classes sometimes allowed their older children to walk to class alone from the gate, so they could escort their youngest children to class. Some parents entered the piazza and spoke to each other while their children played before walking them to class. At the end of the day, this process was repeated, with students waiting inside classrooms for parents/guardians to pick them up. However, once the students were collected from their class, the parents would often stay to talk with other parents, and the students would play together in the piazza. Due to so many parents being on the school site, there were many conversations and familiarity, which provided a strong sense of community and inclusion. This community atmosphere would not be as strong if, like many other schools, parents dropped their kids off and picked them up from the car on the side of the road. Therefore, the expectation that parents escort their children to the classroom influences the school culture and the physical activity of the students. As students were generally escorted directly to and from their classrooms by their parents, they often did not use any playground facilities before or after school.

Conclusion

The qualitative and quantitative data collected demonstrate that the case study school had non-traditional learning environments that allow students to be physically active but did not always encourage it. Although these results were from a small sample, the mixed-method research approach allows the complexities within the single case to be understood in depth. The architectural analysis presented through thick description provides a detailed picture of the whole school and the three observed classrooms. As highlighted by Bryman (2004), this allows others to decide if the findings have potential relevance or comparability to other settings. The physical activity data demonstrate that participating students are, on average, active for more than half (52.3%) of the school day and sedentary for the remainder (47.7%). High-intensity activity is predominantly gained during recess with lower, middle and upper primary students spending 19.8%, 33.2% and 32.1%, respectively, in MVPA during recess time, compared with class time where lower primary students only achieved 5.5% mean MVPA and middle and upper primary students achieved 5.7% mean MVPA. The ethnographic observations within the classrooms provide detailed information that provide context for the physical activity behaviours of participating students. The triangulation of these results provides grounded theories that are presented in Chapters Six and Seven.

6. A Place for Calm and Quiet

There are many socio-spatial barriers to improving students' physical activity behaviours in learning environments, including expectations by schools and the design of learning environments. This chapter uses analysis from the case study school to provide lessons that could be applied to other non-traditional school learning environments to improve students' physical activity behaviours. In the case study school, students were expected to remain seated during academic tasks, walk 'purposefully' through the classroom and were only permitted to run in external spaces; however, there were limited opportunities for students to achieve MVPA during class time. Movement within the case study classrooms was often considered bad behaviour due to acoustic issues, safety concerns and the distraction of other students. The second part of the chapter focuses on the spatial influences on students' physical activity behaviours that were identified in the case study school, including external classroom space, the sense of openness, furniture and acoustics.

Students are Permitted to Move Calmly in Learning Environments

The idea that movement is linked to the perception of naughtiness seems to invade the case study classrooms, even though movement is a crucial part of the Montessori method. During ethnographic observation, I noticed that movement is always required in between tasks, although this movement was not encouraged for prolonged periods. When students were moving within the classroom, they were expected to be doing so with purpose; in other words, they should not be aimlessly wandering (interview with upper primary teacher, 30 November 2018). Students were permitted to walk but not run inside the classroom; however, there were limited opportunities to run during class time. This is reflected in the accelerometer data collected at the case study school, which recorded low levels of MVPA during class time. This demonstrates the influence that social and organisational factors can have on students' physical activity behaviours. In this section, I discuss how the perceived naughtiness of movement within learning environments is linked with student discipline through primarily social and organisational factors.

Physical Activity in Montessori Classrooms

While all education systems (including traditional and Montessori) acknowledge the need for physical activity, Montessori principles encourage children to perform specific physical tasks and train specific muscles (Montessori 1909). During an interview, the upper primary teacher said, 'Montessori pedagogy has always included movement in it. Montessori saw it as being a very important part of the day' (interview with upper primary teacher, 30 November 2018). The physical body develops in parallel with mental development, and Montessori (1909) believed that activities should benefit the whole child. Montessori (1909) outlines that physical movement is built into many learning tasks to allow students to build physical strength and to achieve incidental physical activity. For example, one task in the lower primary class is the pink tower of blocks, which is a set of 10 pink cubes ranging in size from 1 cm to 10 cm, which students should stack in order. Montessori (1909) describes that students should kneel and rise multiple times to stack the tower. In reality, students can build the tower while remaining sitting or kneeling on the floor so this physical activity is not always incorporated. However, incidental physical activity was achieved in collecting and packing up the task, as students were instructed to carry one block at a time to and from their chosen workspace.

Montessori (1909) also discusses how specific tasks can be completed across two different places within the classroom, which encourages students to practice concentration and memory while they walk back and forth between two places. During the case study observations, I only observed this behaviour within the lower primary classroom, and it would likely not be appropriate for the type of tasks conducted in the middle and upper primary classrooms. In the lower primary classroom, I only observed students working across two different places when specifically instructed by the teacher, but when students repeated the task, they chose to complete it in only one place and therefore did not add the extra movement.

The tasks completed by middle and upper primary students were primarily sedentary; however, they were generally completed within 10 to 20 minutes, with light physical activity required in between tasks to put materials away and retrieve a new task. As noted in Chapter Five, participating students spent close to half of their day (47.7%) in sedentary behaviours, but the average maximum sedentary bout was 24 minutes, which is considered a short bout of sedentary behaviour in the definition by Diaz et al. (2019). The participating students were, therefore, on average, not sitting for prolonged periods.

Many studies have reported that students' MVPA declines as they age (see for instance McCarthy et al. 2021), which was not the case in the case study school. As outlined in Chapter Five, the upper primary students' mean MVPA was very similar to the middle primary students and higher than the lower primary students. Across the whole school day, a mean of 6.4%, 8.0% and 8.2% was spent in mean MVPA by the lower, middle and upper primary students, respectively. This might be due to the increased freedom of the upper primary students to roam around the school campus, and therefore achieve MVPA outside the classroom through incidental physical activity throughout the day. The upper primary students frequently moved between their classroom and the other upper primary classroom throughout the day, as well as to the library and the adolescent program buildings.

Discipline and Control of Students' Physical Activity

The expectation within the case study classrooms is that students should be in control of their behaviour. For example, when upper primary students ran through the front door, the teacher would often ask them to go back out and come in the back door calmly and quietly. This makes students aware of their behaviour and gives them the space to calm down before re-entering the classroom. Being quiet allows students to calm themselves, whether this involves being still or moving slowly. Montessori (1909) believed that students performing a task are calm and in their most natural state, whereas students who are not in control of their bodies are not calm. Montessori (1909, 406) stated that students want to be in control of their bodies, and often this involves being quiet and still: 'then we say that such children are quiet and good; external discipline, so eagerly sought after in ordinary schools is more than achieved'. However, the theory of calmness by Montessori (1909) is different to the traditional notion of controlling students by forcing them to be sedentary and silent. Montessori (1909, 127) uses the term 'discipline' and clearly outlines that movement should not be considered a bad behaviour, stating:

> The first idea that the child must acquire, in order to be actively disciplined, is that of the difference between good and evil; and the task of the educator lies in seeing that the child does not confound good with immobility and evil with activity, as often

> happens in the case of the old-time discipline. And all this because our aim is to discipline for activity, for work, for good; not for immobility, not for passivity, not for obedience. A room in which all the children move about usefully, intelligently, and voluntarily, without committing any rough or rude act, would seem to me a classroom very well disciplined indeed.

It is clear that the Montessori method encourages thoughtful movement through the classroom, which is likely to be light physical activity. In the case study school, the students were considered ‘well behaved’ when they were busily working on their tasks, whether this was sedentary, standing or slow moving. This explains why the levels of MVPA makes up only a small percentage of class time behaviours.

The perception of movement as bad behaviour within learning environments relates to student discipline and teacher control: ‘teachers commonly place value on maintaining orderly relations, and the control of noise and movement in the classroom can be seen as a measure of teaching success as much as what pupils know or have learned’ (McGregor 2004b, 16). Woodman (2016) discusses the traditional notion that movement within classrooms is not acceptable behaviour. However, they outline that as classrooms move away from traditional arrangements and students are no longer sedentary in rows, the idea that movement is bad needs to be rejected by both teachers and students. Woodman (2016, 65) states that ‘some teachers saw student movement in terms of a loss of control. In contrast, some of the interviewed students indicated that had they been offered the opportunity to be more mobile in their learning they would have respected and acted on that responsibility’. This suggests that the ability for students to remain disciplined while moving is a crucial barrier to teachers allowing more movement within classrooms. If students remain respectful in their behaviour while increasing physical activity behaviours, then teachers can retain the feeling of control of their classroom. This notion of control by teachers will be further discussed in Chapter Seven in relation to the physical, social and organisational factors within learning environments.

Inside Classrooms, Sedentary Behaviour is Expected While Working

The traditional notion that students should remain seated to complete academic work remains in contemporary learning environments, even though it is widely known that students need to move. The upper primary teacher said, ‘they are expected to sit down for periods of time and do their work so that you get that concentration flowing through' (interview with upper primary teacher, 30 November 2018). This implies that the teacher believes students concentrate more when sedentary and, conversely, that non-sedentary students were not concentrating or not being productive. This is contradictory to academic research (see for instance Lopes et al. 2016) that has shown that there is not an association between sedentary behaviour and academic achievement. There is, however, a positive relationship between CBPA (sometimes referred to as active lessons) and academic achievement and cognitive function (see for instance Donnelly and Lambourne 2011).

Students Are Expected to Remain Calm

Students in the case study school were expected to remain calm, which was often synonymous with being quiet and still. For example, before leaving the classroom for any whole class activity, the students were asked to line up quietly, and any students who were fidgeting or being noisy were reprimanded. The lower and middle primary students line up daily for recess, bi-weekly for fitness/sport and weekly for assemblies. Lower primary students were also frequently asked to sit quietly (sometimes silently) on the red carpet (see Figure 6.1) before then lining up quietly at the door. Upon first observation, this instruction seems at odds with the freedom offered to students within the Montessori framework; however, it relates to what Montessori (1909, 142) calls the 'collective order' where students learn to behave with discipline as a large group, which is learned through first learning individual control and discipline. This could be why most tasks in lower primary were completed individually or in very small groups (as pairs or trios). As students progress through to middle and upper primary, they have learned how to behave within larger groups, so the group size for lessons may increase to four to eight students. The only activities that were observed to be completed as whole classes or multiple classes was fitness/sport, music and drama, as well as recess, which was usually at the same time for the whole school.

Figure 6.1 Lower primary classroom showing the red carpet and the vinyl oval for meditating.

After recess, all students perform quiet tasks, which was described by the upper primary teacher as aiming to give the students space to bring their energy levels down after vigorous physical activity. Upper and middle primary students individually read books or draw in their sketchbooks. The upper primary students primarily spread themselves out around the classroom, so they were not too close to others, whereas the middle primary students tended to cluster together, and more students sat on the carpeted area. Lower primary students ‘meditated’ in a two-stage process, which suggests that lower primary students do not yet have the skills to calm themselves quickly. The built environment was used as the tool to facilitate this process. The red carpet was first used to contain students in one area, making teacher observation easier, but the confined space meant some students interfered or chatted with others. The younger students who left after lunch to go home or to after school care were asked to retrieve their bags and then sit on the red carpet and when their guardian arrived, they left the class. The remaining students who took their shoes and socks off as they entered the classroom remain seated on the red carpet. When they were calm (quiet and still), the teacher asked them to walk slowly around the oval line marked on the floor, placing their feet heel to toe, which again contained students in one area. The teacher walked the line with the students and often reprimanded students if they were rushing or interfering with other students. When the students were calmly (slowly and quietly) walking around the line, the teacher would ask them if they would like to start a new task. The students were able to choose any quiet task in the classroom, and most students seemed to choose a task to complete on the west side of the carpeted area, as the tasks to be completed on the vinyl would be very close to those still walking around the oval line. This example typifies how teachers communicated expectations to students for calm and quiet movement inside the classroom.

Movement Permitted, but Only with a Purpose

The upper primary teacher related that they do not want students to remain sedentary for extended periods, but they also expect students only to move around the classroom 'for a direct purpose' to obtain their resources (interview with upper primary teacher, 30 November 2018), so they should not be walking around the classroom or school aimlessly. Therefore, incidental physical activity during learning tasks was acceptable behaviour in the teacher's eyes, as long as students remain focused. All other walking or standing (and definitely running) within the classroom was generally deemed unacceptable. I observed that this became a problem when students were trying to decide on their next task to complete. For example, some upper primary students walked around the classroom watching other students work before choosing their next task. However, because these students were not walking for a direct purpose, they were often asked to retrieve a new task by the teacher, which was just another way of the teacher asking students to sit down. Likewise, in between tasks, lower primary students tended to wander around looking at others. Some lower primary students sat in the observation chair to watch others. Sometimes when students were seen wandering to watch others, they were encouraged by the teacher to sit in the observation chair instead. The observation chair was also often used as what I would describe as a 'naughty spot', where children were told to sit and observe the good behaviour of other students. This was discussed by Montessori (1909, 138) as a 'comfortable little armchair' to isolate students who were disrupting others and allow them to watch their peers at work and calm themselves. However, the observation chair in the lower primary class was not always used to calm disruptive students but merely to stop students from wandering aimlessly.

One classroom activity within the lower primary that was solely based on movement was the oval line, as previously described. In the lower primary classroom, I observed two students walking around the oval line when they arrived at class in the morning, and then a third student also joined in. The teacher then took two of the students by the hands and led them over to the shelves next to the kitchen to pick a task to complete. Later the same day, two students were walking around the oval line, making beeping and burring noises. The teacher asked one of them to choose a new task to do, and the other student stopped to tell me they were walking on the line. They completed two more laps before they moved on to another task. In both instances, the lower primary teacher allowed one student to continue walking on the oval line, which suggests that it was a task to be completed individually. This was likely because the students tend to play around when multiple students were walking on the line. This example shows that teachers did not allow students to wander around the classroom for extended periods; however, individually walking around the line could be encouraged for longer periods. Perhaps it was not the movement itself that was considered a distraction to others, but rather the associated noise. As students walk around, they sometimes sing to themselves and often talk with other students, which would distract them. Movement could create noise that could distract other students who were trying to concentrate, which is a notion discussed in the second half of this chapter. The classrooms all had sufficient open space to enable students to walk around without disturbing others, but students often chose to distract others.

‘Walk, Don’t Run’ inside Classrooms

The analysis of the quantitative physical activity data collected during class time provides insight into the behaviours of participating students and indicates there were low levels of running. To reiterate from Chapter Five, during the class time (excluding recess but including formal fitness and sports) of the data collection period, the students spent 45.5%, 50.7% and 53.6% in sedentary behaviours for lower, middle and upper primary students, respectively. The students spent between 5.5% and 5.7% of class time in MVPA, which roughly translates to between 17 and 20 minutes per day. The lower, middle and upper primary students, respectively, spent 49.0%, 43.5% and 40.7% in light physical activity during class time. These percentages and ethnographic observations show that when students were moving around the classroom, they were primarily walking, as the MVPA was likely to have been achieved during formal fitness or sports when high-level physical activity was encouraged. The low levels of MVPA could also be because of the methods of data reduction, which used a 15-second epoch length. However, due to the nature of children’s activity frequently changing and bursts of running through the class may not last more than 15 seconds, the average activity can seem lower. Due to the length of the classrooms, it could be assumed that MVPA is unlikely to last more than 15 seconds at a time, as a student could run across the whole length of the classroom faster than this.

All students were expected to walk through the class as a courtesy to others, and they were not allowed to run, to avoid accidents. I observed many times when students were asked to slow down and walk when running through the classroom due to safety concerns. During the observation period, students who were less frequently reprimanded were often not told off for short bursts of running; however, students who were more frequently reprimanded throughout the day seemed more likely to be told off for running. I only observed one student fall over due to running inside the middle primary classroom. Lower primary students sometimes jogged, skipped or twirled through the classroom but were usually only asked to slow down if they were running. The upper primary teacher said, ‘the kids in this age group like to run so the tables are strategically put in a place which would block the motion of running’ (interview with upper primary teacher, 30 November 2018). They reiterate that tables were moved to block straight paths to limit running and therefore improve safety. This will be discussed in the following section with regards to furniture arrangements, but it is clear that the teacher was aware that the arrangement of the built environment can influence the physical activity behaviours of students.

Although running was not permitted in classrooms, it was encouraged within larger external environments. For example, as discussed in Chapter Five, when the upper primary students were cold, the teacher recommended running around the piazza to warm up. Middle primary students frequently ran to the bathroom, so the location of the bathroom outside the classroom and accessed via an external pathway allowed this MVPA during class time. One middle primary student specifically said ‘I love running’ to me after they were told they were not allowed to run around the piazza. I did not observe the upper primary students running to the bathroom; however, many ran when moving between the two upper primary classrooms. Lower primary students were not given the same opportunities for running during class time because they were not permitted to leave the classroom without a teacher, and the courtyard space did not provide enough space to run.

While movement is linked to perceived naughtiness within classrooms, this seems to be more associated with the discipline of students and teachers' sense of control. While movement is described as a key part of the Montessori method, only particular behaviours were permitted. Within the case study school's observed classrooms, all types of students' physical activity behaviours were heavily controlled, including standing, fidgeting, walking and especially running. This is reflected within the quantitative physical activity results of the participating students who recorded very little MVPA during class hours. There is a time and a place for all behaviours, which can be supported through the design of the learning environments, which will be discussed in the following section.

Spatial Influences on Students' Physical Activity

The influence of the physical learning environment is a key focus of this research; hence, this section of the chapter has an extended discussion. There are numerous aspects of physical learning environments that influence students' physical activity behaviours, as identified in the case study school. In this section, I focus on four aspects of the physical learning environment: external classroom space, the sense of openness, furniture and acoustics. External classroom space, such as the courtyards attached to each of the classrooms in the case study school, provides a space for students to be more physically active. The pervasive idea that physical activity occurs outside was mentioned by various stakeholders such as teachers and architects. This idea limits the opportunities for students to be physically active because it focuses solely on activities such as running, which may need space for movement, and ignores incidental physical activity that could be undertaken indoors. In the case study school, students' behaviour was also influenced by the actual or perceived sense of openness within physical learning environments due to a students' perception of comfort and privacy; however, this is a very subjective preference. Openness in learning environments allows students to view others being physically active and encourages them to be physically active also. Various types and arrangements of furniture in learning environments can influence the comfort and physical activity behaviours of students, but they are generally not able to change this to suit their preferences. Last, in this section, I will discuss the importance of acoustic design within learning environments because noise is a key barrier to increasing student movement within classrooms.

External Classroom Space Provides Opportunities for Physical Activity

Each classroom in the case study school has a designated courtyard that is private or semi-private. The courtyards are large enough to provide some space for incidental light physical activity but not large enough for students to achieve MVPA through running, however other forms of MVPA could be achieved through activities such as jumping jacks. The observed upper primary classroom does not have a designated courtyard since the room was designed to be a library, so these students use the main piazza as their courtyard. Based on my observations and interviews, in this section, I discuss how the school (both the principal and teachers) and the architect assume that students' daily movement is primarily achieved in outdoor spaces such as the play areas and courtyards. While this might be true of the play areas, the designated courtyards are treated as an extension of the classroom where classroom rules of remaining calm and quiet apply, and the courtyards do not encourage MVPA. The exception to this was the observed upper primary class, as the main piazza is large enough to allow multiple students to simultaneously achieve MVPA through runnings, which suggests that larger shared outdoor spaces could be more beneficial to improving students MVPA during class time.

Courtyards Were Highly Valued by the School Organisation

The courtyards seem to be a key design factor that the case study school strongly values. When organising the data collection dates, the principal specifically requested that upper primary data be collected first, then middle primary and lower primary collected last as the weather warmed up towards the end of the year. This was so I could witness the lower primary students using their courtyard, which demonstrates the perceived value of the courtyard, especially to the lower primary classroom. Although scheduling data collection to hopefully gain observations during sunny weather, it rained on some days during data collection periods in all three classrooms. The perceived importance of the courtyards in the eyes of the principal does not seem equal to the actual use of these spaces. They were used daily if weather permitted, but I observed the spaces to be underutilised. Perhaps the courtyard is highly valued because this is an element that comes directly from Montessori herself. Montessori (1909, 115) stated the importance of 'ample playground with space for a garden as an important part of this school environment'. Montessori goes on to say, 'the novelty lies, perhaps, in my idea for the use of this open-air space, which is to be in direct communication with the schoolroom, so that the children may be free to go and come as they like, throughout the entire day' (Montessori 1909, 115). This demonstrates why the courtyards are valued as an extension of the classroom, but this also means that the classroom rules apply, and students are expected to walk, keep busy with tasks and respect others who are working. These rules limit the types of physical activity behaviours that can be completed in the courtyards.

Designated 'Private' Classroom Courtyards

The lower and middle primary classrooms each have a private courtyard for students to use throughout the school day; however, the designs are very different, which affects how they are used by students. The lower primary courtyard is larger and fenced in on all sides with a bigger roof, so it feels like an outdoor room with lush green plants (see Figure 6.2), whereas the middle primary courtyard is partially open to the main school walkway, with sparse plants and it feels like a thoroughfare rather than an outdoor room. The sense of privacy is created in the lower primary courtyard through the solid rammed earth walls and the solid classroom walls. This provides a very pleasant space for students to work in, and during the observation period, the courtyard was used by many students. Some of the lower primary learning tasks encouraged movement or light activity within the courtyard, such as painting, collecting herbs or watering the garden, while other tasks encouraged sedentary behaviour such as using magnets. In comparison, the middle primary courtyard has no privacy as two sides are glass walls with views from the observed classroom as well as the neighbouring classroom to the south. There are no specific learning tasks set up for middle primary students to undertake in the courtyard, which limited students' potential use of the space. As the courtyards are an extension of the classroom and students are expected to remain 'on task' with learning activities, the middle primary students were not provided with opportunities for moving around the courtyard as part of learning. There seems to be a disconnect between the value that the private courtyards hold as spaces for students to be physically active and the actual movement that occurred in the courtyards during the observation periods. In comparing the lower primary and middle primary courtyards, the lower primary courtyard provided more opportunities for physical activity because it is larger and has multiple learning activities that encourage walking and standing; however, there were no opportunities for MVPA.

Figure 6.2 Lower primary courtyard collage.

In comparison to the case study school, the Delft Montessori School designed by Herman Hertzberger creates a connected school community by avoiding unarticulated walls along main walkways by offsetting classrooms (Hertzberger 1969). Each class at the Delft Montessori School does not have a designated outdoor courtyard, but they do have an area adjacent to the entrance, which is part of the shared hall. The area has no direct function, so it is able to be used in a variety of ways by any student (Hertzberger 1969). Although the space belongs to the hall, due to its proximity to the classroom entrance, the students of that classroom can feel ownership over it and remain connected to their class. This could have been implemented in the case study school to create a greater sense of connection between the classrooms and from the classrooms to the outside environment. A lack of articulated spaces in the case study school also limits opportunities for the school community to linger in external spaces. There was also limited connection from inside classrooms to the external environment due to restricted visibility.

Shared Piazza Courtyard

The design of the school aims to be a 'village' where the main 'streets' lead off the central piazza (interview with architect A, 20 September 2018); however, in practice, this seems to be for the school community as a whole rather than the students themselves. For example, families congregate in the main piazza before and after school, but for the majority of the day, the piazza is empty. The piazza is used by upper primary students because they do not have access to a designated classroom courtyard since their classroom was designed as a library space. They sit in the piazza daily for morning tea and lunch and infrequently for learning tasks if the weather permits. Some students from the other upper primary class also use the piazza for morning tea and lunch, but this choice seems more associated with friendship groups, as many chose to stay within their designated classroom courtyard. Some upper primary students infrequently run laps around the piazza if they are cold and trying to warm up; however, there is not sufficient space for this type of running in the designated classroom courtyards. This suggests that shared outdoor spaces could be utilised to encourage MVPA and be used for learning tasks. The piazza is considerably larger than individual classroom courtyards and allows for MVPA; however, it is still primarily used for sedentary behaviours. This is because the piazza is most used during morning tea and lunch, which are not considered 'play' time within the case study school. Play is provided after lunch only when students use the two playground spaces. So, it could be part of the expected behaviour that students should not be physically active during mealtime.

Outdoor Physical Activity

Research has found that ground surfaces within the exterior school spaces affect students' physical activity behaviours, with grass and play areas generating the most time spent in MVPA (Andersen et al. 2015). Solid surfaces such as asphalt or paving had higher rates of sedentary behaviour (Andersen et al. 2015). In the case study school, the designated classroom courtyards are exclusively paved with raised planter boxes accounting for more than one-third of the floor space. The main piazza does provide the additional space required for MVPA, but it is primarily paved with only a small amount of grass. Due to the relatively small area of the designated classroom courtyards, perhaps a larger courtyard space shared between two or more classrooms could provide additional areas for students to achieve not only light physical activity but also more opportunities for MVPA. In an interview, the middle primary teacher discussed how the piazza is sometimes used for running during class time if some students are restless because there is supervision available due to the upper primary classrooms overlooking the space. The north playground would be a more ideal space for middle primary students to run due to the grass surfaces; however, the disconnection between the north playground and the classrooms reduces visibility and supervision. The north and south play areas are primarily grassed with some sand with a paved court for netball and basketball in the north play area and poured concrete paths for riding tricycles in the south play area; however, during class time, these two play areas are only used for fitness and sports, so they are not used for a large portion of the day. If these playgrounds had similar visibility from the classrooms as the upper primary class has with the piazza, perhaps these spaces could be utilised for learning tasks and MVPA during class time. A teacher at the school also stated during a casual conversation that they believed the north play area is not big enough and should be redesigned. They stated that the old school buildings that remain onsite take up a potential play area, and the school has more land available that would need a new fence to secure it.

During interviews, it was found that when discussing physical activity, most interviewees tended to think of outdoor spaces. During the interview with the architect who designed the case study school (interview with architect A, 20 September 2018), when questions centred on physical activity, the architect kept bringing the discussion back to outdoor spaces, which suggests that they assume this is where all active movement occurs. Similarly, another architect discussed how the traditional notion that physical activity occurs outside means that during the briefing stage of a school design project, the only discussion of students' physical activity occurs when discussing external landscaping (interview with architect B, 8 October 2020). However, the same architect also outlined that discussions with schools often discuss students as mobile groups moving between different learning zones (interview with architect B, 8 October 2020), which is in reference to contemporary learning environments such as NGLEs, which are quite similar to the Montessori model. So perhaps the term 'physical activity' is being confused with 'physical education', which is considered sport or fitness classes. This use of language is important to consider when disseminating research findings and recommendations to various stakeholders. The above example also demonstrates that students' movement is considered during the design phases but perhaps not thought about in depth with regards to specific physical activity behaviours or the various intensities of physical activity that are required.

Openness Allows Students to See Others Moving

The school building feels open, but the actual or perceived openness of space seems to influence the behaviour of students due to a students' perception of comfort and privacy; however, this is a very subjective preference. During observations of the case study school, this was particularly noticeable within the courtyard spaces, and the preferences tend to depend on the activity being performed. It seems that openness negatively affects comfort in the interior or semi-enclosed spaces due to a lack of privacy, but that openness within open spaces such as play areas is preferred by students. Glazing allows for visibility into and out from the interior spaces, which creates passive observation and in turn encourages 'self-awareness' and self-regulation of behaviour (McLane 2013, 132).

Openness in the Case Study School

The openness within the case study school learning environments is very different from Australian open-plan schools of the 1970s and open-plan learning spaces within contemporary schools (NGLEs). Both 1970s and contemporary open-plan schools tend to create openness with multiple classes joined together, sharing one large classroom, whereas the case study school maintains individual classrooms and creates openness within every single class. This is not the same for all Montessori schools, but in some respects, similarities can be seen between the case study school and a traditional school, as there is limited interaction between classrooms. An exception to this is that the two upper primary classrooms allow students to move between the two and often do shared tasks; however, the two spaces are completely separated and require a deliberate choice by students to move from one space to the other. The three middle primary classrooms are quite physically disconnected, but each of the three classrooms has views either into the adjacent courtyard or from the courtyard into the adjacent classroom. The only physical interaction between middle primary students is for specialty subjects such as music and sports, where they attend in groups by age rather than by class, although each case study classroom does have a range of student age groups. The north play area is shared during recess time with all middle and upper primary students. The four lower primary classrooms have a visual connection to one another. However, as previously discussed, this does not seem to be a strong connection due to lighting and reflections on the glass blocking views. They do share the play area during recess, fitness and sports.

Openness in Learning Environments Can Affect Comfort

Research suggests that openness within learning spaces has both positive and negative influences on student comfort. McLane (2013) discusses that openness and visibility are often created by including voids, atriums and glazing. The difference between permeable and non-permeable spaces is the inclusion of glass as a physical barrier while allowing for views throughout (McLane 2013). McLane's (2013) case study of a higher education building included interviews that discovered that openness and visibility have both positives and negatives. Positives include a feeling of connection to other people, a sense of spaciousness, preferred light qualities and ease of navigation; however, distraction of students, a feeling of exposure and a lack of privacy were concerns and points of discomfort: 'the sense of discomfort comes from the feeling of being watched and creates a sense of self-awareness' (McLane 2013, 132). Although the findings are based on adult students within higher education facilities, the findings may be relevant to other students, and I found parallels in my observation of the case study school. Students in all observed classes seemed to seek out their peers to maintain a feeling of connection to others. For example, in the middle primary classroom, most students choose to sit at a larger table with a partner rather than the individual tables, and in the lower primary classroom, students would often choose to place their mat on the floor next to other students' mats. The lack of privacy as a point of discomfort in spaces that were too open could explain the underutilisation of the middle primary courtyard. As described above, the middle primary courtyard did not provide similar levels of privacy as the lower primary courtyard. However, the middle primary courtyard could also be underutilised due to a lack of learning tasks that are specifically designed to be completed in the courtyard.

Openness in Learning Environments can Influence Behaviour

The influence of visual openness on students' behaviour was clear during the observation period, as students often 'followed the lead' of their peers when they have the ability to see students in other spaces. For example, students often follow others into the courtyard when they see them move outside since they can see through the glass sliding doors. This also occurs in all classrooms at morning teatime, where one student would begin eating, and others would quickly follow. This was particularly visible in the upper primary classroom, as all students were allowed to have morning tea at the same time if they wished, so most students would join in and eat together, primarily in the piazza, which was visible from the classroom. This knowledge can be used to improve students' physical activity behaviours by arranging spaces where students are able to be physically active, such as the large piazza, in full view of the learning environments to encourage more students to join in on the active behaviours. This is supported by McLane (2013, 150), who identified that glazing allowed students to 'receive visual information that tells them what is happening in these spaces, and may help decide on their decisions whether to use these spaces or not, or plan for their educational activities'.

The architectural design of the learning environment should be carefully designed to positively influence the behaviour of students by controlling visual openness through allowing or blocking students' views into and out from each zone, generally through the use of glazing or articulation of space. Spatial articulation supports students' physical activity behaviours through creating zones for active behaviours and zones for quiet tasks that are more likely to be sedentary based or include only light activity, such as standing. As was outlined in Chapter Five, spatial articulation is a particularly important aspect of Montessori learning environment design since it allows for a variety of activities to occur at one time without disruption to other students (Hertzberger 1969). However, McLane (2013) also found that spaces with no visual openness were generally underused, as there were no visual cues provided to inform students decisions to use the space. They also found 'that the more morphologically divided and dispersed spaces are, or less permeable and less visually accessible they are, the greater chance that the space users will also be divided into smaller groups' (McLane 2013 xviii). In other words, in articulated spaces with less visual openness, users will often work in small groups. This is the aim of the Montessori method. Therefore, articulated space is appropriate and could be used more in the case study school. This may not be suitable for traditional classrooms, but the same finding could be applied to other non-traditional learning environments such as NGLEs. Small articulated spaces can support users working in small groups, which is likely to be quiet spaces with sedentary or light physical activity behaviours. However, these spaces allow students to be more physically active in adjacent spaces without disrupting the students working quietly.

Furniture Directly Influences Students' Physical Activity Behaviours

The arrangement and type of furniture in the classroom can affect the comfort and physical activity behaviours of students; however, students do not hold the control in the classroom. Many elements within learning environments can influence the physical activity behaviours of students, and furniture is the element that is most interacted with by students within a classroom. When I refer to furniture, I include both built-in features such as bench seats and cabinets, semi-moveable items such as shelves, and easily moveable items such as tables and chairs. Most furniture in the case study school cannot be moved by the students, rather the architect controlled the furniture prior to occupation, and the teachers primarily control it during school use. However, the students in the case study school do have control over which furniture they choose to interact with and, at some level, how they use that furniture. This control is due to the Montessori method and would also be similar in NGLEs with contemporary pedagogy. In the 'Physical Activity Design Guidelines for School Architecture' by Brittin et al. (2015), they outline that 'furniture specifications' are an important element to improve physical activity of students in schools. Specifically, classrooms should have dynamic, ergonomic and flexible furniture (Brittin et al. 2015). Numerous intervention projects have studied the effects of sit-to-stand desks and stand-biased desks on students' physical activity behaviours in classrooms, but there remain barriers to their implementation and future use. This section outlines the influence that furniture has on the physical activity behaviours of students in the case study school and discusses the implications for non-traditional learning environments.

Furniture that Supports Physical Activity

Furniture is an important element to improve the physical activity of students in schools, and ideally, classrooms should have 'dynamic furniture that is ergonomically appropriate for age, and embraces children's natural tendency to move and fidget' (Brittin et al. 2015). Dynamic furniture such as wobble chairs encourage small bodily movements, referred to as 'micro-movements' (Garcia et al. 2016, 557), which are beneficial to children during sedentary behaviour. Brittin et al. (2015) relate that learning environments should support students developing bodies to move frequently. Brittin et al. (2015) recommend that schools implement a variety of furniture options for students to choose their workspace depending on whether they are working alone or within groups. This allows students to alter their posture and may encourage movement around the classroom. Gouvali and Boudolos's (2006) research found that classrooms must have different sized furniture to allow for the variations in the size of children within age groups. This is even more important in the Montessori school due to the differing ages of students within each classroom. For example, the lower primary classroom has students ranging in age from three to five years old.

Furniture in the Case Study Learning Environments

The furniture is quite similar across the three case study classrooms, but table heights and furniture arrangements differ according to the age of the students. Montessori (1909) was very particular about the types of furniture that should be used in classrooms, which seems to permeate the aesthetic qualities of Montessori classrooms around the world to this day. This is demonstrated in a preference for natural materials such as wood and light colours. The furniture in the lower primary classroom primarily fit the Montessori preference, with predominantly small timber desks with a single timber chair (see Figure 6.3). The desks and chairs in middle and upper primary were quite typical of traditional WA schools, including desks with laminate tops and metal legs paired with plastic chairs that do not quite fit within the general Montessori aesthetic that focuses on natural materials. The middle primary primarily had desks for pairs, with a couple clustered together for larger group work and only a few individual desks that were generally used at the request of a teacher when a student was misbehaving (see Figure 6.4). The upper primary had a mix of desks for both individuals and pairs, but nearly all were grouped together for collaborative learning (see Figure 6.5).

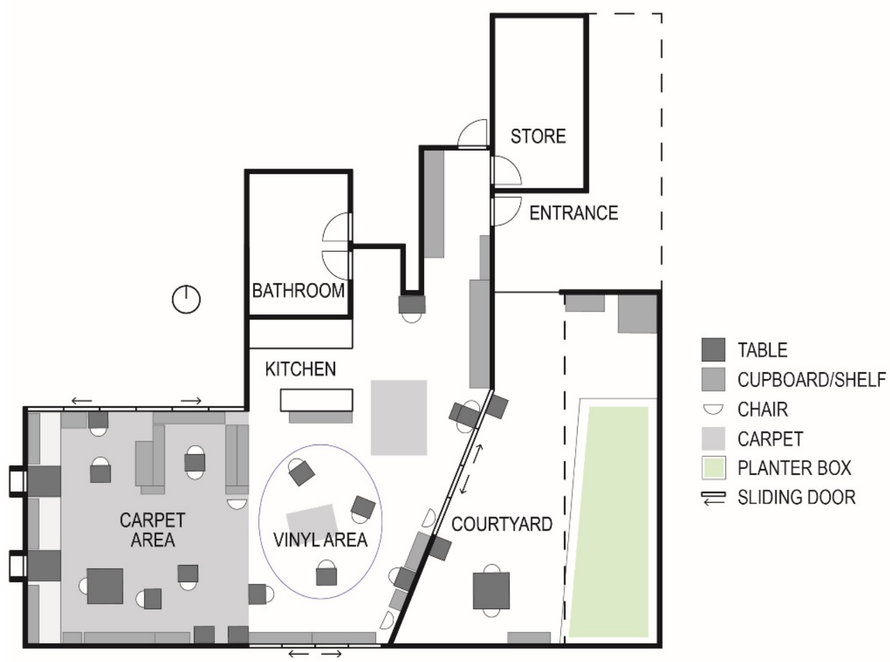


Figure 6.3 Lower primary observed classroom furniture layout diagram.

Figure 6.4 Middle primary observed classroom furniture layout diagram.

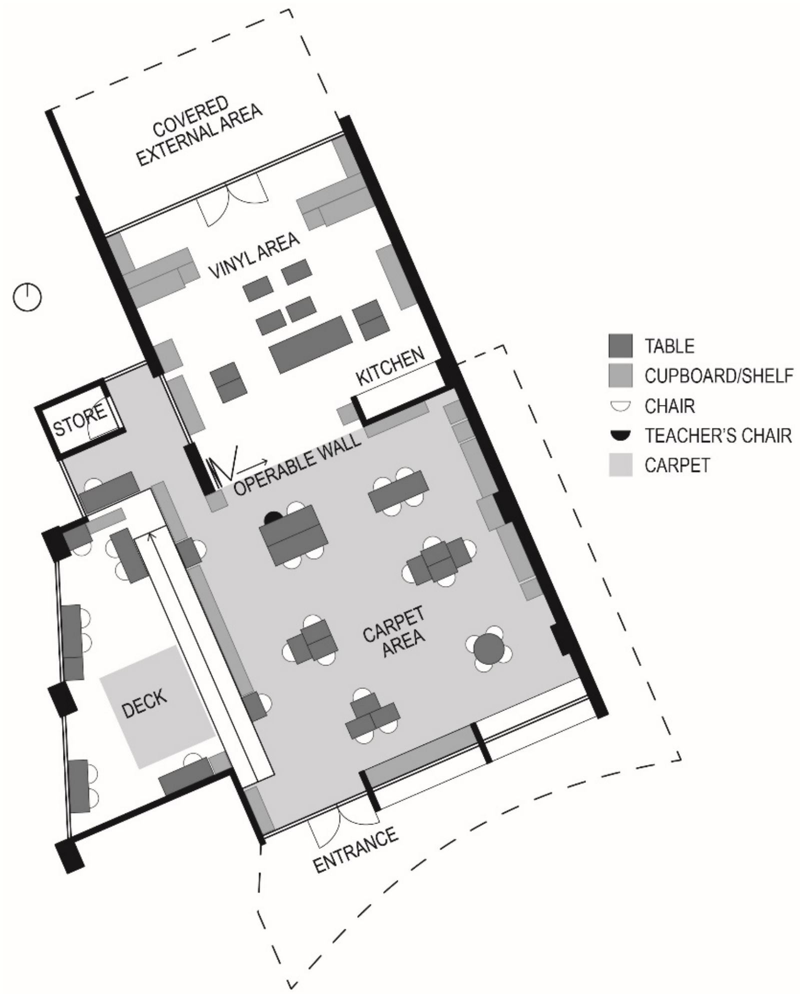


Figure 6.5 Upper primary observed classroom furniture layout diagram.

Sit Properly

The traditional assumption that students should be immobile in their chairs to effectively concentrate and learn is discussed by Montessori (1909), who advocates that children should be able to make themselves comfortable in any position they choose. Montessori (1909) states that this ability to choose is not just a sign of freedom but also a method of education in the use of furniture. For example, if a child makes themselves comfortable in a chair and, in doing so, knocks that chair to the ground, then the child can learn which bodily movements cause this (Montessori 1909). In the observed classrooms, the students were not always given the freedom to choose their own position. As outlined in Chapter Five, I observed within all three classrooms that students were often asked to 'sit properly' if they knelt on chairs or stood at tables during tasks such as maths, which are traditionally thought of as sedentary. This was most frequent in the middle and upper primary classes but did occur within the lower primary classroom. The micro-movements or light physical activity that could be achieved while fidgeting on a chair or standing at a table would be reduced if the teacher informed students to sit properly. Perhaps the request by teachers to ‘sit properly’ is due to the trip hazard of chairs. If a student stands at a desk or kneels on a chair, then it is pushed out further from the desk where other students could trip on it as they walk past. However, other options could solve this problem, such as moving the chair or choosing chairs with straight legs. The interruption by teachers to correct students’ posture goes against Montessori’s (1909) belief that teachers should observe students and only interfere when the student is dangerous, rude or offensive. However, Montessori (1909, 157) is somewhat contradictory when discussing furniture and how it is used as part of a practice of discipline where body position is important, by stating:

> The teacher explains to them [the students] that the normal position is for each child to be seated in his own place, in silence, with his feet together on the floor, his hands resting on the table, and his head erect. In this way she teaches them poise and equilibrium. Then she has them rise on their feet in order to sing the hymn, teaching them that in rising and sitting down it is not necessary to be noisy. In this way the children learn to move about the furniture with poise and with care.

Based on these contradictions, I believe Montessori (1909) views body position as important in some lessons (e.g., when learning discipline), but not in others (e.g., not when students are freely working). However, Montessori’s (1909) discussion of posture could easily be taken out of context and thought to be necessary at all times.

Flexible Furniture can Provide Opportunities for Physical Activity

Flexible furniture that can be adapted to suit various teaching goals is often desired in learning environments since it can allow for multifunctional uses. Britten et al. (2015, 17) state that schools should also ‘specify furniture with casters to promote agile configurations and novel settings’ to support students’ physical activity behaviours. In the case study learning environments, the furniture was predominantly traditional with few opportunities for multifunctional uses by students. One example of a specific multifunctional element in the case study school was the edge of the planter boxes in the courtyards designed to hold soil, but the edges were also used as a seat. Students used the multifunctional element more so in middle primary than in the lower primary courtyard, where the plants were a little more overgrown. The case study school has not implemented other multifunctional furniture elements within the classrooms, but the standard tables do allow for rearrangement. Furniture that is easily rearranged can support physically active behaviours inside the classrooms; for instance, furniture can be moved out of the way to create a large open space for movement. In the case study school, the furniture was easily moveable, but I did not observe this done to support movement specifically. For example, in the lower and middle primary classes, the tables were joined end-to-end to create a long 'dining' table for all students to gather at for morning tea after assembly on Fridays. In both classes, these table arrangements were controlled by the teacher and set up while the students were out of the class, which will be further discussed in Chapter Seven.

Flexible or adaptable furniture in classrooms can also cause problems. During an interview, an architect acknowledged that a major issue with flexible furniture arrangements is that they take time to rearrange, so teachers tend to leave the furniture as it is and work around it (interview with architect B, 8 October 2020). The architect states their opinion that:

> Rather than having flexible spaces, we should have purposeful spaces that you just go to. So I call it go-to spaces. So if you want to have a lecture go to the lecture theatre. If you want to have a sit on the floor beanbag discussion, let's go to that space. Rather than saying I'm going to turn my lecture theatre into a beanbag on the floor room. Which you could do, but it might take 15 minutes and who's got the time? (interview with architect B, 8 October 2020).

These types of purposeful spaces would also allow for incidental physical activity as students moved between the different spaces throughout the day; however, they would likely require a large floor area within each classroom or open-plan shared spaces. In the quotation above from the interview with the architect, they are not describing the case study school; however, they describe a space that would have a similar spatial organisation to the case study classrooms where there are separate zones for various tasks and the space per student is adequate (interview with architect B, 8 October 2020). The difference is that in the case study classrooms, the zones and the furniture used within each zone is very similar, rather than having different furniture for different purposes.

Spatial Articulation Limits Distractions from Physical Activity

The design of classrooms can be altered to allow for increased physical activity through spatial articulation. Hertzberger (1969) discusses how classrooms with articulated space allow for a variety of activities to occur simultaneously without distracting others. This is compared to a traditional rectangular classroom where all students can be seen from any point within the room, so any movement would be disruptive for those concentrating (Hertzberger 1969). In comparison, the articulated classroom allows for privacy by creating various zones for different activities (Hertzberger 2008). This means that an articulated classroom can have some children being physically active in one zone without disturbing students in another zone; however, this also relies on acoustic articulation, which will be discussed in the following section. Lawrence and Stähli (2018, 18) recognise the importance of articulation to create privacy and state ‘the aim is to create islands of concentration’. They discuss how articulation can be achieved through walls, variations in floor height, lighting, shelving or variations in materials. This creates a more complex space, so it is important to maintain a sense of connection to the whole classroom (Lawrence and Stähli 2018). The classrooms within the case study school were primarily articulated in an L-shape; however, due to the relatively large scale and openness with no change in floor levels, zones flowed into one another and were not clearly separated.

Spatial Articulation through the Use of Furniture

Furniture can be used to create impermanent articulated spaces that can support physical activity in learning environments and create small spaces with a sense of privacy, but this was infrequently seen in the case study classrooms. Upon the first view of the case study classrooms, it seemed the resources are spread around the classroom to encourage students to accumulate incidental physical activity while collecting resources for tasks. While this incidental activity does occur, upon further analysis, it became clear that the resources are placed along external walls or other edges, such as along the ramp within the upper primary class and along the edge of kitchen benches in the middle and lower primary classroom. This suggests that resources are generally arranged to be ‘out of the way’ of the central zones where tables and chairs are clustered. It could also be to enable tall furniture to be anchored to the wall to avoid tipping. There is a missed opportunity to create more articulated space through the use of furniture, which is thus a missed opportunity to support the increased physical activity of students. The lower primary does this somewhat more successfully than the other case study classrooms, as can be seen on the carpeted area where low shelves are used to create two smaller working areas (see Figure 6.6). In the middle primary classroom, there is one small zone created with a shelf and rug, as seen in Figure 6.7, but since the shelves have no backing, it is still quite open and gives only limited sense of enclosure. The upper primary classroom only uses furniture to articulate space in the northern end next to the back door where students store their bags, so this space is not used as a learning space (see Figure 6.8).

Figure 6.6 Articulated zones created by furniture in the lower primary classroom.

Figure 6.7 Articulated zone created by furniture in the middle primary classroom.

Figure 6.8 Articulated storage zone created by furniture in the upper primary observed classroom.

Furniture Arrangement to Create Incidental Physical Activity

Students are active during tasks and between tasks due to the placement of resources such as stationery, books, materials and student storage drawers at different places around the perimeter of the classrooms. This is slightly different in the lower primary classroom, where tasks are primarily arranged on trays that hold most materials needed for each task. For example, a task to draw a self-portrait is located on a shelf next to the desk with the mirror and includes paper and coloured pencils. Therefore, lower primary students do not need to walk around to collect paper and pencils from two different locations. However, there are other tasks in the lower primary classroom that require incidental physical activity. For example, a task that involves pouring water from a jug requires students to take the jug to the kitchen to fill it up and bring it back to the table. In the middle and upper primary classes, students usually obtain a task from their drawer or one of the shelves and take it to a table before going to the stationery shelf and retrieving a pencil. This process is repeated multiple times each day for different tasks. As previously discussed, I do not believe the placement of the resources is done with an intention to create physical activity, but rather it is an unintended outcome of the need to store a large number of materials within a limited space. While many of these types of tasks are unique to the Montessori method, the arrangement of the learning environment to support movement between tasks could be applied to other non-traditional learning environments and potentially even traditional learning environments.

Storing materials and resources around the classroom rather than in desk drawers ensures that students are active during tasks and between tasks. This offers more opportunities for incidental physical activity throughout the day than classrooms where students have a drawer under their desk for all their basic supplies and do not need to stand up and walk around between tasks frequently. This could explain the lower rate of sedentary behaviour recorded within the case study school (49.9% of class time) when compared to a study of Australian students in traditional classrooms (67.9% to 70.8% of class time) and in classrooms with sit-to-stand desks installed (58.5% of class time) (Clemes et al. 2016). However, Clemes et al. (2016) and other similar intervention studies globally often do not provide specific information about the types of desks used, especially when describing the furniture in the control classrooms. For instance, a study of New Zealand classrooms described and published photographs of the dynamic classroom (Aminian, Hinckson and Stewart 2015), but did not provide information on the control classroom. This makes comparisons and inferences difficult to draw.

The arrangement of furniture and the spread of materials around the room also relies on social and organisational factors. In the case study school, the students are provided with all their school materials, including stationery, which was described by the upper primary teachers as encouraging equality because no student had materials that were considered ‘better’ than those of another student. While this may be unfeasible in many schools due to budgetary limitations, the storage of personal materials away from desks can still be achieved to improve incidental physical activity within learning environments. The physical arrangement also relies on the classroom rules. For example, when students are allocated a seat to remain in for the term and given a drawer under the desk in which to store their materials, their opportunities for incidental physical activity are reduced. However, when students are given the freedom to choose their own place to work for each task and store their materials in a cupboard or drawer, they have many more opportunities for incidental physical activity.

Standing Desks Can Increase Light Physical Activity

Emerging evidence suggests that sit-to-stand desks and stand-biased desks can improve students' physical activity behaviours and increase energy expenditure within classrooms (see for instance Benden et al. 2011; Clemes et al. 2020). Most learning tasks across all three observed classrooms required students to be sitting on a chair or on the floor, but many of these tasks could also be completed at a standing desk if different height desks were available. As previously outlined in Chapter Three, both sit-to-stand and stand-biased desks have obvious complications due to the varying heights of students, which is especially critical in a Montessori school where the students' age ranges three years within each classroom. Stand-biased desks may be more aesthetically suitable to the Montessori environment, as they could be made out of more natural materials such as timber. Sit-to-stand desks are generally made using metal; however, the middle and upper primary classrooms do currently have desks with metal legs, so this may not be a barrier to implementation. The cost of sit-to-stand desks may also be a barrier, but stand-biased desks (with fixed-height or adjustable legs) and stools only cost 20% more than standard classroom furniture and 'other than the initial investment, schools incur no ongoing costs' (Benden et al. 2011, 1435).

Standing height desks can provide benefits to students learning as well as their physical activity. After the observation period, the upper primary class installed one standing height desk and intends to install a second slightly higher desk for taller students. Once the upper primary teacher noticed that some students wanted to stand while completing traditionally sedentary tasks, they adjusted their rules to allow students to stand at the new desk to work. After only one week of the new standing desk, the teacher had noticed a difference in the duration of concentration, which could lead to improved academic outcomes. The upper primary teacher said, 'there are some students who are very fidgety and they actually produce neater, better work with longer concentration periods at a standing desk' (interview with upper primary teacher, 30 November 2018). The improved concentration is supported by the research of Aminian, Hinckson and Stewart (2015, 643), who found that 'some children's concentration improved when they worked at height-appropriate standing workstations'. The installation of the standing desk suggests that the upper primary teacher is willing to support students in decreasing sedentary behaviours if it assists students in their learning. It also suggests that the school is financially able to purchase new furniture if the teacher sees a benefit. Montessori (1909) refers to the role of the teacher in the classroom as a director who should continue conducting experiments to understand and improve the learning of their students. Thus, the inclusion of the standing desk by the upper primary teacher is exactly what the Montessori method calls for.

In government or private primary schools, the installation of standing desks (either sit-to-stand or stand-biased desks) could be incorporated into both traditional and non-traditional learning environments. In traditional learning environments, standing desks could replace all standard desks, or a 'bank' of tables could be replaced for students to rotate through. Both of these options proved successful in the study by Clemes et al. (2016), with the bank of tables seating six children providing increased levels of physical activity due to the extra movement involved in students rotating around the room throughout the day. In non-traditional learning environments, standing desks could be provided as one type of furniture that students can choose from. The upfront cost would need to be incorporated into the school budget but these are outweighed by the health benefits to the children across their lifetime, as well as the economic benefits to society due to 'a reduction to health-sector costs' (AIHW 2018, 41).

Using Standing Desks for Learning Tasks

To accommodate standing tasks, very few changes need to be made to the classroom furniture; however, as students grow taller, higher desks for standing will be required. Students in the case study school already completed cooking while standing, although some lower and middle primary students needed a step stool because the benches were too high for them. I observed students in all three classrooms complete art while standing, although some middle primary students did sit. Lower primary students used an art easel outside in the courtyard, and upper primary students used tables in the north classroom for art, but middle primary students used the standard classroom desks on the vinyl area while making art, and some would sit while doing so. The lower primary class had two tasks in the northwest corner that were designed to be completed while standing. This includes a language activity that is on a large wooden table roughly 600 mm high (see Figure 6.9) and bells that are placed on a built-in shelf at roughly 500 mm high (see Figure 6.10). These two tasks particularly suit being completed on standing tables since they do not involve writing or drawing. In the case study school, lower primary desks may not need to be any higher for young students to stand. The individual desks used in lower primary are 500 mm high and very lightweight, so when students stand up to work, they lean on them and often accidentally move them slightly, but this occurs more on vinyl flooring rather than carpet. If lower primary students use these small tables as standing desks, there may also be more accidents with desks tipping over. However, Montessori (1909) discusses that lightness and movability of furniture should not be a reason to avoid certain activities, and they specifically note that tables and chairs should not be fixed to the floor.

Figure 6.9 Standing table for language in the lower primary classroom.

Figure 6.10 Standing shelf for bells in the lower primary classroom.

Increasing Opportunities for Standing

A combination of varying height surfaces for students to work at would be beneficial, and this would suit the current classroom organisation where students select their preferred workspace. There are already spaces within the case study classrooms that are underutilised for standing while working. For example, the kitchen is underutilised during much of the school week, but the bench height would be perfect for taller students to use as a workspace. The tops of shelves could also be used, although they would need to be secured not to tip over. The lower primary also has window seats on the west wall, which could be used as a workbench (see Figure 6.11). This also has the additional benefit of the step on the sides for use by shorter students, whereas taller students could stand on the carpet. The upper primary teacher unfolded a large trestle table during one lesson for a student to arrange leaves and small pieces of plants that they had collected from around the school. The student used the table as a standing table, although it was not much higher than the other tables in the room. This demonstrates that some tasks could be completed while standing at various height tables, but tasks such as writing should be done on a height-appropriate table. As there is an age range of three years within each of the case study classrooms and various student heights, the use of appropriate tables could be managed by the individual students themselves. Standing desks provide additional opportunities to swap sedentary behaviour for light-intensity physical activity, and they are a simple change for learning environment furniture.

Figure 6.11 Window seat and steps in the lower primary classroom.

In most schools, students are grouped in a single age level per classroom, so the range of student heights is likely to be less of a problem and even less so in NGLEs, where students have a variety of furniture options to choose from. There is the possibility that highly sedentary students will continue to choose sedentary-based tasks, so furniture alone would not make students more active, but it would remove a barrier for those students who would prefer to be less sedentary. Social and organisational factors could then be combined with the standing desks to encourage students to be less sedentary, which will be discussed in Chapter Seven.

The Importance of Acoustics

The noise associated with physical activity behaviours within a classroom can be a barrier to increasing physical activity and decreasing sedentary behaviour. The Montessori method is challenged by the noise created within the observed classrooms because students were often working on different tasks at any one time, so some students required quiet space for concentration, and others required collaboration with others or completed tasks that are inherently noisy. Therefore, the physical activity behaviours of students were affected because they were often asked to remain quiet and still. The differentiation between sound and noise is important to note because it is very subjective. Hansen (2001, 23) relates that although sound and noise are essentially the same phenomena, noise is defined as 'disagreeable or undesired sound'. So what one person considers sound could be considered noise by another person (Hansen 2001). The literature suggests that distraction by noise is particularly prevalent in open-plan schools where multiple classes work out of one larger space (Wood 2017). Lawrence and Stähli (2018) note that acoustics are a vital component of the architecture within a Montessori school. Silent environments are not the goal, but classrooms should have pleasant acoustics. The opportunity to allow sounds such as birds chirping or water flowing is considered beneficial within learning environments (Lawrence and Stähli 2018); however, these are rather vague descriptions of classroom acoustics. The acoustic design of the space is important not only in the selection of materials but also the shape of the learning spaces. Articulated space can provide better acoustics through reducing the power and direction of the noise (Hansen 2001).

Acoustics in Montessori Classrooms

Montessori (1909) discusses how lessons for the sense of hearing are achieved and specifically outlines how it relates to physical activity. To allow students to learn about hearing, Montessori (1909) says that teachers should call for silence and then whisper to the children and ask them to listen to the quietest noises, such as the ticking of the clock: 'It is necessary to teach the child the various degrees of immobility leading to silence; the movements connected with rising from a chair and sitting down, with walking, with tiptoeing, with following a line drawn on the floor keeping an upright equilibrium' (Montessori 1909, 396). Sedentary behaviour is often required to allow students to be fully aware of the noises around them and the ones they are making through their movements (Montessori 1909). Thus, there is a clear link between the Montessori method and the notion that movement creates noise. However, through the lessons with young students, they learn to move more gently to avoid creating excess noise and distracting others (Montessori 1909).

Montessori (1909) also discusses how architecture can affect a students' ability to learn to discern and control noise. Isolating each sense is critical, so a silent space is best for developing students' sense of hearing, but if this space is also dark, then it will be more effective (Montessori 1909). So, the classroom's physical environment should be able to be manipulated by the teacher for various lessons. For example, it is not ideal to have a dark and quiet classroom all the time, but it is sometimes needed for these types of lessons on the senses. This lesson in the sense of hearing seems to require the whole class to be involved to allow for a silent room, but this type of lesson did not occur during the observation period.

Noise in Open-Plan Learning Environments Is a Barrier to Physical Activity

Noise within open-plan classrooms is a crucial factor to considered in the design, but comparisons between different types of classrooms are difficult. As discussed in Chapter Two, open-plan schools have been implemented all over the world, but they were often considered failures and later divided up into traditional classrooms (Lackney 2015). Lackney (2015) outlines that when open-plan classrooms first emerged in mainstream schools, the most common complaints of teachers in the US were the noise levels and student distraction. However, Lackney (2015) also explains that these teachers often continued using traditional teaching styles that did not suit the new learning space. Shield, Greenland and Dockrell (2010, 227) summarise the data found in comparisons of noise levels in traditional and open-plan classrooms. They point out that although noise levels were often found to be higher in open-plan classrooms, the differences in student density affects the findings and the design differences may mean these data are no longer relevant for contemporary open-plan schools. They also relate that due to the general assumption that open-plan classrooms would be noisy, designers often included more absorptive materials in the first instance. Shield, Greenland and Dockrell (2010) outline that numerous studies discovered that due to the increased amount of absorbent materials that reduce reverberation times, the noise levels were actually often lower in open-plan classrooms. Airey, MacKenzie and Craik (1998) concur with this and add that the teachers in open-plan classrooms attempt to control noise by keeping students quiet and limiting noisy activities that may disturb students in neighbouring classes. So due to the complexity of factors affecting noise, direct comparisons between various classrooms are difficult.

It is clear within research on contemporary learning environments that noise is a significant issue and a barrier to improving students' physical activity behaviours. Contemporary learning environments that are often described as innovative are now turning back to open-plan classrooms or open-plan schools, which are well suited to contemporary teaching styles. This is due to the shift to student-focused learning rather than didactic teaching and the inclusion of digital devices. However, the issue of noise arising from students' physical activity within the learning environment remains a problem. Shield, Greenland and Dockrell (2010) relate that students 'perceived ability to hear their teacher' is reduced when students in neighbouring classes are physically active. Wood's (2017) doctoral thesis findings show that noise is a major barrier to teaching and learning. Although Wood (2017) does not specifically discuss noise affecting physical activity behaviours of students, it is discussed by participants in the research. An interview with one particular teacher exemplifies this when they say that when teaching probability, they would usually encourage student to move with tasks such as measuring things or throwing dice, but this would generate excessive noise (Wood 2017). So when teaching in an open-plan area, they would need to change this to a quieter activity, and they specifically mention that they might swap to using computers (Wood 2017), which is likely to be a sedentary behaviour and increase screen time. Although the government recommendations do not include educational purposes in the recommendations for maximum screen time, reducing physical activity behaviours further is not an ideal outcome. What is most interesting about Wood's (2017) research is that although the questionnaires did not ask any specific questions about noise, it was mentioned as a negative factor in 21 out of the 30 responses: 'In fact, across interviews, conversations and questionnaires, noise stood out as the single greatest cause of concern and influence on teaching' (Wood 2017).

Noise Can Be Disruptive in Learning Environments

The type of noise is an important factor to consider because noise level alone is not a strong indicator of distraction (Shield, Greenland and Dockrell 2010). For example, students may not be easily distracted by continuous noise such as that made by an air conditioner, whereas intermittent noise may be more unexpected and more distracting. A study in the UK found that children self-reported that noise made by children outside their classroom was the most distracting (Dockrell and Shield 2004). Perhaps this is why at the case study school, the classrooms were open-plan to suit the Montessori method, but individual classrooms were separated from each other, as it creates an acoustic barrier. However, during the observation period, lower primary students were still distracted by noisy lessons taking place in the adjacent courtyard, for example, when the students there were singing quite loudly. It is thought that speech is an exceptionally distracting noise. Shield, Greenland and Dockrell (2010, 227) specifically note that ‘irrelevant meaningful speech has been shown to be a particularly distracting source of noise compared to other sources at equivalent levels due to the associated meaning in speech’. Often, the noise that occurs outside the classroom could be considered ‘irrelevant meaningful speech’, but this can also occur within the classroom, for example, when a teacher is taking a lesson with an individual or group of students. In the case study school, the teachers speak softly when instructing a small group of students; however, this is still audible throughout much of the classroom. It has been reported that ‘students reported greater distraction from social conversation than task-oriented conversation’ (Ahrentzen and Evans 1984, 438), but a build-up of noise can happen regardless of the type of conversations occurring.

Acoustic Design in Observed Classrooms

Many materials in the case study classrooms are quite hard (plaster, glass, vinyl, timber, rammed earth and metal), which reflect sound around the room, and thus, classrooms can become noisy quite quickly. There are some soft surfaces (e.g., carpet and pillows) that absorb sound, but these only make up a small portion of the total materials within the classroom and are primarily located on the floor. Shield, Greenland and Dockrell (2010, 231) outline that many studies recommend that classroom flooring should ideally be carpet, ‘but this is mainly to control footfalls and other impact noise (e.g., from furniture movement) rather than to absorb airborne sound’. Shield, Greenland and Dockrell (2010, 231) also advise that ceilings should be no higher than 3.5 metres, and the material should have a minimum absorption of 90%: ‘a fully sound absorbent ceiling is highly beneficial since it not only shortens reverberation time, thus increasing speech intelligibility, but also helps to control reverberant noise build-up and noise transmission from adjacent spaces’.

The noise levels in all case study learning spaces could be lowered with the addition of more soft materials such as carpets and fabrics or with acoustic absorbent panels, potentially on the ceiling since currently, all ceilings are standard plasterboard. The lower primary classroom had timber window seats and steps along the west wall, but these were not a source of excess noise during the observation period. The middle primary classroom had a high proportion of soft flooring (carpet and rugs) but few absorptive materials above floor height. The upper primary classroom was designed as a library rather than a classroom; however, it includes an elevated timber deck area that was a framed timber box that amplifies sound like a drum. The deck was used as a computer area and was infrequently used. However, when it was used, footsteps and chair movement were quite loud. There was a rug placed on the deck, but it did not cover the whole area. During an interview, the architect said it was designed as a library reading deck (interview with architect A, 20 September 2018), so perhaps it was intended to be covered with soft furnishings to absorb some of the noise.

Noise in Observed Classrooms

Noise created within classrooms affected the behaviour of students and provided a challenge for the Montessori method because students were often working on different tasks at any one time. Some students require a quiet environment to concentrate, whereas others require collaboration with peers or physical movement around the classroom. This means that students who were talking or moving were often asked to be quiet or remain still to keep the acoustic levels to a minimum. During observation, some middle primary students frequently rang the classroom bell and asked others to be quiet, but this seemed to be the same group of students, which suggests those particular students were more sensitive to noise. This observation is supported by Hansen (2001), who explains that noise levels are a personal preference: ‘different groups of children have been found to be affected differentially by noise. For example, while older children were found to be more aware of external noise, younger children were more annoyed by it’ (Shield, Greenland and Dockrell 2010, 227). During an observation period, one middle primary student asked everyone to be quiet, adding ‘especially those on the echo-y area’ and pointed to the vinyl area next to the kitchen. This shows awareness by students of the effects of the classroom design on sound levels and demonstrates the effect noise has on student learning.

Some literature suggests that noisy environments affect teachers more than students (Jerome 2012), which could be another barrier to improving students’ physical activity behaviours. If the teacher is more sensitive to noise, they would ask the students to be quiet or stop physical movements before other students are disrupted. This seemed to be the case in the upper primary class, where I observed that students who were standing or walking while talking to their peers were more frequently reprimanded than those students who were seated while talking to their peers. This may also be because students who were being noisy while moving were more visible to the teacher and caught the teacher’s attention.

Acoustic Articulation Can Reduce Student Distraction to Allow Physical Activity

Articulation of the space is a critical factor to regulate noise within classrooms. I previously discussed the importance of articulation of spaces to minimise distraction and allow students to be physically active in certain zones; however, articulation is also essential to control noise within the classroom. Hansen (2001) outlines that the acoustic effect of additional walls to divide a space would be two-fold: creating a reduction in the power of the sound waves as well as altering the direction of that sound. As previously discussed, all case study classrooms have some spatial articulation through the overall L-shape design, but due to the scale of the rooms, they remain quite open, so sound waves travel freely throughout the room. To control noise, ‘significantly more floor area is required for open-plan classrooms than for enclosed classrooms, with 4–5 m^2 per child recommended in the literature’ (Shield, Greenland and Dockrell 2010, 231); however, the three sources of literature cited in this case are dated (ranging from 1972 to 1981). All observed classrooms use shelving to create smaller areas, but the shelves are often quite low and sometimes have no backing, so their acoustic effect is minimal. The designated classroom courtyards provide an additional teaching area to allow for noise separation, but the noise then travels into the adjacent classroom. The teachers close the sliding doors to block the direct sounds, but the noise is still audible through the glass. The upper primary classroom also had an operable wall that separates the larger southern room from the smaller northern room. However, during my observation, the operable wall was not used, even when acoustic separation may have benefited learning, for example, while some students were having an Italian lesson and the rest of the class worked quietly. This indicates not only the importance of design but also of the users of the space and their personal preferences and willingness to alter their learning environment, which will be discussed in Chapter Seven.

Conclusion

In this chapter, I argued that the physical learning environments of the case study school influence the physical activity behaviours of students, with students generally expected to move calmly and remain quiet. Movement in the case study classrooms was often considered bad behaviour, and students' physical activity behaviours were highly controlled within learning environments, especially with high-intensity activity such as running. Spatial articulation within classrooms can enable students to be more physically active because zones can reduce the distraction of others, and acoustic separation between zones can be created. I also outlined the influence that external spaces, visibility and furniture had on students' physical activity behaviours within learning environments using examples from the case study school. External spaces in learning environments are perceived as providing increased opportunities for physical activity, but during my observations of the case study school, the external spaces seemed underutilised. This could be due to various factors, including size, school policies, classroom rules and weather. The openness of space influences students' physical activity behaviours due to their personal preferences and visibility that allows students to see others being physically active, which can encourage MVPA. Furniture is a critical element that directly affects students' physical activity behaviours within learning environments, and standing desks are a simple change that can be made to classrooms to reduce sedentary behaviour and increase light physical activity. In this chapter, I focused primarily on the physical factors within the learning environments, referring to social and organisational factors where relevant. The social and organisational factors influencing students' physical activity behaviours will be the focus of the following chapter. To improve students' physical activity behaviours, the social factors of the perceived naughtiness of movement must be addressed as well as organisational factors such as school and classroom rules.

7. Making Schools for Students' Physical Activity

This chapter argues that students' physical activity behaviours are influenced by physical, social and organisational factors within learning environments that are primarily controlled by stakeholders such as architects, teachers, schools and government organisations. In this chapter, the term 'control' is used to describe the direct influence that stakeholders have over students' physical activity behaviours, as school policies and teacher instructions directly constrain or limit movement, which is not a subtle influence. Due to the complex relationship between the physical, social and organisational factors influencing students' physical activity behaviours within learning environments, the social ecologic model is used as the theoretical framework (Zimring et al. 2005). The first section of this chapter outlines how the social and organisational factors affect students' physical activity behaviours during the whole school day through school policies and the physical activity culture of the school. In order to improve students' physical activity behaviours in learning environments, I outline how architects and school organisations can collaborate through stakeholder consultation, and I outline the benefits and challenges of stakeholder consultation. I discuss how state and federal government policies can influence the physical activity behaviours of students through curriculum, laws and the design of public schools. Architects and government organisations can use pre and post occupancy evaluations (PrOEs and POEs) to work together to improve the physical activity behaviours of students in learning environments.

This research project focuses on how aspects of the built environment influence students' physical activity behaviours in learning environments, and this chapter outlines how the findings from the research can inform the processes of primary school design. Physical, social and organisational factors are controlled by various stakeholders, including school organisations, teachers, architects and governments. In this chapter I recommend that all stakeholders involved in school design, use and occupation prioritise students' physical activity behaviours through all stages of school design: from brief development and design, all the way to use and continuing evaluation of school facilities.

Social and Organisational Influence on Students' Physical Activity

Schools are highly regulated environments where all behaviours, especially those of students, are policed through social and organisational factors such as policies, rules and direct control by staff. Physical activity behaviours are heavily controlled, and students are told when they should remain still, when they are allowed to move and what type of movement is acceptable. The power to influence students' physical activity behaviours lies with many different stakeholders. The social ecologic model was used as a framework for this project to understand the complex factors that influence students' physical activity behaviours. After focusing on the physical factors in the previous chapter, this section outlines the social and organisational factors within learning environments that influence students' physical activity behaviours. I analyse how architectural processes intersect with these to produce physical learning environments that reflect the social and organisational factors. In this section, I argue that key stakeholders, including the school organisations, teachers, architects and government organisations, control and influence students' physical activity behaviours through school policies, classroom rules, learning environment design, guidelines and laws. If the controlling stakeholders do not prioritise the physical activity behaviours of students within schools, student movement behaviours will not improve. To improve students' physical activity behaviours, the aspiration to prioritise students' physical activity behaviours needs to be held and acted on by all stakeholders, especially by the school organisation itself, and architects have an opportunity to play a critical role within this relationship.

Risk-Averse Schools Influence Policies and Architecture

The built environment and the students' physical activity behaviours are influenced by the values of the school organisation. Schools (as well as Western societies in general) are often described as being 'risk averse' in terms of any risk of injury to students (Gill 2007; Harper 2017), which can lead to limitations on students' physical activity behaviours. To reduce the risk of injury, playground rules are often implemented, such as disallowing students from climbing trees or closing playgrounds before and after school (if they are unsupervised at those times). The WA Department of Education defines risk as 'the chance of something happening that will have an impact on objectives. It is measured in terms of consequences and likelihood' (Western Australian Department of Education 2018). Dallat (2009) reveals that risk is often viewed negatively with a focus on preventing or managing risk rather than focusing on potential benefits that may come from taking risks. The WA Department of Education states that they are 'committed to achieving a balance between protecting students from an unreasonable risk of harm and encouraging students' independence and maximising their educational opportunities' (Western Australian Department of Education 2020). This demonstrates the organisation's view of managing risk rather than preventing it. Although this is promising, the same view may not be held or put into practice by individual schools under the jurisdiction. Varnham (2018) states that children are subject to many risks within their communities and school settings and proposes that it would be impractical to attempt to remove all these: 'educators must reach a balance between eliminating unacceptable perils while still affording the opportunity for young people to learn the important qualities of managing risk and personal responsibility, core elements of their education' (Varnham 2018, 60). The Australian Student Wellbeing Framework (Education Services Australia 2020) supports this view with a focus on creating safe and supportive learning environments, rather than a focus on eliminating risks.

Although state and national governments suggest risks should be managed and not eliminated, it seems that does not translate into school architecture. Two of the architects interviewed believe that school organisations are risk averse (interview with architect B, 8 October 2020; architect C, 13 October 2020), and one specifically indicated that risk aversion was a central factor that limited their ability to design learning environments that could improve students' physical activity behaviours (interview with architect C, 13 October 2020). As an example, most primary schools in WA are constructed on single levels (interview with architect C, 13 October 2020). An architect discussed how, in their experience, school organisations want to avoid the use of stairs because these are perceived to pose an injury risk to students and staff (interview with architect B, 8 October 2020). Climbing stairs is classified as moderate-intensity physical activity, whereas walking on a flat surface is only light physical activity (Evenson and Terry 2009). However, many schools do not want to consider constructing multi-storey schools due to the perceived risk to safety posed by stairs and second-storey balconies. An interviewed architect expressed their opinion that school leadership's view of double-storey schools being too dangerous is unfounded as many students live in multi-level homes and would frequently visit spaces with balconies such as shopping centres (interview with architect B, 8 October 2020). Another architect described their experience visiting a school in Denmark where they saw students running on stairs, and one of the students fell over and got back up; the teachers at the Danish school described it as a normal part of childhood education (interview with architect C, 13 October 2020). While the safety of students is obviously important, I have not discovered any evidence that suggests stairs or ramps pose an unnecessary risk to students' safety. Rather, it appears they can provide benefits to students' physical activity behaviours through encouraging moderate-level activity.

Another benefit of multi-level schools is the additional space that could be available as external landscaping for outside learning or play if the school footprint is stacked rather than spread out. As was previously discussed in Chapter Three, research has shown that larger sites, buildings and play areas per student significantly affects the level of physical activity gained by students (Cradock et al. 2007). In external school environments, the increased incidental physical activity that could be achieved through stairs or ramps is lost on flat school sites. Not only does this limit the possible physical activity outcomes but it also influences the sites that are chosen for school development locations. An architect spoke about the benefit of creating schools on sloping sites, as it allows for increased physical activity, such as jumping on the ramps and stairs in the landscaping (interview with architect C, 13 October 2020). However, on single-storey schools located on flat sites, this opportunity for increased physical activity through interaction with the built environment is minimised or would need to be specifically designed because flat ground surfaces do not offer students any built elements that they can climb onto or jump off.

In addition to design processes shaping the physical activity behaviours of students, risk-averse school policies can also affect physical activity in schools. Many schools try to limit any potential risk of injury to students and staff (interview with architect B, 8 October 2020), which can lead to risk-averse school policies that ban students' physical activity before and after school. It is a contentious topic that is often debated in the news. For instance, in 2019 the ABC News published an article with interviews with both WA Primary Principals' Association and Nature Play WA that demonstrated the conflicting views (Carmody 2019). WA Primary Principals' Association stated that many schools in WA had banned play before school because school organisations did not have the resources to provide adequate supervision 'to meet their "duty of care" obligations' (Carmody 2019). Nature Play WA agreed that supervision was a barrier but expressed that the school policies created a missed opportunity for play and physical activity (Carmody 2019). In the case study school, some policies limit physical activity behaviours before and after school. As discussed in Chapter Five, parents escort their children to and from the classroom, so they are not able to make use of the play areas or open space within the school for physical activity. However, I did observe an exception to this when parents stopped outside the classroom to talk to other parents. I saw the children use this opportunity to run around and play with their friends. This activity generally occurred within the main piazza area, so the two play areas were not utilised during this time. Generally, when schools do not allow students to use play areas before and after school, it is due to safety concerns and a lack of supervision. Nature Play WA proposed the solution of volunteer parents acting as supervisors (Carmody 2019), but this would rely on the prioritisation of physical activity by the parents and school community.

Martin (2010, 120) argues that 'schools with a positive physical activity culture are more likely to assign higher priority to physical activity related resources and programs, such as being more prepared to invest funding and time to increase and maintain physical activity facilities'. The interviewed upper primary teacher does not believe that the school policies of the case study school affect their ability to improve the physical activity behaviours of the students in their class (interview with upper primary teacher, 30 November 2018). They believe that the school policies about health, such as requiring families to pack healthy food into lunch boxes and no junk food, make it easier for teachers because parents are 'a conscious body of people who think about health' (interview with upper primary teacher, 30 November 2018). The upper primary teacher believes that families work with the school to encourage kids to be healthy, both with physical activity and healthy eating. This suggests that families are supportive of physical activity behaviours, and 'research suggests that parents who provide support and encouragement for their children to be active are more likely to have active children' (Fedewa et al. 2018, 591).

To summarise, the influence of beliefs about risk affect students' physical activity behaviours through school policies of playground use and design implications such as reluctance to construct multi-storey schools and the avoidance of sloping sites to avoid the need for stairs.

Culture of Physical Activity in Learning Environments

The school organisation controls overall school policies, and within classrooms, teachers further influence students' physical behaviours through additional rules and direct instructions. Teachers hold a great deal of power to influence the behaviours of students, which can be either negative or positive in terms of physical activity, depending on how the teachers prioritise students' physical activity. Individual teachers hold the power to control students' physical activity behaviours within the classroom, and due to their own personal preferences, this differs from classroom to classroom. This variation was observed within the case study school, as the three teachers controlled students' physical activity behaviours in different ways. For example, the students in the participating upper primary class were given significant freedom to move around the classroom and the school, but they were told to sit still while working. In the middle primary classroom, the students were allowed to leave the classroom if they were going to the bathroom, a scheduled class or if specifically requested by the teacher, and the students asked permission before using the courtyard. In contrast to this is the lower primary classroom, which was heavily controlled. The lower primary students were not allowed to leave the classroom unless supervised by a teacher or upper primary student; however, the courtyard was viewed as an extension of the classroom, so students did not need to ask permission to use it while working. This illustrates that in each classroom, the students were able to move around the classroom as part of their learning tasks, but their physical activity was limited by what was considered acceptable by the teacher.

Individual Teacher Control of Students' Physical Activity

Individual teachers also controlled students' physical activity behaviours outside the classroom around the school campus, often through direct instructions. For example, in the middle primary school, I observed that some students (generally those perceived as 'well behaved') were asked to leave the classroom to collect resources from other classes or from around the school. During these types of tasks, students would often run through the school, which gave these students more opportunities for vigorous physical activity during the school day compared to those who were not called on for these tasks. So, students opportunities to leave the classroom and move through the school provided more opportunities for MVPA, but this was controlled by individual teachers.

As teachers control students' abilities to be physically active in the classrooms, it is important to understand teachers' opinions concerning physical activity. Research into teachers' opinions of students' physical activity behaviours does not often relate to incidental physical activity but instead generally focuses on specific elements, such as health and physical education (HPE), as part of the curriculum and the effect on academic achievement (see for instance Morgan and Hansen 2008) or classroom-based physical activity (CBPA often referred to as activity breaks or brain breaks) (see for instance Dinkel et al. 2017). A study by Morgan, Bourke and Thompson (2001, 12) found that teachers 'who were more involved in sports, held more positive beliefs about physical education and its potential benefits'. They also found that personal factors such as previous experience during their own education and feelings of confidence to teach HPE adequately influenced teachers' attitudes towards students' physical activity (Morgan, Bourke and Thompson 2001, 12). In the case study school, the middle primary teacher had a particular interest in HPE and physical activity in general, so they chose to undertake professional development opportunities related to HPE (interview with middle primary teacher, 7 December 2020); however, the upper primary teacher outlined that they had not undertaken any HPE training in a long time (interview with upper primary teacher, 30 November 2018).

Teachers also control whether active tasks are conducted within the classrooms since 'students cannot be physically active in a classroom setting without the support and guidance of the teacher' (Martin and Murtagh 2015b, 122). This is particularly the case with the class-based physical activity incorporated into academic lessons reviewed in Chapter Three. During an interview, the upper primary teacher revealed that they do not incorporate specific 'active lessons' as part of the day because students were often completing different tasks to others in the class; therefore, active movements would distract those who were concentrating. This is also due to students in upper primary having a 'solid knowledge of things that you would do repetitive motion for' (interview with upper primary teacher, 30 November 2018). Academic learning is instead incorporated into fitness, as the upper primary teacher stated that 'we incorporate maths into fitness, not fitness in maths' (interview with upper primary teacher, 30 November 2018). This suggests that the CBPA interventions are more appropriate for traditional classrooms where the teacher organises learning tasks for the whole class to undertake at the same time. The student-centred pedagogy used in non-traditional classrooms may not support CBPA, as implemented in numerous studies reviewed in Chapter Three, so further research is required to understand the implications for NGLEs.

The teachers' attitudes to their own physical activity can also influence students' physical activity behaviours through role modelling and positive culture. During an interview, one of the architects discussed that during the master plan design phase, they often discuss the options of spreading out the learning spaces, which would enable students and teachers to walk longer distances during the day to increase incidental physical activity, but the teachers often do not like to travel too far (interview with architect C, 13 October 2020). This is a genuine concern because teachers do have a significant amount of pressure placed on their time; however, if teachers prioritise their own physical activity behaviours, then the incidental physical activity could be seen as a positive. Research also suggests that time taken out of academic lessons to include physical activity breaks does not negatively affect students' learning (Ahamed et al. 2007), so I would expect similar findings on the short amount of time taken to walk through a school campus. If teachers are willing to model positive physically active behaviours, then their students may be encouraged to take advantage of learning environments that support movement, although mobility constraints for staff and students could be a barrier. Biddle and Mutrie (2007) highlight the importance of social influences within various exercise settings and consider leadership the most significant motivating element. This is supported by Martin (2010, 120), who states:

> The impact of a physically active PE coordinator (or other school staff, including the classroom teacher and principal) on children may not just be via modelling behaviour, but also due to the creation and support of a positive physical activity culture within the school.

A positive culture regarding physical activity is created through the beliefs of individuals in that environment and strong leadership. As teachers control student movement during class time, their personal beliefs about physical activity are likely to influence their prioritisation of students' physical activity throughout the school day.

The classroom rules of individual teachers within the case study school will be outlined below to identify rules that both intentionally and unintentionally influence students' physical activity behaviours. Overall, teachers hold significant power to directly control students' movement within learning environments, which can be a positive or negative influence depending on the individual teacher's personal beliefs about physical activity.

Students' Physical Activity Is Influenced by Classroom Rules

Some classrooms rules implemented by teachers affect students' physical activity behaviours, sometimes unintentionally and others intentionally. For example, as discussed in Chapter Six, a teacher's desire to maintain quiet within the classroom can lead to rules around movement being implemented. Coffey and Delamont (2000, 23) state that 'a common assumption is that a competent teacher is one who can keep a class quiet, for a quiet class is one that can be managed where learning can be achieved'. In the effort to keep a classroom environment quiet, students are often told to remain still. So, while the influence on students' physical activity behaviours is unintentional, the result remains the same. Within each case study classroom, the teachers implement different rules that intentionally affect the movement of students to maintain order within the classroom. McGregor (2004b) discusses the control that teachers hold over the rules and daily routines of students that affect student behaviour. It is important to understand how the classroom rules affect students' physical activity behaviours because active classrooms rely on the willingness of teachers to incorporate movement into the learning tasks (Martin and Murtagh 2015b, 122). Most academic sources studying the control of teachers in learning environments focus on traditional classrooms where teachers use traditional didactic methods (see for instance Coffey and Delamont 2000; Fenwick 1998). However, research is likely still relevant to non-traditional learning environments because teachers remain in control of the classroom rules and dictate the types of student behaviours that are acceptable. There is also an opportunity for future research focused on classroom rules that unintentionally influence students' physical activity behaviours. Through this project, my ethnographic observation allowed these rules with unintentional influence on students' physical activity behaviours to be documented and understood in the content of socio-spatial learning environments.

Differences between students' physical activity behaviours in traditional classrooms compared to non-traditional learning environments could be due to classroom rules. Research in traditional schools shows that as students grow older, their overall physical activity levels and MVPA decrease (see for instance McCarthy et al. 2021; Farooq et al. 2018). As outlined in Chapter Five, when comparing the lower, middle and upper primary participating students in the case study classes, the overall physical activity was lower for upper primary students, but MVPA was highest among upper primary students; however, neither of the results was statistically significant. The contrast between the physical activity behaviours of participating students in the case study school and the numerous studies within traditional schools could be due to the classroom rules. I observed in the case study school that as the students' age increases, they have more freedom and fewer rules that limit their physical activity behaviours, which seems to be due to maturity and the older students' ability to regulate their behaviour, as per Montessori's (1909) lessons in the 'collective order' discussed in Chapter Six. The students in all three case study classrooms were quite active, but as previously discussed, all students are expected to only move around the school or classroom to complete their learning tasks. That is, students are generally not allowed to move for the sake of moving, and there are parts of the day during which they are expected to remain still. For example, in all classrooms, at the end of the day, all students are expected to remain seated inside while waiting for their parents to pick them up. These classroom rules intentionally control students' physical activity behaviours to maintain what is seen as orderly classrooms. While all learning environments have classroom rules, the difference between traditional and non-traditional classrooms is that the expectations around student movement are very different, so the rules affecting students' physical activity behaviours are different. This highlights the opportunity for future research to focus on the influence that classroom rules have on students' physical activity behaviours.

There are many rules in the case study lower primary class that intentionally affect student movement due to safety concerns and a perceived effort to maintain order or quiet. As a safety precaution, the lower primary students must remain within the classroom or designated courtyard at all times, which limits the distance students can move. To facilitate the students remaining in their class, each pair of classrooms shares a bathroom, and when the lower primary students leave the classroom for a specialist class such as music or sport, they are instructed to line up inside the classroom and are escorted through the school by the teachers. Within the classroom, students have a great deal of freedom to move around and choose where they would like to work, but there are still rules that affect their physical activity behaviours, which seemed to be in place to maintain order or control noise. For example, students are expected to remain seated for the duration of their chosen learning task unless it is one of a few learning tasks that specifically involves standing or movement to complete it. Another lower primary class rule that influences physical activity is that only two or three students are permitted to be in the courtyard at any one time, which is likely because there are only limited tasks that should be completed outside. I did observe more than three students completing tasks in the courtyard on a few occasions, but the teachers would ask some students to return indoors. While these rules in the lower primary class intentionally control student behaviour, based on my observations, I do not believe it is to reduce physical activity specifically but rather to ensure student safety and keep students focused on their tasks. Lower primary students' physical activity behaviours could be increased, without compromising safety, through small changes to the classroom rules and design of the learning environment; for instance, through the use of external classroom space, the sense of openness, furniture and acoustics, as discussed in Chapter Six.

Middle primary students are given more freedom than lower primary students to move around the school, but there are more restrictive rules within the classroom due to misbehaviour, which affected their physical activity behaviours. For example, students are allowed to go to the bathroom in the piazza, but only one boy and one girl can go at a time, and they have to put their name on the fridge as they leave the room and remove their name upon returning. The middle primary teacher mentioned that this rule was brought in due to misbehaviour and students congregating in the bathrooms. During the observation period, a new rule was mandated because a group of students was misbehaving within the classroom and disrupting other students. This led to assigned seating of all students for one day and assigned seating of the misbehaving students for further days. This limited the physical activity behaviours of students because the teachers had less tolerance for students wandering around. This highlights that a challenge for increasing physical activity behaviours inside classrooms is student misbehaviour. In the middle primary case study class, all students continued to move around the room between tasks to obtain materials and stationery but were quickly told to obtain a new task if the teacher noticed them not working. In an interview with the middle primary teacher, they spoke about a classroom rule with an intentional positive influence on students' physical activity that was not observed in action during the observation period, which is that if the teacher observes students 'needing a bit of a run' they will let them run around the piazza (interview with middle primary teacher, 7 December 2020). The teacher stated that the piazza was chosen for running because the students could be supervised by the other classes with windows overlooking the space. This demonstrates the importance of a supportive physical learning environment in combination with social and organisational factors such as school policies and classroom rules.

In the upper primary classroom, the students were given the most freedom and the most opportunity for increased physical activity behaviours; however, there were still some rules that intentionally affected students' movement in both positive and negative ways. Similar to the lower and middle primary classes, the upper primary students were not permitted to run inside the classroom due to safety concerns. The upper primary classroom rules permitted students to move around the classroom and school to complete any learning task or everyday activity. For example, upper primary students moved freely around the classroom, into the piazza, to the bathrooms, to the other upper primary classroom, to specialist classes and to the adolescent program without asking for permission. However, I observed students asking permission from the teacher before visiting the library, which suggested that this was outside the scope of their usual routine. Upper primary students were permitted to run outside the classroom, which was a positive influence on students' physical activity behaviours. Uniquely, before sport and fitness, the upper primary students were asked to line up along the external wall of the bathrooms in the piazza before moving to the northern play area as a whole class group. This was a surprising observation because students were otherwise allowed to run through the school campus, so I expected students would run to the play area to wait for the teacher. Perhaps this rule to walk as a group is to ensure all students were present or because close observation is required to maintain student discipline, which is difficult due to the separation of the northern play area from the rest of the school. Although the upper primary students were given the freedom to move around the classroom and school during the day, there remain rules that intentionally had both positive and negative influences on students' physical activity behaviours. This demonstrates the importance of the classroom rules and that the physical school environments support increasing students' physical activity, such as through ensuring visibility for student supervision.

Adults Control the Furniture

The furniture is controlled by the architect, the school and the teachers. Frith and Whitehouse (2009) express that it is very common globally for budget restrictions to result in school projects where architects and designers are only contracted to design the building envelope; thus, the interior fit-out and furniture selections are left to principals, teachers or facility managers. This was the case with the case study school, which the architect stated was due to budget restraints and the architect considered the school to be 'experts with the sorts of things they want in their classrooms' (interview with architect A, 20 September 2018). Brittin et al. (2015) acknowledge the issue of architects not being involved in the furniture selection process and therefore include furniture as an item separate from architecture within their guidelines. Frith and Whitehouse (2009) argue that the same budget constraints lead to further gaps in research in regards to interior design, as well as the predominantly quantitative focus of available interior design analysis.

In an interview, an architect spoke about the importance of furniture selections and the problems that occur if the design team are not involved in that process (interview with architect B, 8 October 2020). They discussed how each learning space is designed with a particular type and arrangement of furniture in mind, but if the school chooses their own furniture, they may not understand the type and placement of furniture that would best support the use of that space. The architect gave a specific example where this occurred and the school put 'way too much stuff in the room and then what was intended to be flexible was not flexible at all because you couldn't move around without tripping over furniture' (interview with architect B, 8 October 2020). Due to this problem, the architect expressed that they often assist the school in selecting the furniture even when they are not being paid for this service (interview with architect B, 8 October 2020).

The arrangement of classroom furniture is generally controlled by the teacher. McGregor (2004b, 14) relates that 'in creating structures such as furniture layouts, certain behaviours are encouraged or suppressed, which function almost invisibly to display teacher expectations and reinforce adult control of knowledge, teaching and learning'. In the case study school, the individual teachers decided on the layout of classroom furniture and where resources were placed (interview with upper primary teacher, 30 November 2018). Not only are teachers in control of the use and placement of furniture, but they also use the furniture to influence the behaviours of students further. The upper primary teacher said, 'the kids in this age group like to run so the tables are strategically put in a place which would block the motion of running' (interview with upper primary teacher, 30 November 2018). The desks were arranged to block straight paths, so students were forced to 'zig-zag' through the class to limit running and improve safety. It is clear from the interview that the upper primary teacher was aware that the arrangement of the built environment could affect the physical activity of students. However, when asked if they alter the classroom to affect physical activity, the teacher focused on how they limit running by moving furniture to block straight paths to prevent possible injury (interview with upper primary teacher, 30 November 2018). This suggests that their aim was to reduce running rather than increase light physical activity or decrease sedentary behaviour, and it could also mean that the teacher was not aware of how furniture is able to encourage or support safe physical activity within the classroom; which highlights an opportunity for further research into teachers' objectives and knowledge of students' physical activity behaviours. The teachers' use of furniture to reduce running may also link to the notion that students should accumulate their physical activity outside in the schoolyard and not in the classroom. I observed the upper primary teacher tell students not to run in the classroom but suggest that they should run around the piazza. Although this was recommended to warm up students who were cold, it demonstrates the expectation that students should be physically active outside rather than inside. The teacher's statement also indicates that they were not opposed to students undertaking MVPA during the school day and that there is a positive attitude towards physical activity within the school. Negative associations towards physical activity may lead to physical activity being used as punishment or disciplinary measure, which is inappropriate (NASPE 2009).

Social factors such as classroom rules often dictate which learning tasks can be completed while standing. For example, when middle primary students stood at the table while completing art, they would not be asked to sit down, but if it was a different task (such as maths), they would often be asked to sit down. This suggests that some teachers believe students should be sitting down while doing academic work, which could limit students' ability to decrease sedentary behaviour.

Student Control of Furniture

The only furniture that the students control in the case study school are the small individual tables and the chairs, as only the teachers move the larger tables in the rooms. Not only is there a physical limitation due to the weight of the larger items of furniture, but there are also classroom rules to consider, as the control available to students is limited. For example, in the upper primary classroom, students move small individual tables to suit their needs and preferences, such as moving to sit with friends or moving to improve their view of a particular board. The lower primary students sometimes moved the small individual tables that were placed on the vinyl area near the oval on the floor. However, these movements within both classrooms were relatively minor (under one metre), which suggests students were only permitted to make minor changes to individual classroom tables. The middle primary students did not move any furniture during the observation period except as instructed by the teacher, for example, stacking all chairs at the end of each day. As the students in all three classrooms were generally free to select where they worked, perhaps they did not feel the need to make major changes to furniture arrangements.

In this section, I argued that the social and organisational factors influence students' physical activity behaviours within the physical learning environments. I outlined that the beliefs and values of the school organisation inform the school policies and the built outcomes through influencing the architect during the design process. If schools are risk averse and do not prioritise students' physical activity behaviours, then opportunities for improved behaviour is limited. Teachers have control of students' behaviour within internal and external learning environments through direct instruction, classroom rules and furniture. Individual teacher preferences and opinions about physical activity and physical education influence their choices around students' physical activity behaviours, which may be influenced by student behaviour and misbehaviour. In order for students' physical activity behaviours to be improved in learning environments, it is important that the physical, social and organisational factors are all supportive of students' movement.

Architects and Schools Can Collaborate to Improve Students' Physical Activity in Learning Environments

In this section, I argue that if we want to improve students' physical activity behaviours in learning environments, then architects and school organisations need to collaborate through all stages of school design, use and occupation. Architects are often influenced by many factors during the design phase of learning environment design, including the school organisation, the brief and the limited information available regarding students' physical activity behaviours in learning environments to inform design decisions. I analyse the benefits and costs of stakeholder consultation and outline the influence it can have on students' physical activity behaviours. Stakeholder consultation can ensure learning environments are fit for purpose and provides the users with a sense of ownership, however challenges also arise, such as communication challenges and time constraints.

Stakeholder consultation is one method that can be used to improve students' physical activity behaviours in learning environments, but it relies heavily on architects and schools prioritising students' movement. Communication and consultation with stakeholders as a process of design is referred to by many names: stakeholder engagement, participatory design, cooperative-design (or co-design) and collaborative design. While similar and sometimes used interchangeably, these terms describe different levels of involvement by stakeholders along the same spectrum of knowledge sharing. Stakeholder engagement is a process of consultation with key parties involved in a project. In contrast, participatory design is a more in-depth process where stakeholders are often more deeply involved in the design process (Jerome 2012).

Various architects who design primary schools utilise different methods of engaging with stakeholders to varying degrees, but in this section, I use the general term 'stakeholder consultation' to encompass all types of stakeholder engagement. Many stakeholders are involved in the design and construction of learning environments, including school leaders, teachers, students, architects, engineers, builders and many others, who each bring their own knowledge and perspectives to the process.

These stakeholders are often grouped into one of two categories: users and designers. Communication between these groups is often cited as a challenge within the design process, which is linked to the environmental competence of users and the educational literacy of designers. A specialist in education design in Australia, Featherston, believes that a critical difficulty between stakeholders is the 'lack of shared vocabulary' (The Featherston Archive 2017). However, there are methods for overcoming communication challenges such as simplifying language, using visual tools and precedent site visits. Stakeholder consultation is required throughout the design, construction and occupation processes to ensure all stakeholders are working towards the same goal of improving students' physical activity behaviours.

Architects are Influenced by School Organisations

As the client within the school design process, school organisations hold a great deal of power over the architects. In an interview with an architect, they described how the beliefs of school organisations that try to limit any potential risk of injury to students and staff can influence the design outcomes and the physical activity behaviour of students (interview with architect B, 8 October 2020). The school's design is often affected because school leaders wish to avoid stairs, double-storey buildings and spaces that are not fully observable from specific vantage points. In learning environments that do not allow students to have any sense of privacy, the architect discussed how, in extreme cases, this can lead to learning spaces that feel like a 'prison' which is a 'really unpleasant outcome that in some ways might end up with poor behaviour because you are actually not catering for the needs of a child' (interview with architect B, 8 October 2020). Although this may be an extreme example, it demonstrates this architect's belief that school organisations can influence school policies and design decisions.

Students' physical activity outcomes can be influenced by the architect before the school is constructed, and architects are influenced by many factors, including the brief, their own priorities and the priorities of the school organisation. Two of the architects interviewed said that they were more confident in finding information regarding physical activity that takes place outside, such as sport or play, which suggests that research into physical activity in external spaces is more widely researched or circulated than studies concerning physical activity that takes place in interior spaces. This is demonstrated in 'Physical Activity Design Guidelines for

School Architecture’ by Brittin et al. (2015), in which nearly all strategies supported with substantial evidence are related to external space or fitness facilities. Other strategies have only emerging evidence or are considered best practice with no formal supporting evidence (Brittin et al. 2015). In an interview, one architect indicated they would likely look to precedent projects to understand how other architects have attempted to improve physical activity (interview with architect C, 13 October 2020). This demonstrates the importance of publishing academic research and architectural precedents. The case study methodology and mixed-methods approach chosen in this project are ideal for providing architects with quantitative data about students’ physical activity behaviours and qualitative information relevant to learning environment design.

During the brief development phase, the school or controlling organisation advises the architects of their requirements, and if the school does not highlight a strong desire to improve students’ physical activity behaviours, then the architect is highly unlikely to focus on this unless they have a prior desire for this and pitch it to the school. Two of the architects interviewed acknowledged that, in their experience, students’ physical activity behaviours were not a focus during design phases but indicated that if a school wanted to improve the physical activity behaviours, then the design team would research this and incorporate it into their design (interview with architect B, 8 October 2020; architect C, 13 October 2020). This demonstrates the vital role that architects can play in improving students’ physical activity behaviours through both highlighting student movement to schools during the design phase and testing potential design solutions. However, as there is limited research on improving students’ physical activity behaviours inside classrooms, architects are unlikely to find academic research to inform their design decisions. This project begins to fill this gap in the literature and provides information to architects seeking to improve students’ physical activity behaviours in learning environments.

In the interview with the architect of the case study school, they expressed that there was very little, if any, discussion of students’ physical activity behaviours in the brief development phase (interview with architect A, 20 September 2018). This suggests that both the school and the architect did not prioritise students’ physical activity behaviours because it was not a key consideration during the initial design stages. The architect described how the only brief requirement related to physical activity was that classrooms should have spaces for both quiet, passive activities as well as spaces for more active tasks such as cooking. However, the architect outlined that they thought about how students would use and move around the classrooms within their design process. The design outcome was linked to layout and zoning—that spaces designated for sedentary activities had lighting levels that would minimise harsh shadows to improve comfort for reading and writing tasks. The architect also considered courtyard spaces as linked to physical activity behaviours as well as the feeling of connection between the classrooms (interview with architect A, 20 September 2018). The architect considered how students would move through the school and classrooms but did not specifically discuss physical activity with the school. The stakeholders in the case study school missed an opportunity to discuss their ideal visions for students' movement and physical activity within the school. The lack of discussion of students' movement during the design process of the case study school demonstrates that students' physical activity behaviours are influenced by social and organisational factors throughout the whole design process, which then affects the physical design of the learning environment.

Stakeholders Involved in Learning Environment Design

Stakeholders relevant to the design of primary schools generally fall into one of two categories: users and designers. User stakeholders include students, teachers, principals, other school leaders, general staff and organisations that affect schools (such as government departments). The designer category includes architects, engineers, builders and any other professionals involved in the construction industry. Luck (2018, 145) discusses the dynamics and complications with stakeholder groups, relating that the 'categories "designer" and "user" do not always accurately reflect what people do, as users evidently do design in some situations'. While users can be involved in the initial design phases, they are more likely to be involved in design and re-design through the use of the physical spaces after project completion.

Through using the spaces, teachers and students continue designing and re-designing their learning environments, which can be both positive and negative. In interviews, the architects discussed the challenges and opportunities for schools to continue altering the spaces after construction is completed. For instance, the architect who designed the case study school described the school stakeholders, such as principals and teachers, as ‘experts’ for choosing loose furnishings (interview with architect A, 20 September 2018) and therefore re-designing classrooms into the future is viewed as a positive. Another architect positively described students’ alteration and unexpected use of learning environments as ‘creative’ (interview with architect C, 13 October 2020), whereas another architect discussed the challenges of schools ‘incorrectly’ purchasing and arranging furniture in a manner that is at odds with the design intent of the learning environment (interview with architect B, 8 October 2020). They discussed how the rooms were overstuffed with furniture, limiting the flexibility of the spaces because users ‘couldn’t move around without tripping over furniture’ (interview with architect B, 8 October 2020), which also restricts the ability for students to be physically active in the classrooms. To combat these problems, the architect believes they should be involved in the furniture selection process (interview with architect B, 8 October 2020), which is contradictory to the views of the case study architect (interview with architect A, 20 September 2018). In these two scenarios, the differences lie in the school’s expertise with the type of learning environment. If a school (such as the case study school) is established in their pedagogy, they may be viewed as ‘experts’ with furniture layouts, whereas if a school is transitioning from a traditional to a contemporary pedagogy, they may be viewed as needing assistance from the architect with learning environment use. An opportunity arises with schools that otherwise need architectural assistance while transitioning to a new spatial or pedagogical approach, for architects to highlight ways that students could improve their physical activity behaviours in learning environments. This demonstrates the importance for architects to prioritise the physical activity behaviours of students to ensure this is front of mind for all stakeholders.

Hierarchies and power dynamics within stakeholder groups can complicate the consultation process. When people are grouped into categories, there is an ‘assumption that a collective decision has been reached through a deliberative, democratic process’, which is often not the case (Luck 2018, 145). The architect generally has the most power within the group of design stakeholders, so they can choose which ideas to include and exclude following the consultation process. Power dynamics within the user stakeholder group are also important to acknowledge because the voices of some stakeholders are viewed as more important. The main architectural client is generally the school principal, who is at the top of the user category hierarchy (interview with architect C, 13 October 2020). Therefore, while students and teachers may be consulted through workshops, surveys or in class exercises, the principal's opinions will generally override any other opinions. This was discussed by an architect who identified students' and teachers' opinions as highly important but related that the principal's opinions are given the highest priority (interview with architect C, 13 October 2020).

If user opinions are at odds with each other, the perspectives of the stakeholders with less power are generally excluded from the design. To lower-ranked stakeholders, this would feel like changes were being placed on them in a top-down approach. The open-plan movement of the 1960s and 1970s demonstrated the failures of top-down approaches during attempts to implement significant changes (Ehrenkrantz 1999). To create major improvements to student physical activity behaviours, we must learn from past mistakes and ensure change involves genuine stakeholder consultation. If the stakeholders with the most power do not prioritise student physical activity, behaviours will not improve. An architect also discussed the need for a wide variety of voices during the consultation process (interview with architect B, 8 October 2020). They gave the example that they specially ask the school leaders to invite a range of students into workshops, not only the top achieving or most well-behaved students. Speaking to a wide range of stakeholders ensures multiple voices are heard and taken into account during the design process.

Benefits and Costs of Stakeholder Consultation

Stakeholder consultation ensures that school facilities are fit for purpose, as users advise designers on how they currently use their school and desired outcomes for the future. Stakeholder consultation also ensures that users are leading the design process and are not having a foreign building type pushed onto them (Clark 2002). This was identified as a problem in open-plan schools in the 1970s, where teachers were placed in large open classrooms with no training on how to use the spaces adequately, so they remained teaching in traditional ways, which meant the spaces were unsuitable (Ehrenkrantz 1999). Some schools use test classrooms to allow teachers and students to test a new layout or room type before construction; this can be installed as a portable classroom placed on the school site or as an internal refurbishment (see for instance Kilbourne, Scott-Webber and Kapitula 2017). Not only does this ease teachers and students into a new environment, but it also allows them to provide feedback and alter the design of the final building outcome to best suit their preferences. These types of interventions provide the perfect opportunity for data collection prior to the commitment of funds for a permanent project. Test classrooms could be useful for schools seeking to improve students' physical activity behaviours in future learning environments because they can provide the whole school community with an opportunity to test and provide feedback on the changes before the changes are made more permanent. It also provides architects, teachers and students with an opportunity to collaborate and test ideas for furniture arrangements that may improve students' physical activity behaviours.

Stakeholder consultation can provide users with perceived ownership over space, which is an important element within buildings and especially schools:

> Central to the participatory process is the gradual building consensus and ownership that creates a sense of community and shared intentions. People feel more attached to an environment they have helped to create; they will therefore manage and maintain it better, reducing the likelihood of vandalism, neglect and costly replacements in the future (Martin 2006, 100).

One way of creating a sense of ownership for all users of the space is through stakeholder consultation, where users work with designers throughout the design process. This gives users a voice to share their desires for the building outcome. In an interview, an architect discussed the importance of working closely with all stakeholders asked to bring ideas and issues into the discussion to ensure they feel ownership over the process (interview with architect C, 13 October 2020). A sense of ownership during the process can then lead to that same feeling towards the finished building. When teachers feel ownership over their learning environments, they may be more likely to alter the furniture or other moveable elements to best suit them and their class (Lackney 2008). A sense of ownership may encourage teachers to rearrange furniture to create more opportunities for students to be physically active within learning environments. Ownership provides students with a sense of control, and they are more likely to take care of the space (Martin 2006). If students feel a sense of control, they may be more likely to alter the classroom to better suit their own physical activity goals.

One of the challenges when undertaking stakeholder consultation is the time and money required during the design phase. In an interview, one architect discussed the process of meeting weekly with the key group of stakeholders (usually principals and business managers) in addition to scheduled meetings with other stakeholders such as teachers and students. Genuine stakeholder consultation will undoubtedly extend the time required for the design process, costing more money. However, stakeholder consultation is often an essential aspect of the design process; therefore, the cost is accounted for during the initial briefing stages (Clark 2002). Across the lifetime of a building, the additional cost is a small portion of the total cost and could 'save money over the long-term' (Clark 2002, 23). Through stakeholder consultation, designers can ensure that the learning environments will be fit for purpose and would be less likely to need changes to be made in the near future. As previously discussed, when stakeholders are instructed on how to use the climate control features of a building effectively, this can lower ongoing costs. Therefore, across the lifespan of a building, the upfront cost of stakeholder consultation is likely to balance out.

Stakeholder Communication Challenges Influence Students' Physical Activity

A regularly cited challenge of the school design and construction process is a lack of environmental competence (or spatial literacy) of school stakeholders, which causes communication challenges. This was broadly discussed in Chapter Two. In this section, I discuss the communication challenges regarding my research's specific contribution to improving students' physical activity behaviours in learning environments. The perceived lack of environmental competence within school users is widely publicised by architects and designers, such as Dr Kenn Fisher, who argues that 'teachers and students are seemingly unconscious of their surroundings, or alternatively helpless to change them due to a lack of funding' (Fisher 2004, 1). However, these types of assessments are overly critical and seek to shift the blame onto users rather than providing useful solutions. It assumes that users are the problem but does not consider the pressures that teachers are under and adds another role to their already expanding list of responsibilities within our communities. In an interview, an architect discussed that designers should remember that school stakeholders (principals and teachers) are employed full time as educators, so any work on new construction projects is added to their existing workload (interview with architect B, 8 October 2020). Therefore, we cannot expect school staff alone to fix low levels of physical activity among students because they do not have the time capacity to do so. However, we can ask architects to work with all school stakeholders to find workable solutions. The Global Education Monitoring Report 'Accountability in Education: Meeting Our Commitments' (UNESCO 2017, 65) found that teachers are under pressure, and their responsibilities continue to grow, with expectations that they produce high-quality instruction while also acting as 'counsellors, researchers or data analysts'. It is unreasonable to expect principals and teachers to be experts in design and construction; however, they do not need to be. Architects and other design-focused stakeholders are the experts in those fields, while principals and teachers bring their expertise on educational issues. Clear communication between the two stakeholder groups is key to overcoming miscommunication and, if each group uses simple language and visual tools, communication barriers can be overcome.

Overcoming Communication Challenges to Improve Students' Physical Activity

As the critical mediator between the two stakeholder groups (users and designers), architects are responsible for ensuring clear communication between all stakeholders, which gives them the opportunity to encourage improvements to students' physical activity behaviours. In an interview, one architect discussed the multiple aspects of communication challenges, including architectural jargon, architectural drawings, the role of the architect and the design process and the ability (or inability) of school stakeholders to understand the proposed design (interview with architect B, 8 October 2020). The same architect stated that school stakeholders, such as principals and teachers, are 'not in the construction industry, so what we think is easy to understand and is straightforward, for them is something they've never done before' (interview with architect B, 8 October 2020). They outlined that one of their methods of overcoming communication barriers is using computer software to generate images of what learning spaces might look like and physical models made out of cardboard (interview with architect B, 8 October 2020). They also create colour-coded building plans to explain ideas; however, they believe sometimes the stakeholders say they understand what the architect is discussing even if they do not fully understand. So, the architects must spend a great deal of time ensuring that the client understands not only the design process and the role of the architect, but also what the final outcome will be and how they can use those learning spaces. This explanation process throughout the design phases provides architects with an important platform to encourage schools to improve the physical activity behaviours of students.

Communication challenges also arise with misunderstandings of the architect's role in creating a unique architectural solution for the school. Due to stakeholders often lacking skills to understand architectural drawings, one architect stated that they preferred to visit precedent projects in person with key stakeholders to show them real-life examples (interview with architect C, 13 October 2020). However, another architect discussed how this can then cause further complications because stakeholders can misunderstand the design process and expect their own school to look the same as the ones visited (interview with architect B, 8 October 2020). This is a misunderstanding of the design process, as some stakeholders may not realise that architects cannot replicate designs by others but rather take inspiration and form their own design.

Through experience, architects develop various methods for overcoming communication challenges between stakeholders. One architect related that one of their methods of overcoming communication barriers with teachers was to conduct pre-occupancy meetings at the finished school where they set up and rearrange the classrooms in different ways to physically show the teachers the opportunities for adaptation (interview with architect C, 13 October 2020). The architect found that these meetings allow teachers to understand the opportunities within various furniture arrangements because they can physically see and move the furniture while being guided by the architect (interview with architect C, 13 October 2020). Another method of assisting teachers who might have lower environmental competence or have experience in only traditional classrooms is 'introducing cues to help them understand how they can use a space' (interview with architect C, 13 October 2020). For instance, vinyl floor coverings can indicate to teachers that an area supports activity-based tasks or messy activities such as art, whereas carpet flooring or soft furnishings could suggest that an area best suits sedentary-based activities such as reading. These types of physical cues were used in the case study school. For instance, all participating classrooms used vinyl flooring in zones for messy activities and carpet flooring in zones for tasks that would be considered traditionally academic. The design of spatial cues can be used to signal to teachers and students that specific spaces are appropriate for physical activity within learning environments, and when paired with pre-occupancy meetings, the teachers have the knowledge to set up and arrange the classroom to support students' physical activity behaviours.

Post-Construction Communication

Communication challenges can also exist at the end of the project completion when a finished building is handed over to the users. Miscommunication may affect spaces designed for adaptability, as users may not fully understand the options at their disposal or may choose not to use these options. In an interview, one architect explained that the issue with adaptable learning environments, such as spaces with operable walls, is that they are 'actually quite a lot of work, and quite hard to do' (interview with architect B, 8 October 2020). The architect also related how teachers are viewed by other architects as lacking environmental competence if they do not choose to use these adaptable features; however, the interviewed architect believes that many people, including architects, choose not to use adaptable features. They provided the example that in their own offices, the architectural staff rarely alter even basic features such as opening or closing blinds (interview with architect B, 8 October 2020). As outlined in Chapter Six, rather than adaptable spaces, the same architect instead proposes the inclusion of purposeful spaces within learning environments that are used for various functions (interview with architect B, 8 October 2020). These spaces signal their use to teachers and students through size, materials, furniture design and arrangement and provide opportunities for physical activity because students move between the various zones; however, as previously discussed, this specifically assists teachers with low environmental competence.

In the case study school, the teachers did not seem to lack environmental competence. In the interviews with two primary school teachers, they demonstrated their environmental competence by discussing how they specifically manipulate the physical environment to control the physical activity behaviours of their students (interview with upper primary teacher, 30 November 2018; middle primary teacher, 7 December 2020). However, the teacher's discussions focused on their efforts to prevent movement rather than support increased physical activity within learning environments. For example, as discussed in Chapter Five, the upper primary teacher arranged tables to block straight paths through the classroom to stop students from running to prevent injuries.

There is often miscommunication (or no communication at all) by the architects with the school teachers on how the final outcome has been envisaged to be used (Lippincott 2009). For instance, if the furniture is not installed before handover, the users may position furniture in ways that do not align with the design intention. This can occur in non-traditional learning environments, with miscommunication and a lack of environmental competence resulting in the space being used traditionally (Byers 2015): 'the notion that the physical environment could help them meet their goals goes largely unrecognized by educators, who continue with traditional patterns of instruction despite innovations in school design' (Lackney 2008, 136). This is similar to the failures of the open-plan classrooms in Australia during the 1970s, as discussed in Chapter Two, when teachers were not provided with the training and support needed to use the new classrooms successfully. This is not to say that teachers and students must use the spaces as they were envisaged by the designer; however, if the teachers and students have knowledge of design intentions and opportunities for use, they can then make informed decisions on the best way to use the spaces. If learning environments are designed to support increased physical activity behaviours of students, then the teachers should be trained to make the best use of the spaces. This suggests that architects play a crucial role in not only designing spaces that support increased physical activity but also in communicating to the school organisation (specifically teachers) how they can arrange and use the learning environment to best support students' physical activity behaviours.

Communicating with Students

Physical cues help not only teachers to understand how to best use a space but also students. For instance, a small window seat can indicate to students that quiet individual work best suits this space. One architect discussed in an interview that they believed students' environmental competence was much stronger than that of most adults, with better imagination and creativity with using space (interview with architect C, 13 October 2020). They believe that students need a variety of spaces available to them so that they can choose the most suitable workspace for a particular activity; however, this is generally not available to students in traditional classrooms who are provided standard furniture and often in assigned seating. An example they spoke of was an observation of a student being asked to work individually; the student chose to sit under a desk because there were no other spaces available to give the desired sense of enclosure (interview with architect C, 13 October 2020). This observation made by the architect demonstrates students' environmental competence to make the most of the learning environment available to them. The same architect also believes that students should be able to alter their environment to suit their learning because they each have preferences with using learning environments (interview with architect C, 13 October 2020). However, often school policies or teacher rules limit students' ability to make changes to their learning environments.

Although students are generally the lowest-ranked stakeholder, one of the architects stated that their best advice to other stakeholders was to listen to children because learning environments should primarily support students (interview with architect C, 13 October 2020). After working as an architect for 35 years and being involved in designing more than 40 schools, they believe that students' voices are the most important consideration during the design process (interview with architect C, 13 October 2020). They explained how they always gain new and insightful information to influence their design outcomes when consulting with students. The architect recommended a combination of observation and discussions with students as certain information may come out with one of the methods but not the other (interview with architect C, 13 October 2020). For instance, at one school, the architect conducted workshops where the students commented that they did not have enough seats to use during break times, as their friendship groups were much larger than current seating accommodated for. The architect believes this information would not have been noticed during observations only (interview with architect C, 13 October 2020). This is supported by my own mixed-method data collection and analysis, which demonstrated that certain information can be drawn from each method and combined to understand the complex picture of learning environments.

Consultation with students as stakeholders can be undertaken in a variety of ways. In an interview, one architect discussed the methods they used to gain student opinions and how they vary based on student age (interview with architect C, 13 October 2020). The architect pointed out that the workshop activities should be 'at their level where they can engage' so should be tailored to students' abilities (interview with architect C, 13 October 2020). For instance, they described how young students can be asked to create art of what they would like their new school to include or how it might look. Older students, such as those in secondary school, can have verbal discussions with the architects to describe how they learn and the types of activities they enjoy doing. The same interviewed architect also stated that through 'engaging with kids, you can discover things about the site, you can discover things about what they do and what's important to them' (interview with architect C, 13 October 2020). They related that the students would often provide information that surprised even the teachers (interview with architect C, 13 October 2020), which demonstrates the importance of consulting with multiple stakeholders from different groups. This is especially relevant with physical activity behaviours because all students have different preferences for movement.

Architects have the power to influence students' physical activity behaviours before the construction of the school buildings; however, they are strongly influenced by the school organisation. There is an opportunity for this project to fill a gap in the literature, as there is currently limited knowledge to help architects design school buildings to improve students' physical activity behaviours. It is clear that to improve students' physical activity behaviours in learning environments, all stakeholders involved with school design, use and occupation should be involved, and stakeholder consultation is a critical method to use. Stakeholder consultation as a process of design builds on the knowledge of the various stakeholders, including architects, school leaders, teachers and students; however, challenges in communication and environmental competence need to be managed. Stakeholder consultation is required throughout all stages of the design, construction and occupation to ensure that all stakeholders prioritise students' physical activity behaviours within learning environments.

Architects and Government Can Work Together to Improve Students' Physical Activity in Learning Environments

In Australia, state and federal government organisations have control over many aspects of school environments, including curriculum and the design of the standard pattern brief, and they have the power to create widespread change within learning environments through policies. POEs are a method of data collection commonly used to inform government decisions about school environments; however, POEs must ask questions about students' physical activity behaviours to make improvements to students' movement in the future. In this section, I argue that architects and government organisations must work together to improve students' physical activity behaviours within learning environments. The discussion builds on the information presented in Chapter Two regarding the standard pattern brief and PrOEs and POEs of learning environments.

Government Influence on Physical Activity

Policies by state and federal government organisations can also affect students' physical activity behaviours within learning environments, for instance, through minimum accommodation requirements. In an interview, an architect stated that outdoor space for physical activity has minimum requirements for young children since they fall under the childcare laws, whereas there are no minimum outdoor space requirements for older children (interview with architect C, 13 October 2020). As previously discussed, larger campuses, buildings and play areas per student significantly affect the level of physical activity gained by students (Cradock et al. 2007). Research has also found that students gain more MVPA on grass surfaces than hard surfaces such as paving (Andersen et al. 2015). During my observation of the case study school, a teacher stated that in their opinion, the upper and middle primary playground space was not big enough for the number of students using that space. Policies dictating minimum outdoor space requirements for all levels of schooling could support the increased physical activity of students.

As outlined in Chapter Three, national curriculum policies in Australia stipulate that every primary school must provide at least two hours of physical activity per week to all children (Australian Government 2016). However, the level of physical activity is not stipulated within the guidelines, so it is unclear whether students would be achieving MVPA for those two hours. School organisations can interpret these guidelines in various ways for incorporation into their school policies. In the case study school, the two hours were split into two sessions across the week, with one session generally focusing on fitness and the other on specific sports skills such as ball sports. On one occasion, I observed a fitness class cut short due to cold weather, and there was no alternative indoor exercise space for MVPA to occur at the case study school. This highlights the importance of government policies as well as school facilities.

The control of the standard pattern brief gives government organisations the power to dictate the design of public primary schools in Australia, which has wide-ranging implications for WA primary school design. As discussed in Chapter Two, the template for the standard pattern brief in WA dictates the design of schools and learning environments from masterplan design through to furniture selection. Although the case study school in this project was not a public primary school, insights from this school are relevant to the standard pattern brief as contemporary schools move towards non-traditional learning environments. If architects and government organisations work together to include considerations of students' physical activity behaviours within the standard pattern brief, the activity levels of a large number of students could be improved.

Purpose and Benefits of Pre- and Post-Occupancy Evaluation

PrOEs and POEs are the most common form of building analysis, and they provide information to a variety of stakeholders, including architects and government organisations. As outlined in Chapter Two, POEs and PrOEs are commonly used to evaluate schools. Their primary goal is to provide managers and designers of school buildings with feedback to improve future buildings and avoid repeating mistakes (Jerome 2012). Formal POEs typically focus on physical elements that can be quantitatively assessed. They focus on questions such as how well does the physical learning environment support the teaching and learning goals? (Lackney 2001). However, to improve students' physical activity behaviours, POEs should also ask questions such as how well do the physical, social and organisational factors of the learning environment encourage student movement and discourage long bouts of sedentary behaviour? Without asking specific questions about students' physical activity behaviours, school stakeholders will not have adequate information to inform their design decisions.

There are numerous advantages to conducting PrOEs and POEs. As outlined in Chapter Two, PrOEs and POEs can support communication between stakeholders; provide information for monitoring, comparing and improving buildings; inform decisions and policies; and reduce recurrences of failures (Lackney 2001, 2). POEs of schools typically evaluate whether the construction quality meets the original brief and rarely focus on physical activity goals of the learning environments. When the data provided by POEs do not focus on building use or students' physical activity behaviours, POEs cannot improve these aspects. In an interview, an architect explained that POEs allows them to witness the surprising ways that teachers and students used space (interview with architect C, 13 October 2020). For instance, the architect related that in one school they designed, the classrooms have a small alcove that each teacher can use in different ways: one teacher put cushions to create a kids' retreat; another teacher put curtains across it to create a stage; and another teacher used it as storage space (interview with architect C, 13 October 2020). Without conducting a POE, these types of adaptations by teachers would not be viewed by the architect and therefore could not inform their future designs. The observations conducted during POEs have the opportunity to provide insight into students' physical activity behaviours and how they are affected by the built environment. To improve students' physical activity behaviours, PrOE and POE questions must reflect all the essential aspects of learning environments, including analysis and observations of students' movement.

As was outlined in Chapter Two, PrOEs can provide additional benefits to the design process of learning environments that seek to improve students' physical activity behaviours. For example, a PrOE can be conducted at an existing school prior to the design of a new school to provide baseline information that can then be compared to future data collected through a POE. This can allow for analysis of the effects of the changes implemented within the design. For instance, physical activity data can be recorded before and after interventions to understand the implications of altering learning environments. In one interview, an architect discussed their process, which they referred to as 'pre-occupancy meetings', that they conduct prior to the school moving into the space (interview with architect C, 13 October 2020). They do this to combat problems caused by the extended length of construction projects, which often results in staff changes since the initial design phase. Their pre-occupancy meetings process ensures that all current staff are aware of the design concepts, opportunities for furniture layouts and anticipated use of different spaces. However, the architect also commented that teachers are of course able to adapt the spaces to suit their needs (interview with architect C, 13 October 2020), which could then be observed through a POE. This pre-occupancy meeting process is not technically a pre-occupancy evaluation, but it would be suitable for any school attempting to improve student physical activity behaviours because it would ensure all teachers are fully informed before occupying the spaces.

Informal Pre- and Post-Occupancy Evaluations

Formal PrOEs and POEs are not a compulsory part of many school projects in Australia; however, informal evaluations are usually conducted by architects as part of their design processes. As discussed in Chapter Two, Hay et al. (2018) state that architects generally only consider formal evaluations to be POEs and ignore informal evaluations, which limit their own evaluation practices. This was demonstrated in the interviews with architects, as all three gave ambiguous or contrasting statements about their POE practices (interview with architect A, 20 September 2018; architect B, 8 October 2020; architect C, 13 October 2020). They stated that they did not regularly conduct POEs; however, I posit that they do conduct them informally because they stated that they received feedback from schools. Two architects stated that they are often contracted on an ongoing basis at independent schools, as they are usually built in stages across many years (interview with architect C, 13 October 2020; architect B, 8 October 2020). This means they work closely with the schools, learning from each stage before designing the next. Both architects referred to this as ‘feedback’ that enables them to implement changes to future projects based on both successful and unsuccessful aspects (interview with architect C, 13 October 2020; architect B, 8 October 2020). The architect who designed the case study school discussed the staged construction process that took place over 10 years; however, the design process was not spread over this time (interview with architect A, 20 September 2018). So, feedback from early construction stages did not influence the design of later construction stages. However, they did state that the final construction phase yet to commence has been somewhat redesigned based on feedback from the school (interview with architect A, 20 September 2018). To improve students’ physical activity behaviours, architects could adapt their informal feedback processes to include questions for the school organisation about students’ movement within learning environments. Architects could also include observation periods within learning environments to see firsthand how students and teachers use learning environments after construction.

Quantitative and Qualitative Evaluations

PrOEs and POEs rarely focus on qualitative elements such as how a building feels, if the building is fit for purpose or if users enjoy spending time in the spaces, and instead focus on quantitative elements such as size, energy use, materials, ventilation and air quality, lighting and acoustics (Hay et al. 2018). Hay et al. (2018, 706) state that building evaluations should concentrate on 'wider impacts, embracing not just quantitative or technical aspects, but also how a building works in spatial, social and cultural terms'. As discussed in Chapter Two, POEs are often conducted by stakeholders such as facility managers or employees from government organisations (Vischer 2001) who may be untrained in analysing architecture or collecting qualitative data; however, architects are uniquely skilled to evaluate buildings through both a qualitative and quantitative lens. Students' physical activity behaviours can be evaluated using both qualitative and quantitative methods, as demonstrated by the methods used in this project. Each method provides different knowledge about student movement that is useful for use in POEs of learning environments.

Although architects have the skills to analyse space in qualitative and quantitative ways, designers seem to view quantitative data as more important in POEs. In an interview with an architect, when asked if they conducted POEs for their school designs, they said no and specifically mentioned that they did not collect quantitative data (architect A, 20 September 2018). However, they then clarified that they were often back at the school and know that the users are happy with the design but did not know why from a 'statistical point of view' (interview with architect A, 20 September 2018). Therefore, the architect did not seem to view qualitative observations or informal discussions as important or consider them to be POEs. As previously outlined, a similar discussion was also had during interviews with two other architects who stated that they did not conduct POEs but then went on to describe their informal qualitative reviews of the schools (interview with architect B, 8 October 2020; architect C, 13 October 2020). So, although architects did not view qualitative observations or informal feedback from the schools as POEs, important lessons can be learned from all forms of POE. Hay et al.'s (2018) study found that although academic researchers focused on building evaluations and POE toolkits frequently debate the importance of mixed-methods evaluations, this same debate has not translated into architectural practice: ‘the divide between practice knowledge and the academy appears to remain intact’ (Hay et al. 2018, 706). This may also be due to a lack of dissemination of POEs, especially in relation to informal or qualitative evaluations that may not be thoroughly recorded in the same way formal or quantitative evaluations often are, which will be discussed in the following section.

The Dissemination of Pre- and Post-Occupancy Evaluation Data

Even if PrOEs and POEs are recorded, they are unlikely to be disseminated beyond the project team, so the information is not available to a wider audience. This may be due to privacy or copyright concerns. An architect explained in their interview that the school organisation owns the data collected through evaluations, so they would need to give permission to the architect to disseminate the information beyond the project team or architectural office (interview with architect C, 13 October 2020). A lack of dissemination could also be due to the lack of an appropriate platform for the sharing of this type of information. Vischer (2001) relates that POEs are likely to be disseminated if they are conducted as academic research but that POEs undertaken in other cases are unlikely to be disseminated for various reasons but predominantly due to a lack of established systems. One participant in the study by Hay et al. (2018, 704) described it as a ‘leakage of knowledge’ within the architectural discipline.

The dissemination of PrOEs and POEs is important because architects learn from other built or unbuilt examples of architectural design. This is often called ‘precedent analysis’. All the architects interviewed stated that they study precedent projects as part of their design processes; however, none of the architects had heard of any projects that specifically encouraged student physical activity within classrooms (interview with architect A, 20 September 2018; architect B, 8 October 2020; architect C, 13 October 2020). This suggests that there may be a gap in publications focused on school design that seeks to improve students’ physical activity behaviours and an opportunity for both formal and informal building evaluations to be more widely disseminated on the topic. PrOEs and POEs could provide architects with information to allow the architects to make a more informed analysis of precedent projects. One architect discussed their preference to visit precedent projects in person because they felt the information available online was limited, noting the particular difficulty of obtaining floor plans (interview with architect B, 8

October 2020). However, they noted that publications by the Association for Learning Environments often provided floor plans as well as photos and detailed descriptions of the schools, which were useful (interview with architect B, 8 October 2020). This demonstrates the usefulness of professional organisations such as the Association for Learning Environments and that in order for architects to use building evaluations to inform their own design practices, a combination of visual and written information is needed.

If architects could show the data from PrOEs and POEs of past schools to stakeholders in a current construction project, this could allow stakeholders to be more informed. The process of analysing previously built buildings and learning environments can be useful not only to the architect but also to the other stakeholders in a school project. The architects can show previously built schools (designed by them or by others) to stakeholders to explain design ideas that could be incorporated. One architect explained that this was particularly useful when working with stakeholders who had limited experience with different types of learning environments, as it opened them up to new (non-traditional) ways of designing and using learning spaces (interview with architect C, 13 October 2020). The same architect preferred to take the stakeholders to the precedent projects in person, if possible, but otherwise, photos or videos are used (interview with architect C, 13 October 2020).

PrOEs and POEs are vital methods of data collection within architectural fields, but the focus must shift from quantifiable questions about the physical environment to qualitative questions about the use of learning environments to influence students' physical activity behaviours positively. The analysis and recording of learning environments from a physical and quantitative lens rather than a qualitative one are not confined to PrOEs and POEs only, but also precedent analysis. Frequently, discussion of learning environments focuses on the physical characteristics of how the building looks rather than how the spaces are used and how users feel within them. This can be seen within the publications by LEA, which feature the projects entered into their awards program in a primarily descriptive way (see for instance LEA 2020). Many of the photos of these schools in these publications feature empty learning spaces that do not give a true sense of how the school might be used. However, because the members are all stakeholders interested in learning environment design, this organisation and its members would benefit greatly from the dissemination of PrOEs and POEs.

Hay et al. (2018) outline that professional institutes such as the Royal Institute of British Architects, which is equivalent to the Australian Institute of Architects, need to promote and prioritise building evaluations to ensure architects use PrOEs and POEs more widely. Professional institutes also have a role to play in informing architects of highly regarded evaluation toolkits and in disseminating building evaluation research. For school buildings specifically, the Association for Learning Environments is another important organisation for promoting and publishing building evaluations.

It is clear that to gain information about students' physical activity behaviours in learning environments through PrOEs and POEs, the architects and government organisations (or other stakeholders) must ask questions about students' physical activity behaviours. PrOEs and POEs are vital methods of building analysis used to inform architects design decisions to make improvements for the future. However, evaluation toolkits generally focus on quantitative elements with little regard for qualitative methods or students' physical activity behaviours. For stakeholders, and architects, in particular, to design learning environments that encourage student movement, they need to be armed with the knowledge of critical design factors that influence students' behaviour. PrOEs and POEs can be used to provide this knowledge to architects.

Conclusion

In this chapter, I argued that stakeholders such as architects, teachers, schools and government organisations control the physical, social and organisational factors within learning environments that influence students' physical activity behaviours. I outlined how students' physical activity behaviours during the whole school day are influenced by social and organisational factors such as school policies and the school's culture. School organisations' beliefs about risk and safety can negatively affect students' physical activity behaviours through school policies regarding playground use and design implications such as reluctance to construct multi-storey schools and build on sloping sites to avoid the need for stairs. However, architects and school organisations can collaborate to improve students' physical activity behaviours through stakeholder consultation to create lasting change. Genuine stakeholder consultation and collaboration can ensure new learning environments are fit for purpose, although there are challenges such as communication problems and issues with environmental competence. Architects play a crucial role in designing spaces that support increased movement and communicating to the school organisation (specifically teachers) how learning environments can be arranged to best support students' physical activity behaviours. State and federal government organisations can influence the physical activity behaviours of students through curriculum, policies and the design of public schools. Architects and government organisations can use PrOEs and POEs to work together to improve the physical activity behaviours of students in learning environments.

8. Conclusion: Working Together to Improve Students' Physical Activity in Learning Environments

In this thesis, I used a case study research project to examine how the architectural design of learning environments influences students' physical activity behaviours. I saw that the physical learning environment is an influencing factor, and social and organisational factors, as well as the processes used to design and evaluate schools, can influence the physical activity behaviours of students within primary schools. In this chapter, I highlight the key conclusions of the project and discuss the recommendations for school organisations, architects and government organisations to improve students' physical activity behaviours. I argue that a holistic approach to the design, occupation and use of primary schools is needed to create physical, social and organisational environments that support children being physically active. The holistic approach will need to involve all stakeholders involved in schools, such as school organisations, teachers, architects and government organisations.

Schools have been identified as a key focal area for research and targeted physical activity interventions because Australian children spend a large portion of their waking hours in school, yet children are consistently failing to meet guidelines for physical activity (AHKA 2014, 2015, 2016, 2018). Australian school-aged children are recommended to obtain at least 60 minutes of MVPA every day and accumulate no more than two hours of non-educational screen time (Australian Government Department of Health 2014). Health promotion practitioners also highlight the need for children to increase movement across all intensity levels and decrease sedentary behaviour, particularly in long bouts (see for instance Healy et al. 2008; Peddie et al. 2013). The best methods to create behaviour changes in learning environments have not yet been discovered, and little was previously understood about how the architectural design of learning environments influence the physical activity behaviours of students in Australian schools. This project aimed to identify how the physical, social and organisational factors of learning environments and the processes of their design influence students' physical activity behaviours to provide knowledge to key school stakeholders such as architects, school leaders, teachers and government organisations. To achieve this, I used a multidisciplinary mixed-method case study approach using a single case study school with non-traditional learning environments. The social ecologic model by Zimring et al. (2005) was used as the theoretical framework, which provided a lens through which to understand the various physical, social and organisational factors that influence students' physical activity behaviours in learning environments.

Learning Environments Influence Students' Physical Activity

Through documenting historical and contemporary architectural theory and design trends in school architecture, it is clear that generally, the design of learning environments across the globe has changed very little during the past century. Although societal and pedagogical ideas changed from teacher-centred to student-centred learning modes, the architecture of schools was slow to keep up. Novel designs were tested in Australia following overseas trends, such as the open-plan schools of the 1970s; however, they continued to be seen as progressive rather than the norm. They were often viewed as failures because teachers continued implementing traditional teacher-centred practices pedagogies (Lackney 2015). Most Australian schools still divide students into classrooms controlled by a single teacher (Byers and Lippman 2018). More recently, contemporary schools with classrooms that are often referred to as New Generation Learning Environments (NGLEs) or Innovative Learning Environments (ILEs) are becoming more widespread (Imms, Cleveland and Fisher 2016). These non-traditional learning environments suit student-centred pedagogies, as they include open-plan spaces with zones for various activities and allow students to move around the learning spaces throughout the day.

The learning environments of the case study Montessori primary school in Perth, WA, are physically and pedagogically non-traditional and similar to NGLEs. Through architectural analysis and ethnographic observations, I documented learning environments in the case study school designed in an L-shape with light-coloured materials, carpet and vinyl flooring, abundant natural light and ventilation, a kitchen and opening onto a private courtyard or external space. As reported in Chapter Five, the quantitative physical activity data collected via accelerometers revealed the participating students spent close to half of their school day (47.7% or 2:49 hours) in sedentary behaviours, less than 8% (28 minutes) in MVPA and the rest (44.7% or 2:38 hours) in light activity. In comparing the three classrooms, the lower primary students achieved less MVPA and more light activity than the middle and upper primary classrooms, who each recorded similar results. A particularly interesting finding is that the participating students' MVPA did not decline significantly in older students, which is a trend seen in many studies of traditional schools globally (see for instance McCarthy et al. 2021). The participating students spent between 5.5% and 5.7% of class time in mean MVPA, which is low when compared to results from another study based in Perth, which reported that mean class time MVPA was 11% for girls and 12% for boys in primary schools (Martin et al. 2013). Participating students' high-intensity activity is predominantly performed during recess, with students spending between 19.8% and 33.2% in MVPA during that time. This is lower than the 45.7% reported in the study of Perth primary schools (Martin et al. 2013); however, the proportion of participating students spending at least 40% of recess in MVPA is significantly higher (32%) than a recent Australian study (3.8%) (McCarthy et al. 2021). The mixed-methods analysis shows that physical, social and organisational factors influence the physical activity behaviours of participating students. For example, I observed that class time MVPA was primarily achieved during physical education lessons or outside the classroom as students ran through the school campus.

The interior design of learning environments provides spatial cues that indicate to students what behaviours are acceptable in an environment. Traditional classrooms indicate that students should remain seated in their chairs, whereas contemporary learning environments such as NGLEs with zones for various activities indicate to students that they can move around. The physical design of the case study learning environments generally allows students to be physically active throughout the day; however, it is not always encouraged by social and organisational factors. In the observed classrooms, students moved a great deal around the classroom, but their movements were heavily controlled by the teachers through general expectations, rules and specific instructions. For example, students were permitted to walk (not run) around the classroom as part of their learning tasks, but they were told to 'sit properly' on chairs at desks while working. Student misbehaviour is a crucial challenge for increasing students' physical activity behaviours inside classrooms.

School policies and classroom rules due to safety concerns and to maintain order or quiet often affected students' physical activity behaviours. The complexity of the socio-spatial relationship is clear within the case study learning environments. For example, the acoustic design of the physical learning environment influences the noise created when students are physically active, which leads teachers to implement rules against movement to maintain a quiet learning environment. However, architects can design the physical environment with spatial and acoustic articulation, supporting non-traditional pedagogies and students' physical activity behaviours.

Generally, discussions of children's high-intensity physical activity behaviour in schools are focused on external environments such as playgrounds (NICE 2008, 10). While it is true that students achieve more MVPA outside rather than inside, that is because high-intensity physical activity behaviours are generally not permitted inside classrooms or schools (Brittin 2015, 116). Outdoor access ways, such as those seen in the case study school, can provide opportunities for high-intensity physical activity when moving between learning environments. There is a lack of research surrounding the interior design of Australian schools in general and even more so when looking at influences on physical activity behaviours. Most literature relating to school interior environments focuses on academic outcomes, which is unsurprising given the primary goal of schools is to educate students; however, with a renewed interest in health, the field of research into factors that influence physical activity is growing. Classroom-based physical activity (CBPA) is becoming more widely utilised; however, traditional learning environments continue to act as a barrier to widespread implementation due to size limitations, furniture arrangements and a lack of adaptability (Dinkel et al. 2017).

While the single case study school provided only a small sample to draw from, the large amount of mixed-method data collected provide an in-depth study to build grounded theory. The interviews with participating teachers and architects provide additional information and context to the ethnographic observations and quantitative data. The data specifically relate to the single case study school from where they were collected, but the reflections and analysis relate to broader ideas of students' physical activity behaviours and the architectural design of learning environments. Although the research focuses on the single case study primary school, the lessons learned and theories developed apply to other learning environments, especially other non-traditional learning environments. The architectural analysis presented through the thick description in Chapter Five provides a detailed picture of the whole case study school and the three observed classrooms. As highlighted by Bryman (2004), this allows others to decide if the findings have potential relevance or comparability to other settings.

Making Improvements to Students' Physical Activity Behaviours within Learning Environments

Upon starting this project, I thought the research would identify specific elements within learning environments that act as barriers and facilitators to students' physical activity behaviours. I envisaged it being similar to past research that looked singularly at elements such as sit-to-stand desks, classroom area per student or active lessons that incorporate MVPA into academic tasks. However, I found that while these singular factors may influence the physical activity behaviours of students, the complexities of a learning environment mean that no individual factor can be the silver bullet to improve students' physical activity behaviours. Therefore, I recommend a holistic approach be taken by all stakeholders to prioritise students' movement within learning environments throughout the design, occupation and use of schools. Throughout Chapters Six and Seven, I highlighted key physical, social and organisational elements that stakeholders should focus on within school facilities and that researchers could focus on for future research, which I will outline in the following section.

Through this research, I found that larger shared outdoor spaces can be used during class time by students for learning tasks while providing adequate space for MVPA; however, visibility by teachers is required to allow adequate supervision. In the case study school, the designated courtyards adjoining classrooms were highly valued by the school organisation and were thought to provide additional opportunities for students' physical activity behaviours, but these courtyards were often underutilised and did not provide adequate space for MVPA. In contrast, the upper primary students used the shared piazza, which was significantly larger, allowed for MVPA and was visible from multiple rooms to allow supervision by teachers. This differs from the playground spaces that were not used informally during class time due to either physical separation or lack of visibility from the classrooms, and were only used formally during sport or fitness classes. This finding is particularly important for schools on small sites where outdoor space is at a premium. Architects should prioritise shared outdoor spaces with good visibility for supervision. It is important to note that improving opportunities for students to be physically active relies on the school's design, as well as the social and organisational factors such as policies and rules. For instance, the case study school did not allow students to use the outdoor play equipment before school, and the teachers did not allow students to use the play areas during class time. All school stakeholders need to prioritise students' physical activity behaviours to ensure the physical, social and organisational factors support movement.

Inside learning environments, visibility and the control of openness and noise are important. In the case study school, openness allows for visibility, and if students are able to see others being physically active, they can be encouraged to increase their own movement. Architects can control visibility through glazing and spatial articulation, which can be achieved through permanent walls or moveable furniture. Spatial and acoustic articulation within learning environments supports students' physical activity by creating zones for various activities to avoid distraction and control noise. Social and organisational factors are also crucial concerning openness, visibility and noise within learning environments because teachers and school organisations enforce rules and policies that influence students' physical activity behaviours to control safety, noise and distraction. For instance, in the observed classrooms, students who were talking or making noise while moving around were often asked to be quiet or remain still to keep the acoustic levels to a minimum, and at the end of the day, all students were expected to remain seated inside the classroom while waiting for their parents to pick them up.

Furniture is the physical architectural element that students interact with most, and it can have a significant effect on students' physical activity behaviours when supported by social and organisational factors. For instance, many learning tasks could be completed by students while standing at various height desks, which is a simple intervention to reduce sedentary behaviour and increase light physical activity (see for instance Benden et al. 2011; Clemes et al. 2020). The arrangement and type of furniture can also influence students' physical activity behaviours. High-intensity physical activity can be supported through moving furniture to create larger open spaces; however, during an interview, when asked if they alter the classroom to affect physical activity, the upper primary teacher focused on how they limit opportunities for running by moving furniture to block straight paths (interview with upper primary teacher, 30 November 2018). This suggests that the upper primary teacher is not aware of how furniture is able to encourage or support safe physical activity within the classroom, because their aim is to reduce running for improve safety, rather than to increase light physical activity or decrease sedentary behaviour. Incidental physical activity can be encouraged through the placement of key resources around the classroom. For example, in the case study classrooms, materials such as stationery, notebooks and learning resources are spread around the classroom and students are permitted to walk around the room to collect various materials. This differs from traditional classrooms where students' materials are often stored in a tray underneath their desk, limiting opportunities for students to achieve incidental physical activity during class time. School organisations generally control the type of furniture, and the arrangement and use of furniture are generally controlled by individual teachers and differ according to teachers' personal preferences and the overall culture of physical activity in the school. All stakeholders must work together to ensure furniture types and arrangements support students' physical activity behaviours within learning environments.

As discussed in Chapter Seven, school organisations are often risk averse in terms of any risk of injury to students (see for instance Harper 2017), which can lead to school policies that limit students' physical activity behaviours. For instance, in the case study school, one of the reasons students are not permitted to run inside is to reduce the risk of injury (interview with upper primary teacher, 30 November 2018). These types of risk-averse beliefs can also influence the design of school facilities through school organisations reluctance to construct multi-storey schools and their preference for flat sites to avoid the need for stairs (interview with architect B, 8 October 2020; architect C, 13 October 2020).

Students' physical activity behaviours can be considered throughout all stages of school development, including during the briefing stage. In one interview, an architect stated that the only discussion of students' physical activity during the briefing stage usually occurs when discussing external landscaping due to the traditional notion that physical activity occurs outside (interview with architect B, 8 October 2020). However, the same architect stated that in discussions with school organisations, students are discussed as mobile groups moving between different learning zones (interview with architect B, 8 October 2020). This was in reference to contemporary learning environments such as NGLEs, which are similar to the Montessori model. Perhaps the term ‘physical activity’ is being confused with ‘moderate to vigorous physical activity’ (MVPA) or ‘health and physical education’ (HPE), which highlights the importance of ensuring published research uses clear language and emphasises the benefits of physical activity across all levels of intensity.

Architects and school organisations can collaborate to improve students’ physical activity behaviours through stakeholder consultation; however, there are challenges that need to be managed by architects. A regularly cited challenge of the school design and construction process is a lack of environmental competence of school stakeholders, which causes communication challenges. Clear communication between stakeholder groups is vital to overcoming miscommunication, and if all stakeholders use simple language and visual tools, communication barriers can be overcome. Stakeholder consultation also takes additional time and therefore costs more money within the design phase; however, stakeholder consultation is an essential aspect of the design process (Clark 2002). Stakeholder consultation provides many benefits, including ensuring the learning environments are fit for purpose, allowing teachers and students to provide feedback to architects and providing the school organisation and users with a sense of ownership (Martin 2006). Test classrooms can be useful during stakeholder consultation to provide a space for collaboration and feedback prior to permanent changes. In order to significantly improve students’ physical activity behaviours in learning environments, we must learn from past mistakes and ensure that genuine stakeholder consultation is undertaken.

Government policies can influence the physical activity behaviours of students through curriculum, laws and the design of public schools. PrOEs and POEs are vital tools that architects and government organisations can use to improve the physical activity behaviours of students in learning environments. Currently, PrOE and POE toolkits generally focus on quantitative elements with little regard for qualitative methods (Hay et al. 2018) or students' physical activity behaviours. Hay et al. (2018) highlight the ongoing gap in applying academic PrOE and POE research to architectural practice, which could be due to a lack of dissemination. This limits the knowledge available to inform architects and government organisations during the design of schools since PrOEs and POEs could be used to provide knowledge about how learning environments influence students' physical activity behaviours.

The research demonstrates that all stakeholders, including architects, schools, teachers and government organisations, have power and control in learning environments; therefore, all stakeholders must prioritise students' physical activity to improve these behaviours. Both academic research and learning environment evaluations must be widely disseminated for genuine positive changes to be made to students' physical activity behaviours within Australian schools. It is important that academic case studies are published; an interviewed architect indicated that they would look to precedent school projects to understand how other architects have attempted to improve students' physical activity (interview with architect C, 13 October 2020). The case study methodology and mixed-methods approach chosen in this project are ideal for providing architects with quantitative data about students' physical activity behaviours and qualitative information relevant to learning environment design. Chapter Five acts as a precedent study for architects to gain a clear idea of the design of the case study learning environments to inform their own design decisions.

If schools want to improve students' physical activity behaviours in classrooms by lowering sedentary behaviour and increasing movement, a holistic approach needs to be undertaken. This will need to span architectural design, school policies, teacher training and collaboration with all stakeholders, including students. To lead this process within new schools, architects need to be informed of the physical barriers and facilitators of student movement within classrooms. Schools must ensure they implement policies that do not unduly restrict student movement and, instead, provide learning environments that allow and encourage physical activity. Teachers should be provided with training to understand the benefits of movement and the detriments of sedentary behaviour and have the knowledge, tools and environmental competence to encourage students to improve their physical activity behaviours within learning environments. Most importantly, all stakeholders should collaborate to share knowledge and ensure teachers and students can use the learning environments to support their learning goals and physical activity behaviours.

This research highlights the importance of multidisciplinary research to understand (before attempting to change) the physical activity behaviours of students within complex learning environments. The mixed-methods case study was successful in understanding the factors that influence students' physical activity behaviours, as it provided quantitative data and qualitative contextual information. The results demonstrate the importance of future research following similar mixed-methods research to ensure the complexities of learning environments physical and social aspects are further understood.

I offer the research findings to those working in or studying learning environments, to identify whether the theories I have developed are relevant or useful to them. As noted by Bryman (2004), ethnographic observations recorded through thick description, as I have done, allow others to decide if the findings have potential relevance or comparability to other settings as well as relevance for future studies. Through this research, I do not present a guideline for creating the perfect learning environment where students can achieve perfect levels of physical activity. Besides the fact that no environment or behaviour pattern is ever perfect, the theories developed from the research remain theories and are not proven successful in all instances. However, I provide information that could be used by those seeking to improve the physical activity behaviours of students in learning environments.

Future Research Directions

Research into physical and social influences on students' physical activity behaviours is limited, so this project does not attempt to fill that large gap in the literature; rather, it acts as a continuation of emerging research focusing on Australian learning environments. The research builds on the important work of WA researchers such as Martin (2010) and Christian et al. (2018) with a narrowed focus on architectural implications. This thesis contributes to a deeper understanding of the factors within the design of learning environments that influence students' physical activity behaviours. As the single case study was a non-traditional Montessori school, the findings may be relevant to other non-traditional schools such as NGLEs, which are becoming more common. Stakeholders, including school organisations and architects, would benefit from further research using similar methods at traditional schools and other non-traditional schools. Future research should continue to discover the factors within learning environments that influence students' behaviours until physical activity guidelines are met.

School stakeholders would benefit from the future development of a POE (or PrOE) toolkit that specifically focuses on students' physical activity behaviours within learning environments. As highlighted by the success of the mixed-methods approach in this project, future POE toolkits could utilise both quantitative and qualitative questions. These toolkits could focus solely on the students' physical activity behaviours or include questions about movement within toolkits that look more broadly at learning environments. To summarise the architectural design recommendations and potential directions for future research, the key recommendations for each stakeholder group can be seen in Table 8.1. All recommendations would also benefit from future academic research by multidisciplinary teams.

Table 8.1 Recommendations for design implications and future research of learning environments.

Recommendations for architects: • Learning spaces can support students' physical activity behaviours through spatial articulation and flexibility of space to allow adaptable furniture and purposeful use of zones. • Acoustic design (including absorbent materials and acoustic spatial articulation) can support students' physical activity behaviours. • Non-traditional learning environments support student-centred pedagogies, which can encourage students to be more physically active. • Spatial cues can prompt students to be more physically active and pre-occupancy meetings with teachers can ensure teachers are informed and confident using new spaces. • Shared outdoor spaces can provide adequate space for high-intensity activity and acoustic separation for noisy academic tasks. • Test classrooms can provide schools an opportunity to test, collaborate and provide feedback on changes such as learning environment layout and furniture arrangements before changes are made permanent.
Recommendations for school organisations and teachers: • Consider the influence of acoustic design on students' physical activity and teachers' perceptions of noise. • Furniture selection and arrangement should remove trays from under desks and encourage students to move around the learning environment to collect and use learning resources. • Dynamic furniture and standing desks can encourage students to perform micro-movements and light physical activity. • Policies and rules that unduly restrict students' physical activity should be limited, and instead, policies should encourage students to be physically active and reduce sedentary behaviours. • Non-traditional learning environments support student-centred pedagogies, which can empower children to make their own choices of workspace.
Recommendations for government organisations:

- The standard pattern brief should be reviewed to ensure the design suits best practice and current research, and it should be designed to encourage students to be physically active.
- Post-occupancy evaluations should include qualitative methods and questions about students' physical activity behaviours.

Conclusion

Through this research project, I found that physical, social and organisational factors are intrinsically interlinked and that these combined socio-spatial factors affect the physical activity behaviours of students in learning environments. I argue that a holistic approach to primary school design, use and occupation is needed to ensure the physical, social and organisational environments support improved physical activity behaviours of students. Improved physical activity behaviours need to be developed in learning environments, and this improvement is linked to lifelong health and productivity outcomes.

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10. Appendices

Appendix 10.1. Ethics Approval Letters

Curtin University

Office of Research and Development

GPO Box U1987
Perth Western Australia 6845

Telephone +61 8 9266 7863
Facsimile +61 8 9266 3793
Web research.curtin.edu.au

24-Apr-2018

Name: Robyn Creagh
Department/School: School of Design and the Built Environment
Email: R.Creagh@curtin.edu.au

Dear Robyn Creagh

RE: Ethics Office approval
Approval number: HRE2018-0188

Thank you for submitting your application to the Human Research Ethics Office for the project **Architecture and Children's Physical Activity in Perth Primary Schools.**

Your application was reviewed through the Curtin University Low risk review process.

The review outcome is: **Approved**.

Your proposal meets the requirements described in the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007)*.

Approval is granted for a period of one year from **24-Apr-2018** to **23-Apr-2019**. Continuation of approval will be granted on an annual basis following submission of an annual report.

Personnel authorised to work on this project:

Name	Role
Creagh, Robyn	CI
Pages-Oliver, Rachel	Student
Jancey, Jonine	Supervisor
Blackford, Krysten	Supervisor

Approved documents:

Document

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
   - proposed changes to the approved proposal or conduct of the study
   - unanticipated problems that might affect continued ethical acceptability of the project
   - major deviations from the approved proposal and/or regulatory guidelines
   - serious adverse events
3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)
4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a completion report submitted on completion of the project
5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
8. Data and primary materials must be retained and stored in accordance with the Western Australian University Sector Disposal Authority (WAUSDA) and the Curtin University Research Data and Primary Materials policy
9. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
10. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
11. Approval is dependent upon ongoing compliance of the research with the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research, applicable legal requirements, and with Curtin University policies, procedures and governance requirements
12. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Special Conditions of Approval

None

This letter constitutes low risk/negligible risk approval only. This project may not proceed until you have met all of the Curtin University research governance requirements.

Should you have any queries regarding consideration of your project, please contact the Ethics Support Officer for your faculty or the Ethics Office at hrec@curtin.edu.au or on 9266 2784.

Yours sincerely

[redacted]

Amy Bowater
Acting Manager, Research Integrity

THE UNIVERSITY OF NOTRE DAME AUSTRALIA

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8 June 2020

Dr Robyn Creagh & Ms Rachel Pages-Oliver
School of Arts & Sciences
The University of Notre Dame Australia
Fremantle Campus

Dear Robyn and Rachel,

Reference Number: 2020-086F

Project title: "Architecture and Children's Physical Activity in Perth Primary Schools."

Thank you for submitting the above project for review. It is noted that you have ethics approval for this project from Curtin University HREC, reference number HRE2018-0188. Your application has been assessed as qualifying for a Cross-Institutional approval and is therefore exempt from HREC review. I am pleased to advise that ethical clearance has been granted for this proposed study.

Other researchers identified as working on this project are:

Name	**School**	**Role**
Prof Sarah McGann	School of Arts & Sciences	Co-Supervisor
A/Prof Jonine Jancey	Curtin University	Co-Supervisor
Dr Krysten Blackford	Curtin University	Co-Supervisor

All research projects are approved subject to standard conditions of approval.
Please read the attached document for details of these conditions.

Should you have any queries about this project, please contact me at [redacted] or Natalie.Giles@nd.edu.au.

Yours sincerely,

[redacted]

Dr Natalie Giles
Research Ethics Officer
Research Office

Cc: Dr Robbie Busch, SRC Chair, School of Arts & Sciences

Broome Campus 88 Guy St (PO Box 2287) Broome WA 6725
Sydney Campus 140 Broadway (PO Box 944) NSW 2007

Fremantle Broome Sydney

ABN 69 330 643 210 | CRICOS Provider Code: 01032F

nd.edu.au

Note: name of candidate changed during research process

Appendix 10.2. Consent Forms

School Consent Form:

INFORMATION STATEMENT

HREC Project Number:	HRE2018-0188
Project Title:	Architecture and Children's Physical Activity in Perth Primary Schools
Chief Investigator:	Dr Robyn Creagh Lecturer, School of Design and the Built Environment
Student researcher:	Ms Rachel Pages-Oliver PhD Candidate, School of Design and the Built Environment
Version Number, Date:	3, 26/04/2018

Introduction

- The built environment influences behaviour in a variety of ways and often provides cues as to how individuals should behave in certain spaces. Children in Australia are failing to meet recommended levels of physical activity and sedentary behaviour. As children spend a large amount of time in schools, it is important to understand how the architectural environment of schools influences physical activity behaviours.

Researcher

- Rachel Pages-Oliver is conducting the research to fulfil a Doctor of Philosophy project at Curtin University funded by the Australian Government Research Training Program Scholarship. The project supervisors are Dr Robyn Creagh, School of Built Environment; Associate Professor Jonine Jancey, School of Public Health; and Dr Krysten Blackford, School of Public Health.

Importance

- This research is significant to fill a gap in knowledge about how the design of Australian primary schools impact physical activity behaviours of children. This will provide new information for schools, architects and designers to influence the physical activity behaviours of children through design of Australian primary schools.

Participants

- Western Australian primary schools will be invited to participate in the study to be conducted in 2018. The researcher will require access to the school grounds for the duration of the study. Photos may be taken within the school and the classrooms.
- I will ask you to nominate 3 classrooms (year 1, 3 and 5) from each school to participate in the research, with each classroom monitored for 10 school days. The architecture of the school will be analysed and the selected classrooms will be studied in detail. Participating students within the selected classrooms will be fitted with an accelerometer (ActiGraph GT3X+) to record their physical activity behaviours for the 10 school days. An accelerometer is a small device on an elastic band which is worn around the waist on the outside of clothing. It records physical activity data such intensity of movement and step count. The students will be instructed by the classroom teacher to remove the accelerometer before leaving school each day and reminded to re-attach it when they arrive each morning.
- During the first 5 days of study, the researcher will be present within the classroom to observe the student's physical activity behaviours. Informal interviews with students and teachers may be conducted during the observation period. These will be casual conversations as the students and teachers go about their daily learning to identify their opinions of school architectural environments and perceived influences on physical activity. These informal interviews will be documented in field notes and will not be audio recorded.
- Photos will be taken within the school and classrooms which may include students and staff.

- The teachers from each of the participating classrooms will be interviewed after the observation period. Questions will centre on teacher opinions of children's physical activity behaviours and the role of the built environment. Interviews will be semi-structured and will take roughly 1 hour. These interviews will be audio recorded for transcription.

Benefits and Risks

- This research provides a unique opportunity to schools, parents and children to gain knowledge about current physical activity behaviours of children. This research will provide new information for school management and governing bodies to influence the future design of Australian primary schools to improve physical activity behaviours of children. We will make a presentation to all staff in participating schools to provide information and generate discussions on children's physical activity behaviours and how architectural design can be used to its full potential. Morning/afternoon tea will be provided. This presentation will be of particular benefit to schools which are considering building works in the future.
- We will make all attempts not to disrupt the teaching or learning within the classroom or school. Rachel Pages-Oliver holds a current Police Clearance and Working with Children card.
- Accelerometers are a relatively non-invasive form of movement tracking as they are worn around the waist. It is recognised that accelerometers are more invasive than other methods of data collection (e.g. surveys), however due to the age of the students, it is unlikely that accurate quantitative data on physical activity behaviours could be collected with other methods.
- Participation is completely voluntary and consent can be withdrawn at any time during the study. No further data will be collected if consent is withdrawn. Data already collected may be used in the research, unless otherwise requested. Students not participating in the project can still attend classes within the monitored classroom, however they will not wear an accelerometer, will not be recorded within any field notes, and will not be engaged by the researcher.

Confidentiality

- All data will be coded to maintain anonymity of all participants and will be stored securely at Curtin University. Data will be used for the process of the PhD research and may be made publically available. Published material may include but is not limited to PhD dissertation, de-identified data, and peer reviewed journal articles. No identifiable data will be released unless required by law. All data and results will be kept for a minimum of 7 years after project completion or until all participants have reached 25 years of age, whichever is later, then destroyed.
- Published photos will de-identify individual students or staff.
- To maintain privacy, participants will not be advised on their individual physical activity behaviours, however a summary of overall results will be given to each school to make available to teachers, students and parents.

Ethics

- Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2018-0188). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

CONSENT FORM

HREC Project Number:	HRE2018-0188
Project Title:	Architecture and Children's Physical Activity in Perth Primary Schools
Chief Investigator:	Dr Robyn Creagh Lecturer, School of Design and the Built Environment
Student researcher:	Ms Rachel Pages-Oliver PhD Candidate, School of Design and the Built Environment
Version Number, Date:	3, 26/04/2018

- I have read the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I consent to photos being taken of students and staff during the study.
- I voluntarily consent for the below listed school to take part in this research project, and understand I can withdraw consent at any time during the study.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007) updated March 2014.
- I understand I will receive a copy of this Information Statement and Consent Form.

School Name	
Principal Name	
Principal Signature	
Date	

Declaration by researcher: I have supplied an Information Statement and Consent Form to the participant who has signed above, and believe that they understand the purpose, extent and possible risks of their involvement in this project.

Researcher Name	
Researcher Signature	
Date	

Teacher Consent Form:

INFORMATION STATEMENT

HREC Project Number:	HRE2018-0188
Project Title:	Architecture and Children's Physical Activity in Perth Primary Schools
Chief Investigator:	Dr Robyn Creagh Lecturer, School of Design and the Built Environment
Student researcher:	Ms Rachel Pages-Oliver PhD Candidate, School of Design and the Built Environment
Version Number, Date:	3, 26/04/2018

Introduction

- The built environment influences behaviour in a variety of ways and often provides cues as to how individuals should behave in certain spaces. Children in Australia are failing to meet recommended levels of physical activity and sedentary behaviour. As children spend a large amount of time in schools, it is important to understand how the architectural environment of schools influences physical activity behaviours.

Researcher

- Rachel Pages-Oliver is conducting the research to fulfil a Doctor of Philosophy project at Curtin University funded by the Australian Government Research Training Program Scholarship. The project supervisors are Dr Robyn Creagh, School of Built Environment; Associate Professor Jonine Jancey, School of Public Health; and Dr Krysten Blackford, School of Public Health.

Importance

- This research is significant to fill a gap in knowledge about how the design of Australian primary schools impact physical activity behaviours of children. This will provide new information for schools, architects and designers to influence the physical activity behaviours of children through design of Australian primary schools.

Participants

- Western Australian primary schools will be invited to participate in the study to be conducted in 2018.
- 3 classrooms (year 1, 3 and 5) from each school will be nominated to participate in the research, with each classroom monitored for 10 school days. The architecture of the school will be analysed and the selected classrooms will be studied in detail. Participating students within the selected classrooms will be fitted with an accelerometer (ActiGraph GT3X+) to record their physical activity behaviours for the 10 school days. An accelerometer is a small device on an elastic band which is worn around the waist on the outside of clothing. It records physical activity data such intensity of movement and step count. The students will be instructed by the classroom teacher to remove the accelerometer before leaving school each day and reminded to re-attach it when they arrive each morning.
- During the first 5 days of study, the researcher will be present within the classroom to observe the student's physical activity behaviours. Informal interviews with students and teachers may be conducted during the observation period. These will be casual conversations as the students and teachers go about their daily learning to identify their opinions of school architectural environments and perceived influences on physical activity. These informal interviews will be documented in field notes and will not be audio recorded.
- Photos will be taken within the school and classrooms which may include students and staff.

- The teachers from each of the participating classrooms will be interviewed after the observation period. Questions will centre on teacher opinions of children's physical activity behaviours and the role of the built environment. Interviews will be semi-structured and will take roughly 1 hour. These interviews will be audio recorded for transcription.

Benefits and Risks

- This research provides a unique opportunity to schools, parents and children to gain knowledge about current physical activity behaviours of children. This research will provide new information for school management and governing bodies to influence the future design of Australian primary schools to improve physical activity behaviours of children. We will make a presentation to all staff in participating schools to provide information and generate discussions on children's physical activity behaviours and how architectural design can be used to its full potential. Morning/afternoon tea will be provided. This presentation will be of particular benefit to schools which are considering building works in the future.
- We will make all attempts not to disrupt the teaching or learning within the classroom or school. Rachel Pages-Oliver holds a current Police Clearance and Working with Children card.
- Accelerometers are a relatively non-invasive form of movement tracking as they are worn around the waist. It is recognised that accelerometers are more invasive than other methods of data collection (e.g. surveys), however due to the age of the students, it is unlikely that accurate quantitative data on physical activity behaviours could be collected with other methods.
- Participation is completely voluntary and consent can be withdrawn at any time during the study. No further data will be collected if consent is withdrawn. Data already collected may be used in the research, unless otherwise requested. Students not participating in the project can still attend classes within the monitored classroom, however they will not wear an accelerometer, will not be recorded within any field notes, and will not be engaged by the researcher.

Confidentiality

- All data will be coded to maintain anonymity of all participants and will be stored securely at Curtin University. Data will be used for the process of the PhD research and may be made publically available. Published material may include but is not limited to PhD dissertation, de-identified data, and peer reviewed journal articles. No identifiable data will be released unless required by law. All data and results will be kept for a minimum of 7 years after project completion or until all participants have reached 25 years of age, whichever is later, then destroyed.
- Published photos will not identify individual students or staff.
- To maintain privacy, participants will not be advised on their individual physical activity behaviours, however a summary of overall results will be given to each school to make available to teachers, students and parents.

Ethics

- Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2018-0188). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

CONSENT FORM

HREC Project Number:	HRE2018-0188
Project Title:	Architecture and Children's Physical Activity in Perth Primary Schools
Chief Investigator:	Dr Robyn Creagh Lecturer, School of Design and the Built Environment
Student researcher:	Ms Rachel Pages-Oliver PhD Candidate, School of Design and the Built Environment
Version Number, Date:	3, 26/04/2018

- I have read the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I consent to photos being taken of me during the study.
- I voluntarily consent to take part in this research project, and understand I can withdraw consent at any time during the study.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007) updated March 2014.
- I understand I will receive a copy of this Information Statement and Consent Form.

Teacher Name	
School Name	
Teacher Signature	
Date	

<u>Declaration by researcher:</u> I have supplied an Information Statement and Consent Form to the participant who has signed above, and believe that they understand the purpose, extent and possible risks of their involvement in this project.

Researcher Name	
Researcher Signature	
Date	

Parent/Guardian Consent Form:

INFORMATION STATEMENT

HREC Project Number:	HRE2018-0188
Project Title:	Architecture and Children's Physical Activity in Perth Primary Schools
Chief Investigator:	Dr Robyn Creagh Lecturer, School of Design and the Built Environment
Student researcher:	Ms Rachel Pages-Oliver PhD Candidate, School of Design and the Built Environment
Version Number, Date:	4, 14/06/2018

Introduction

- The built environment influences behaviour in a variety of ways and often provides cues as to how individuals should behave in certain spaces. Children in Australia are failing to meet recommended levels of physical activity and sedentary behaviour. As children spend a large amount of time in schools, it is important to understand how the architectural environment of schools influences physical activity behaviours.

Researcher

- Rachel Pages-Oliver is conducting the research to fulfil a Doctor of Philosophy project at Curtin University funded by the Australian Government Research Training Program Scholarship. The project supervisors are Dr Robyn Creagh, School of Built Environment; Associate Professor Jonine Jancey, School of Public Health; and Dr Krysten Blackford, School of Public Health.

Importance

- This research is significant to fill a gap in knowledge about how the design of Australian primary schools impact physical activity behaviours of children. This will provide new information for schools, architects and designers to influence the physical activity behaviours of children through design of Australian primary schools.

Participants

- Western Australian primary schools will be invited to participate in the study to be conducted in 2018.
- 3 classrooms (upper, middle and junior) from each school will be nominated to participate in the research, with each classroom monitored for 10 school days. The architecture of the school will be analysed and the selected classrooms will be studied in detail. Participating students within the selected classrooms will be fitted with an accelerometer (ActiGraph GT3X+) to record their physical activity behaviours for the 10 school days. An accelerometer is a small device on an elastic band which is worn around the waist on the outside of clothing. It records physical activity data such intensity of movement and step count. The students will be instructed by the classroom teacher to remove the accelerometer before leaving school each day and reminded to re-attach it when they arrive each morning.
- During the first 5 days of study, the researcher will be present within the classroom to observe the student's physical activity behaviours. Informal interviews with students may be conducted during the observation period. These will be casual conversations as the students go about their daily learning to identify their opinions of school architectural environments and perceived influences on physical activity. The interviews with students will be documented in field notes and will not be audio recorded.
- Photos will be taken within the school and classrooms which may include students and staff.

Benefits and Risks

- This research provides a unique opportunity to schools, parents and children to gain knowledge about current physical activity behaviours of children. This research will provide new information for school management and governing bodies to influence the future design of Australian primary schools to improve physical activity behaviours of children. We will make a presentation to all staff in participating schools to provide information and generate discussions on children's physical activity behaviours and how architectural design can be used to its full potential. Morning/afternoon tea will be provided. This presentation will be of particular benefit to schools which are considering building works in the future.
- We will make all attempts not to disrupt the teaching or learning within the classroom or school. Rachel Pages-Oliver holds a current Police Clearance and Working with Children card – a copy has been provided to the school.
- Accelerometers are a relatively non-invasive form of movement tracking as they are worn around the waist. It is recognised that accelerometers are more invasive than other methods of data collection (e.g. surveys), however due to the age of the students, it is unlikely that accurate quantitative data on physical activity behaviours could be collected with other methods.
- Participation is completely voluntary and consent can be withdrawn at any time during the study. No further data will be collected if consent is withdrawn. Data already collected may be used in the research, unless otherwise requested. Students not participating in the project can still attend classes within the monitored classroom, however they will not wear an accelerometer, will not be recorded within any field notes, and will not be engaged by the researcher.

Confidentiality

- All data will be coded to maintain anonymity of all participants and will be stored securely at Curtin University. Data will be used for the process of the PhD research and may be made publically available. Published material may include but is not limited to PhD dissertation, de-identified data, and peer reviewed journal articles. No identifiable data will be released unless required by law. All data and results will be kept for a minimum of 7 years after project completion or until all participants have reached 25 years of age, whichever is later, then destroyed.
- Published photos will de-identify individual students or staff.
- To maintain privacy, participants will not be advised on their individual physical activity behaviours, however a summary of overall results will be given to each school to make available to teachers, students and parents.

Ethics

- Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2018-0188). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

CONSENT FORM

HREC Project Number:	HRE2018-0188
Project Title:	Architecture and Children's Physical Activity in Perth Primary Schools
Chief Investigator:	Dr Robyn Creagh Lecturer, School of Design and the Built Environment
Student researcher:	Ms Rachel Pages-Oliver PhD Candidate, School of Design and the Built Environment
Version Number, Date:	4, 14/06/2018

- I have read the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent for my child to take part in this research project. I have discussed the matter with my child, who has agreed to participate (upper primary students see attached consent form).
- I understand that my child and I can withdraw consent at any time during the study.
- I consent to photos being taken of my child during the study.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007) updated March 2014.
- I understand I will receive a copy of this Information Statement and Consent Form.

Parent/Guardian Name	
Parent/Guardian Signature	
Date	

- Child's full name:____
- Child's age:________
- Child's gender: ☐ girl ☐ boy
- Are there any factors which may influence your child's physical activity behaviours? (eg. asthma, disability, illness). Please outline:____

Optional questions:

- How much moderate to vigorous physical activity (eg. fast walking, running, active play) does your child regularly accumulate per day? ☐0-30min ☐30-60min ☐1-2hr ☐<2hr
- How much time per day does your child regularly spend sitting or lying using electronic media for entertainment (eg. TV, computer, tablet, phone)? ☐0-30min ☐30-60min ☐1-2hr ☐<2hr

---

<u>Declaration by researcher:</u> I have supplied an Information Letter and Consent Form to the participant who has signed above, and believe that they understand the purpose, extent and possible risks of their involvement in this project.

Researcher Name	Rachel Pages-Oliver
Researcher Signature	
Date	

Upper Primary Student Consent Form:

Invitation

Hello

My name is Rachel Pages-Oliver and I am from Curtin University. I would like to invite you to take part in a research project that I am doing. It is about student's physical activity in Perth primary schools.

I am asking for your help with the project because your classroom has been chosen for the research. I will be asking students in 3 schools in Western Australia to be involved.

What would I be asked to do?
If you agree to take part, you would be asked to wear a physical activity recorder on a belt for 10 school days.

Do I have to take part?
No. You are completely free to say yes or no. I will respect your decision whichever choice you make.

What if I wanted to change my mind?
If you said no, but then change your mind and want to take part, please let your teacher know.

You can stop at any time, even if you have said yes. Just let your teacher or mum or dad (or the person who looks after you) know, and they will tell me.

Your data can be taken out of the research anytime during the study of your school.

What will you do with the information I give you?
I collect what each student has given to the project, and then I write about it in a publication or journal, which is like a magazine, so that other adults can read about it. When I do this, I won't write or tell anyone your name, or the names of any other students or your school.

How do I get involved?
You have already talked with your mum or dad, or the person who looks after you, about what it means to take part in the project. Now you get to say for yourself.

If you **do** want to be a part of the project, please read the next page and write your name in the space provided.

This letter is for you to keep.

Rachel Pages-Oliver
PhD Candidate, Department of Architecture and Interior Architecture
Curtin University

Consent Form

- I know that I don't have to be involved in this project, but I would like to be.
- I know that I will be recording my physical activity for 10 school days as part of the project.
- I know that I can stop when I want to.
- I know that my data can be taken out of the research anytime during the study of my school.
- I understand that I need to write my name in the space below before I can be a part of the project.

Your name: ____

Today's Date: ____________________

Architect Consent Form:

INFORMATION STATEMENT

HREC Project Number:	HRE2018-0188
Project Title:	Architecture and Children's Physical Activity in Perth Primary Schools
Chief Investigator:	Dr Robyn Creagh Lecturer, School of Design and the Built Environment
Student researcher:	Ms Rachel Pages-Oliver PhD Candidate, School of Design and the Built Environment
Version Number, Date:	2, 26/04/2018

Introduction

- The built environment influences behaviour in a variety of ways and often provides cues as to how individuals should behave in certain spaces. Children in Australia are failing to meet recommended levels of physical activity and sedentary behaviour. As children spend a large amount of time in schools, it is important to understand how the architectural environment of schools influences physical activity behaviours.

Researcher

- Rachel Pages-Oliver is conducting the research to fulfil a Doctor of Philosophy project at Curtin University funded by the Australian Government Research Training Program Scholarship. The project supervisors are Dr Robyn Creagh, School of Built Environment; Associate Professor Jonine Jancey, School of Public Health; and Dr Krysten Blackford, School of Public Health.

Importance

- This research is significant to fill a gap in knowledge about how the design of Australian primary schools impact physical activity behaviours of children. This will provide new information for schools, architects and designers to influence the physical activity behaviours of children through design of Australian primary schools.

Participants

- Selected architects and designers who have been involved in the design of primary school buildings in Australia will be invited to participate in the research with interviews to be conducted in 2018 and 2019. Interviews will take roughly 1 hour of participant's time and will be semi-structured. Questions will centre on architects/designers past experience and opinions of children's physical activity behaviours and the role of the built environment. Interviews will be audio recorded for transcription.

Benefits and Risks

- This research provides a unique opportunity for architects and designers to share their opinions on physical activity behaviours of children and how this forms (or does not form) part of their design process.
- This research will provide new information for designers, school management and governing bodies to influence the future design of Australian primary schools to improve physical activity behaviours of children.
- Participation is completely voluntary and consent can be withdrawn at any time during the study. No further data will be collected if consent is withdrawn. Data already collected may be used in the research, unless otherwise requested.

Confidentiality

- All data will be coded to maintain anonymity of all participants and will be stored securely at Curtin University. Data will be used for the process of the PhD research and may be made publicly available. Published material may include but is not limited to PhD dissertation, de-identified data, and peer reviewed journal articles. Any photos published will de-identify individuals. No identifiable data will be released unless required by law. All data and results will be kept for a minimum of 7 years after project completion or until all participants have reached 25 years of age, whichever is later, then destroyed.
- We will provide each participating architect/designer with a summary of interview themes.

Ethics

- Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2018-0188). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

CONSENT FORM

HREC Project Number:	HRE2018-0188
Project Title:	Architecture and Children's Physical Activity in Perth Primary Schools
Chief Investigator:	Dr Robyn Creagh Lecturer, School of Design and the Built Environment
Student researcher:	Ms Rachel Pages-Oliver PhD Candidate, School of Design and the Built Environment
Version Number, Date:	2, 26/04/2018

- I have read the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent to take part in this research project, and understand I can withdraw consent at any time.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007) updated March 2014.
- I understand I will receive a copy of this Information Statement and Consent Form.

Participant Name	
Company Name	
Participant Signature	
Date	

Declaration by researcher: I have supplied an Information Letter and Consent Form to the participant who has signed above, and believe that they understand the purpose, extent and possible risks of their involvement in this project.

Researcher Name	
Researcher Signature	
Date	

Appendix 10.3. Interview Questions for Teachers

INTERVIEW SCHEDULE FOR TEACHER

Summary for interviewee: this interview will be semi-structured to ascertain your opinions of physical activity behaviours of children and how the design of the classroom or school impacts these behaviours. The questions aim to collect data on your current and past experiences within schools, before finally discussing how you think school environments could improve student's physical activity behaviours while lowering sedentary behaviour. For this interview physical activity refers to any movement from standing to walking, running, or jumping. Sedentary behaviour is sitting still or lying still.

Part 1: introduction

1. How many years of teaching experience do you have?
2. How long have you been teaching at this school?
3. Have you worked in any other schools? If so, how many?
4. Is there a particular age of students that you usually teach?
5. Is part of your teaching role to instruct physical education or sports classes? If so, have you been provided with training on how to teach these classes?

Part 2: children's physical activity and sedentary behaviour

1. What rules do you have in place regarding children moving in the classroom? why?
   Prompt: are children are allowed to move around or are they asked to remain in their chairs?

2. What factors allow or limit children to move around or be active within the classroom?
   Prompt: do you think size, noise, furniture, layout of classroom, supervision issues, or any other factors may be barriers or facilitators to children's movement?

3. Do you include active lessons as part of your class? If so, how long have you been doing these? What activities do you incorporate?
   Prompt: do you plan specific lessons which incorporate physical activity as part of learning? eg. students jump up and down a certain number of times to answer a maths equation.

4. Have you been provided with information or training on increasing physical activity or reducing sedentary behaviours within the classroom?
   Prompt: does training or professional development include active lessons or similar?

5. How much moderate to vigorous physical activity (eg. fast walking, running, active play) do you think children in your class regularly accumulate at school per day? 0-30min, 30-60min, 1-2hrs, or more than 2hrs?

6. Do you think the amount of moderate to vigorous physical activity (eg. fast walking, running, active play) differs with gender?
   Prompt: does gender influence moderate to vigorous physical activity behaviour?

7. How much time at school per day do you think children in your class regularly spend sitting or lying? 0-30min, 30-60min, 1-2hrs, or more than 2hrs?

8. Do you think the amount of time spent sitting or lying differs with gender?

Prompt: does gender influence sedentary behaviour?

9. Do you believe the physical activity behaviours or requirements are different for children of different ages? Why?
   Prompt: do younger or older children move more or less?

10. How do you think children are impacted by physical activity or sedentary behaviour within the classroom?
    Prompt: does physical activity have benefits, impact concentration or energy levels, etc.

11. Do you believe learning outcomes would be impacted by physical activity within the classroom?
    Prompt: would this be a positive or negative impact? why?

12. Do you use digital technologies within the classroom?
    Prompt: computer, tablets, etc.

Part 3: school environments

1. Do you believe the design of schools can impact physical activity behaviours of children? If so, how?
   Prompt: does open circulation (eg. open air stairs/ramps), building scale, natural landscape, etc. impact behaviour?

2. Do you believe that any of the schools you have experienced provide more opportunities for students to be physically active? If so, how?
   Prompt: were there certain elements in the schools which encouraged increased physical activity?

3. Do you believe that any of the schools you have experienced encourage students to be less sedentary? If so, how?
   Prompt: were there certain elements in the schools which encourage movement over stillness?

4. Do you make alterations to the classroom (eg. furniture layout, open/close windows/blinds) to impact the physical activity behaviours of children?
   Prompt: do you move furniture or other items to either to increase physical activity or lower sedentary behaviour?

5. What changes do you think could be made to the school or classroom to improve physical activity behaviours of children?
   Prompt: what changes could increase physical activity or lower sedentary behaviour?

6. Were you the one to arrange the classroom furniture? Can you explain why you've arranged it in this way?

7. Do you allow your students to stand at their desks whilst working? why or why not?

8. Are there school policies which impact your ability to improve physical activity or sedentary behaviours?
   Prompt: for example school policies around teaching in certain ways or occupational health and safety issues?

Appendix 10.4. Interview Questions for Architects

INTERVIEW SCHEDULE FOR ARCHITECTS/DESIGNERS

Summary for interviewee: this interview will be semi-structured to ascertain your opinions of physical activity behaviours of children and how the design of the classroom or school impacts these behaviours. The questions aim to collect data on your current and past experiences within schools, as well as discussing how this forms (or does not form) part of your design process. For this interview physical activity refers to any movement from standing to walking, running, or jumping. Sedentary behaviour is sitting or lying still.

GENERAL:

1. How long have you been an architect/designer?

2. How many Western Australian primary school projects have you been involved in? Were they private or public schools?

PROCESS:

3. When you're commissioned to design a school project, what is the process you follow?

4. Do you analyse precedent projects as part of your design processes? If so, how do you do this?
   Prompt: Is it done online, locally in person?

5. Do you conduct observations within the existing school? Why or why not? How do you think this impacts the final outcome?

6. Are you usually contracted to design the interior of primary school projects?

7. Are you usually contracted to select furniture for primary school projects?

8. Do you carry out post-occupancy evaluations in your primary school projects? Why or why not?
   Prompt: Are these formal or informal?
   - Do you speak to the school leadership or users?
   - Can you tell me about the types of information you collect? What do you do with the information?

9. Do other stakeholders carry out post-occupancy evaluations of your school projects? Are these results shared with you? What type of information do they collect?

COMMUNICATION:

10. When working with stakeholders such as principals, teachers, and students – how do you manage those relationships?
    Prompt: Is communication between stakeholders simple?
    Are there any challenges you've experienced?
    Have you ever used participatory design methods for school designs?

Spatial literacy or environmental competence is defined as "the ability to effectively use the physical environment to meet desired goals" (Lackney 2008, 134). So in relation to schools, we could say that a teacher, principal, or even a student is environmentally competent if they have the ability to alter and use the classroom to best suit their learning goals. If someone is not environmentally competent, they would not see or use the opportunities provided in their learning environments.

11. Have you heard the terms before? Do you think teachers or principals are environmentally competent?
    Prompt: Why? Do you have any examples of your experiences with this?

12. Do you think students are environmentally competent? Why? Do you have any examples of your experiences with this?

13. What order do you prioritise these elements with a school design or redevelopment? Can you reorder these 'cards' from highest to lowest priority? student physical activity, student academic outcomes, construction cost, pleasant aesthetics, room functionality, thermal comfort, natural lighting, Green star rating, innovative design, connection to nature, furniture arrangement + 2 blank cards with texta. **TAKE photo of order.**

14. What order do you think principals prioritise these elements with a school design or redevelopment? Can you reorder these 'cards' from highest to lowest priority? **TAKE photo of order.**

15. Do you think teachers or students would prioritise or order these differently? **TAKE photo of order.**

PHYSICAL ACTIVITY:

16. Do you think physical activity of students is a priority of any stakeholders in school projects? Why or why not?
    Prompt: Do you think principals prioritise student physical activity? Teachers? Policy makers? Student's themselves?
    Was physical activity mentioned during discussions with stakeholders?

17. In any of your primary school projects, did the brief mention children's physical activity – either movement or sitting?

18. If no, did you consider physical activity of children during the project? If so, at what stage was it considered?
    Prompt: was it considered during sketch design, design development, contract admin, after completion? How did it impact the design?

19. Do you believe the design of schools or classrooms can impact physical activity behaviours of children –either movement or sitting? If so, how?
    Prompt: can design increase physical activity or lower sedentary behaviour?

20. Have you seen, visited or heard of other schools which seek to improve physical activity behaviours of children – through increased movement or reduced sitting?

21. What information regarding the physical activity of children is available to inform your design decisions?
    Prompt: best practice, academic papers, general experience.
    Is this information provided to you or do you need to actively seek it out?

22. If a school wanted to improve their student's physical activity, would you expect the school to provide relevant information to you?

23. What factors improve or limit your ability to design schools or classrooms which aim to improve physical activity behaviours of children?
    Prompt: knowledge, available resources, time restraints, budget

24. Lastly, is there any experiences or knowledge you would like to share before we finish up?

Appendix 10.5. Data Normality of Physical Activity Behaviours

Table 10.1 Normality test results of physical activity data.

Data Type	Skewness	Kurtosis
Percentage of time in sedentary behaviours	-0.246*	-0.039*
Percentage of time in light physical activity	0.139*	0.847*
Percentage of time in MVPA	-0.223*	0.797*
Maximum length of sedentary bout	1.561	1.805
Mean length of sedentary bout	2.990	9.474
Step counts	-0.713*	-0.391*
Steps per minute	-0.197*	-0.620*

*normally distributed

Note: The maximum allowable for normality is skew <2.0 and kurtosis <9.0 (Posten 1984). Therefore, the data collected for the percentage of time spent in various behaviours and step counts are normally distributed. The mean length of sedentary bouts is not normality distributed, and a maximum length of sedentary bouts are within the skew and kurtosis limits, however is shown to not be normally distributed on the normal Q-Q plot and box plot. These two data types were therefore not included in calculations of significant differences.

Appendix 10.6. Significant Differences of Physical Activity Behaviours

Table 10.2 Significant differences of physical activity behaviours between categories of participating students.

Data Type	Mean (SD) per Category		P Value
	Observation	**Non-Observation**	
Percentage of time in sedentary behaviours	47.2% (7.8)	48.5% (9.3)	0.215
Percentage of time in light physical activity	45.2% (7.2)	44.1% (7.8)	0.256
Percentage of time in MVPA	7.7% (2.5)	7.4% (3.0)	0.322
Steps per minute	25 (3.4)	25 (4.8)	0.374
	Male	**Female**	
Percentage of time in sedentary behaviours	47.1% (7.8)	48.6% (8.4)	0.593
Percentage of time in light physical activity	44.9% (6.3)	44.5% (8.0)	0.853
Percentage of time in MVPA	8.0% (2.6)	7.0% (2.6)	0.259
Steps per minute	26 (4.0)	24 (3.3)	0.075
	Morning	**Afternoon**	
Percentage of time in sedentary behaviours	50.6% (8.7)	48.6% (9.1)	0.095
Percentage of time in light physical activity	44.2% (8.1)	44.6% (7.5)	0.655
Percentage of time in MVPA	5.3% (1.7)	6.8% (2.9)	<0.001*
Steps per minute	23 (3.4)	23 (4.1)	0.964
	Class Time	**Recess Time**	
Percentage of time in sedentary behaviours	49.9% (8.1)	19.55% (11.3)	<0.001*
Percentage of time in light physical activity	44.5% (7.2)	51.5% (11.1)	0.001*
Percentage of time in MVPA	5.6% (2.0)	29.0% (14.0)	<0.001*
Steps per minute	23 (3.4)	56 (14.7)	<0.001*

*statistically significant (p value of less than 0.05)

Note: no significant differences were noted during observation or non-observation times or between male and female students. Only MVPA is significantly different when comparing morning and afternoon class times, which could be due to the flexibility in the timetable, including some recess time into the afternoon classes. There were significant differences recorded for all physical activity behaviours when comparing class and recess times.

Table 10.3 Significant differences of physical activity behaviours between classrooms.

Percentage of Time	Mean (SD) per Category			P Value
	Lower	**Middle**	**Upper**	
Sedentary behaviours	44.3% (9.3)	47.7% (6.7)	51.8% (7.3)	0.113
Light physical activity	49.2% (6.6)	44.3% (5.6)	40.0% (6.8)	0.008*
MVPA	6.4% (3.7)	8.0% (2.2)	8.2% (1.6)	0.241

*statistically significant (p value of less than 0.05).

Note: No significant differences were recorded in sedentary behaviours or MVPA when comparing participating students in the three classrooms; however, their light physical activity behaviours were significantly different (p 0.008). Specifically, the lower primary and upper primary classrooms showed statistically significant differences (p 0.006), but there were not significant differences when comparing lower to middle, and middle to upper primary.