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TE TĀHUHU O TE MĀTAURANGA

The impact of physical design on student outcomes

Report:
The impact of physical design on student outcomes

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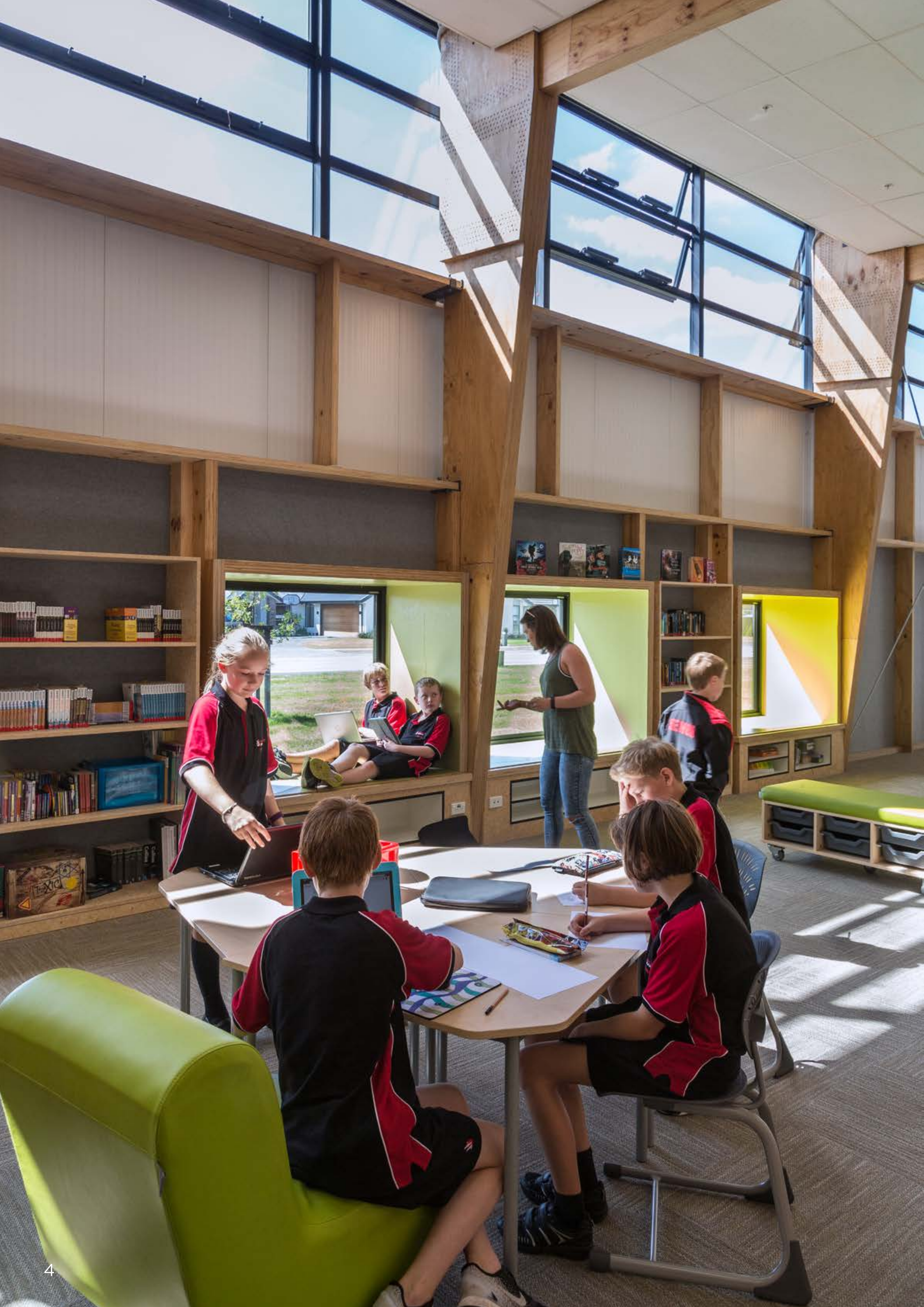

Foreword

As teaching and learning practices evolve, many schools are changing the way they deliver the curriculum. The Ministry of Education is working with schools to ensure property can support these changes.

In recent years, a large number of schools have been moving towards a particular type of practice: innovative learning environments. Between aging school properties reaching the end of their lives, and the sudden need to redevelop and rebuild 115 schools affected by the Christchurch earthquakes, the demand for physical spaces to support innovative learning has boomed in recent times.

To accommodate this shift, we have been building, or supporting schools to create, flexible learning spaces – property that is ready for today and future-proofed for any changes to teaching and learning in the years to come.

Flexible learning spaces consist of multiple spaces for many types of individual and group-based teaching and learning practices. These spaces also enhance and enable innovative learning environments, where student-centred learning and collaborative teaching practices are at the core of a school's educational vision.

With the appearance of these new spaces on the educational landscape, many are curious about what the research says about the link between physical spaces and student outcomes. The Ministry commissioned a literature review to bring together the existing research and help support a national conversation about learning spaces and their place in 21st Century teaching and learning.

A literature review is, by its very nature, backward looking. It relies on what has been of interest to researchers in the past and what can be evidenced at the time. It cannot provide all of the answers, nor should it. The local contexts will differ between schools, just as these contexts may change over time.

Readers interested in how to create new, or upgrade existing, school buildings that are well placed to support education today and in the future can find a wealth of information on the Ministry's website. We will continue to monitor the latest research as it is published to ensure our design guidelines and supporting policies and processes remain fit for purpose.

I am pleased to see the publication of *The impact of physical spaces on student outcomes* and I look forward to discussions with educators, students and wider school communities about what flexible learning spaces mean for our schools now, and in the years to come.

This publication should be read alongside *Māui Whakakau, Kura Whakakau – the impact of physical design on Māori and Pasifika student outcomes*. *Māui Whakakau, Kura Whakakau* complements the overall findings from the literature review with views from focus groups and interviews with Māori and Pasifika communities. It explains the importance of considering New Zealand's unique perspective when designing learning spaces.

I hope these publications will inform and assist schools and their communities when they make decisions about redeveloping or rebuilding their property.

Jerome Sheppard
Head of Education Infrastructure Service

Executive Summary

This report summarises research aimed at better understanding design features of learning spaces in the context of learning and achievement. It should act as a guide for those involved in the visioning and design of schools and other learning spaces. Many findings are applicable to both flexible learning spaces and more traditional classrooms, although cellular classroom arrangements may place limitations on potential configurations and the range of furniture, fittings, and equipment that can be accommodated.

Much of the literature cited in this report is from international contexts, and therefore does not take into account the cultural context of Aotearoa New Zealand. This report is designed to be read alongside its companion document, *Māui whakakau, kura whakakau*, which focuses on cultural inclusivity and combines relevant findings from the literature with information obtained through a series of interviews and focus groups with subject matter experts in the area of Māori and Pasifika education.

Quality teaching is the biggest within school driver of student outcomes. As there are a variety of teaching and learning programmes delivered within learning spaces, academic research has traditionally struggled to isolate the impact of the space on learning. The evidence, however, does demonstrate the importance of a teaching and learning programme suited to the space. It suggests that the learning space must be explicitly considered as part of planning and delivery to leverage the full potential of its impact on student outcomes.

The Ministry of Education's Innovative Learning Environment Assessment Tool divides features of flexible learning spaces into three different levels, with the basic level being physical aspects that affect student comfort and wellbeing at a fundamental level. In addition to these physical aspects, this report also examines how furniture, fittings, and equipment should be used to provide all students with an appropriate minimum level of comfort.

There is evidence that the inadequate provision of the core features of flexible learning spaces is associated with adverse student outcomes, as shown in Table 1.

Table 1: Potential links between core features of flexible learning spaces and student outcomes.

CORE FEATURE	IMPACT ON OUTCOMES
Facility quality	• Higher quality buildings and facilities are linked to better student achievement and engagement outcomes. • Evidence suggests that cosmetic quality is more important to outcomes than structural quality. • Students are happier and feel more valued in a higher quality facility.
Lighting	• Natural light is preferable. • Fluorescent lighting (if used), should be electronic ballast type, to minimise flicker. • Controllability of the lighting by the teacher is important for both teacher and student outcomes. • Windows must be carefully designed to: – Prevent views outside becoming a distraction. – Minimise solar heat gain and glare from objects outside the room. – Prevent strong light contrasts which may impair vision of objects ie the teacher's face.
Heating	• Controllability of the heating source by the teacher is important for both teacher and student outcomes. • Controllability is more important than a specific temperature range, which varies depending on heat source, activity type, and individual requirements. • The safety of the heating source should be considered.
Ventilation	• Poor indoor air quality can cause health difficulties and is linked to lower achievement levels.
Acoustics	• Poor acoustics can cause students to misinterpret the teacher's instructions or to 'tune out'. • Poor acoustics negatively impact the teacher, which then indirectly impacts the students. • Quality acoustics in the learning space and in other traditionally noisy environments like corridors can contribute to a calmer environment. • Effort should be made to minimise sudden noise.

Moderate and advanced features of flexible learning spaces are more concerned with the type, configuration and potential flexibility of school buildings and facilities, including outdoor spaces. This includes design features of the learning spaces themselves, but also the versatility and flexibility of the spaces to support different teaching and learning activities. Table 2 summarises design qualities relating to a number of moderate and advanced features of flexible learning spaces and potential links with student outcomes. This report also considers how furniture, fittings, and equipment can support the flexibility and adaptability of the learning environment, and the integration and use of technology.

Table 2: Moderate and advanced features of flexible learning spaces and potential links with student outcomes

MODERATE OR ADVACNED FEATURE	IMPACT ON OUTCOMES
Interior spaces	• One important feature of flexible learning spaces is that they are of a sufficient size to accommodate a range of different learning activities and groupings, and can be easily reconfigured or adapted to suit the activities taking place. • The increased size means that learning spaces will usually be occupied by more than one teacher, making collaboration and shared planning that specifically considers the learning environment essential for realising the potential opportunities afforded by the learning space. • Types of furniture and its configuration will support different types of teaching and learning. • Learning space users are concerned that visual transparency is distracting or causes a lack of privacy. • Easy access to different learning spaces is related to positive student outcomes. • Access to large group learning spaces is related to increased achievement. • Spaces should minimise fixed partitions and fittings, but should consider whether shifting furniture will create difficulty for students. • Visual transparency is important for observing student activity. • Smaller break out spaces located in close proximity to the learning space can further increase options for different student groupings and learning activities. • Furniture and equipment should be adaptable to meet different student needs, but should also be robust and easily cleanable to last longer. • Equipment that needs to be lowered to be accessible (drinking fountains, lab stations etc) should not be isolated from conventional height items.
Outdoor spaces	• Positive outdoor spaces (those that are well designed and defined) are linked to better student outcomes, particularly for younger primary-aged students. • Outdoor facilities should be accessible to all students and should have minimal thresholds for easy access. • Outdoor equipment should be selected so that students of all sizes have items they can use safely.
Access and circulation	• Pathways that allow freedom of circulation around the school are linked to better student outcomes, although this finding is not consistent across all studies. • There must be equitable and sufficient access for all students located in appropriate places around the school. • Care should be taken to avoid unintentional physical barriers such as kerbs, thresholds, or heavy doors. • Consider corridor width to allow equitable circulation. • Accessibility for those with reduced manual dexterity should be considered during the design phase.
Storage	• Thoughtfully designed storage increases time on task during lessons.
Colour	• Colour can be used as a visual aid, such as in marking routes, and in using contrasting colours or layers of colour to define spaces or objects.
Technology	• Technology only improves student outcomes when it is used to extend teaching and learning practice. • Buildings should be future-proofed by being hard-wired and networked and with provision for charging personal devices safely.


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Introduction

Scope and content of this report

This report summarises research published to the end of March 2016 aimed at better understanding design features of learning spaces in the context of learning and achievement. It is intended as a starting point for stakeholders involved in the visioning and design stages of any school facility, or to inform the purchase of furniture, fittings, and equipment. All schools should have an inclusive environment which caters for the learning needs and preferences of all students, and many of these guidelines are equally applicable to schools aiming to introduce innovative pedagogies within traditionally-constructed learning spaces.

Where schools are not undergoing a build or redevelopment, this report may be used to develop an understanding of the impact of the built environment on teaching and learning. The built environment can then be explicitly considered as part of teacher planning, and aspects of the environment can be altered to support the intended pedagogies, such as by the use of colour or the reconfiguration of furniture.

Some findings are more applicable to schools that will have learning support provision located onsite, and consideration for school sites where a base special school or satellite provision will be co-located are discussed in Appendix A.

Much of the research cited in this report is from international contexts, and therefore does not take full account of the cultural context of Aotearoa New Zealand. This report is designed to be read alongside its companion document, *Māui whakakau, kura whakakau*, which focuses on cultural inclusivity and combines relevant findings from the literature with information obtained through a series of interviews and focus groups with subject matter experts in the area of Māori and Pasifika education.

Environmental psychology emphasizes the interaction between person and environment, and reminds us that students and teachers play an active role in interacting with their environment, rather than being passively acted upon (Gifford, 2002). The presence of intervening variables makes it challenging to isolate the direct impact of the physical environment on student outcomes (Woolner, Hall, Higgins, McCaughey, & Wall, 2007). For example, appropriate furniture, fittings, and equipment can support the learning potential of a flexible learning space, but whether it affects student outcomes will depend on whether teaching and learning programmes recognise and take advantage of those opportunities.

Innovative learning environments recognise that advancing technology and the needs of different student groups mean that learning spaces and other school facilities need to become more flexible and adaptable to meet all student needs, and to support the delivery of different teaching and learning programmes. While 'open learning spaces' is often used in the literature, the Ministry prefers the term 'flexible learning spaces' to reflect the adaptable nature of these spaces and that the provision of smaller break out spaces is also important.

The Ministry of Education's Innovative Learning Environment Assessment Tool divides the features of a flexible learning space into three levels: core (minimum levels of comfort and wellbeing), moderate and advanced (configurations and flexibility). This report will deal with, in turn, each of the four core features of flexible learning spaces included in the Designing Quality Learning Spaces (DQLS) series commissioned by the Ministry of Education and published by BRANZ (BRANZ Ltd, 2007a, 2007b, 2007c, 2007d): Lighting, Heating, Ventilation and Acoustics, in addition to considering the impact of overall facility design and quality.

The assessment tool considers physical access a basic feature, and ease of access both to the school itself and to different spaces within the school is an integral part of whether a school's physical environment could be considered inclusive for all students. Because of the relationship between configuration of spaces and physical access, this report reviews access in association with moderate and advanced features of flexible learning spaces. This report also outlines how the thoughtful and considered use of furniture, fittings, and equipment can support the effective use of flexible learning spaces.

Terminology

The majority of source information was based on the compulsory schooling sector. However, findings would be equally applicable in other educational settings, and so while 'school' is used throughout this report, this should be considered to include other educational facilities such as early childhood centres or tertiary institutions.

The findings generally relate to engagement and achievement outcomes for all students. Where recommendations are more applicable to a particular group of students, such as students of a particular age group or students that require learning support or additional physical support, this is specified. For more on how the Ministry uses this terminology, visit www.ile.education.govt.nz.

While the Ministry uses the terms flexible learning space to describe the physical environment, and innovative learning environment to describe the learning ecosystem as a whole, other countries use different terminology to talk about similar ideas. Terms such as 'modern learning environment' are used throughout this report as they are found in the research. They are not the preferred terms of the Ministry of Education.

Methodology

Secondary data collection

The literature used in this study was sourced from keyword searches of a number of education-related databases, and a search of government publications. The education and psychology databases that were searched were:

- Australian Education Index and British Education Index.
- Education Research Complete.
- Education Resources Information Center (ERIC or EBSCO).
- Index New Zealand.
- PsycINFO

Keywords used were those referring to student ethnicity, and keywords relating to school building and facility architecture, design, construction and location. Terms were searched in English, with some relevant terms searched in Te Reo Māori and Pasifika languages also.

The reference lists of the resulting publications were then searched for relevant additional source material. No limitations were placed on timeframe and country of origin, however resulting publications dated from 2000 and were either published in New Zealand or related to a New Zealand context. Much of the literature informed the structure and thematic content of this report rather than being directly cited, and for that reason this report is followed by a selected bibliography of relevant readings rather than only a list of cited references.

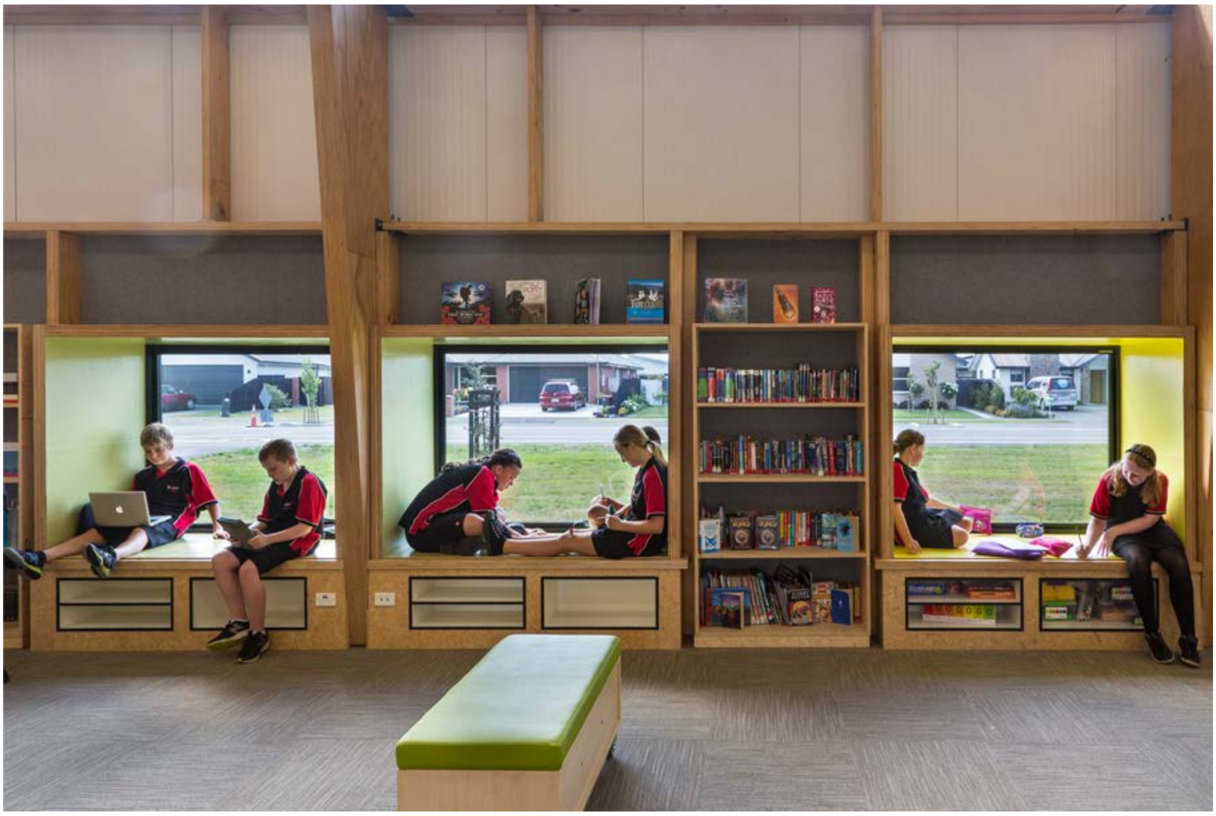
The majority of sources were published by the Ministry of Education, the Education Review Office (ERO), or the New Zealand Council for Educational Research, and others were commissioned by the Ministry of Education though published by other bodies. Other studies that informed this report have been published in national or international journals. Any other types of studies such as masters or doctoral dissertations were carefully considered before inclusion by examining theoretical underpinnings, methodological design and data collection instruments, and ensuring the conclusions reached were justifiable based on the data provided.

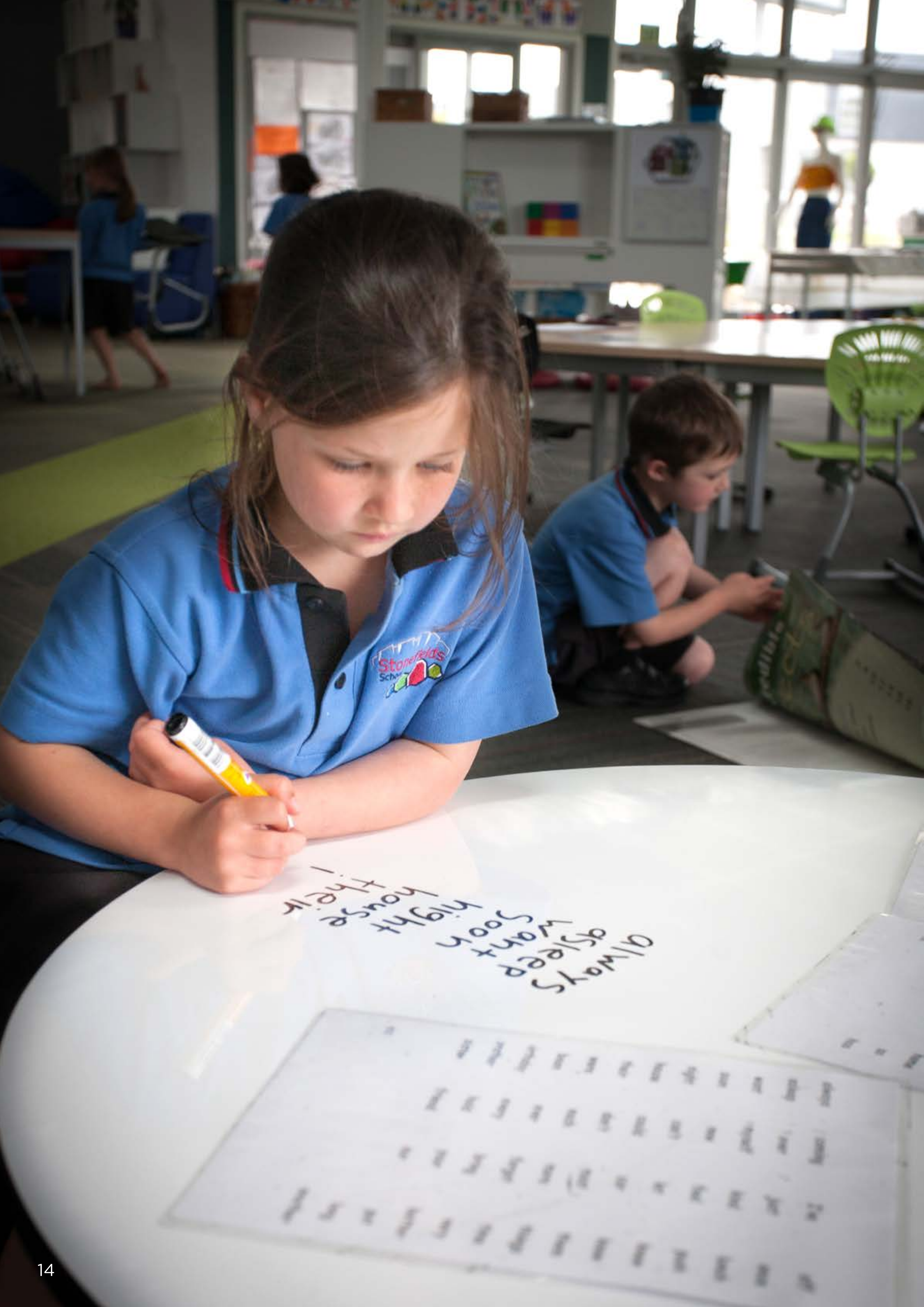
There was a lack of quantitative studies that related to physical design directly, and so quantitative studies in other areas of teaching and learning are sometimes cited where physical design can be inferred as impacting upon these findings, such as physical spaces which support discursive teaching styles, which are beneficial for Māori learners.

Primary data collection

The findings from the literature were triangulated with data from semi-structured interviews and focus groups with subject matter experts. Participants discussed core, moderate and advanced features of flexible learning spaces (as evaluated by the Ministry of Education's Innovative Learning Environments Assessment Tool), in addition to their perspectives on the impact of building facility and design on students that require learning support or additional physical support.

The interviews and focus group were recorded and transcribed, and constant comparative analysis of the qualitative data from the transcripts was used to identify and categorise recurring themes (Krueger & Casey, 2000; Merriam, 1988). Inductive analysis of the transcripts showed a number of themes that aligned with the core, moderate and advanced features of flexible learning spaces.

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Potential links between core features of flexible learning spaces and student outcomes

This section considers overall facility quality and design, and then considers, in turn, each of the four core features of flexible learning spaces included in the Designing Quality Learning Spaces series commissioned by the Ministry of Education and published by BRANZ (BRANZ Ltd, 2007a, 2007b, 2007c, and 2007d): Acoustics, Heating, Lighting and Ventilation. The impact of these four areas is well supported by the literature, with a number of reviews having been carried out (see Lemasters, 1997; Schneider, 2002; Yarbrough, 2001, for detailed lists of findings).

Although some studies question the added value of increasing these features beyond adequate levels (Higgins, Hall, Wall, Woolner, & McCaughey, 2005; Schneider, 2002), several show a link between inadequate provisions of these features and adverse student outcomes. Findings suggest that any area that adversely affects students will tend to have a similar effect on teachers, and these adverse effects may lead to lower levels of teacher effectiveness (see Morris Jr, 2003, for a review of findings relating to teacher outcomes).

Overall impact of facility design and quality

There is a large number of studies reviewing the direct impact of facility quality and design on student achievement and engagement outcomes. Inadequate facilities have an adverse impact on student achievement and engagement, and both earlier and more recent reviews that synthesise multiple studies on this topic relate facility quality to student achievement (see Clark, 2002; Dudek, 2000; Earthman & Lemasters, 1996; Earthman & Lemasters, 1998; McGuffey, 1982; Moore & Lackney, 1993, for previous findings).

Some studies found gains in achievement if facility quality improved from poor to adequate, and further gains in achievement from adequate to excellent. Although some claim that there are diminishing returns on facility quality (Earthman, 2004; Stricherz, 2000), one study found a difference in student results on a standardised achievement test of 5.45% between students at schools rated poor compared with those at schools rated adequate. The study found an overall difference of 10.9% between students at schools rated poor versus those rated excellent (Edwards, 1992), suggesting that additional improvements were associated with further gains in achievement.

One large scale study of 165 schools measured the impact of the quality of learning spaces on student achievement, by comparing student achievement at schools classified as having an obsolete learning environment, modern learning environment, or half-modern environment. The environments were categorised based on their lighting, ventilation and acoustics. Student achievement was highest in the modern learning environments, and lowest in the obsolete learning environment (Chan, 1996).

The relationship between school facility design and quality is also supported by studies measuring student achievement before and after facility upgrades, with such studies concluding that achievement increased following a renovation or rebuild of the school facilities (see Blackmore, Bateman, Loughlin, O'Mara, & Aranda, 2011, for a review). A study that found a similar outcome but also measured achievement during the renovation concluded that achievement decreased during the period of the renovation (Maxwell, 1999), and this was suggested to be due to the disruption caused by the renovation (Maxwell, 1999).

It is worth noting that measures of quality tend towards cosmetics and design rather than structural aspects. One study that included structural conditions found that there was less relationship between achievement and facility quality when considering structural rather than cosmetic or design features (Cash, 1993). Cosmetic measures of facility condition could include features such as the absence of graffiti or the maintenance of exterior paint (Cash, 1993; Earthman, 2004).

Lighting

Many studies suggest a link between appropriate lighting levels and lighting sources and student achievement and engagement. Studies on the effect of lighting on student outcomes cover lighting levels, type, controllability and distribution.

Studies on distribution tend to be more technical in nature, and reach best practice conclusions about the technical aspects of lighting, while generally only making inferences about the likely effects on student outcomes (see Winterbottom & Wilkins, 2009, for a thorough review of technical aspects of learning space lighting). Most other studies focus on adequate versus inadequate levels of lighting, and natural lighting compared with artificial lighting.

Studies tend to agree that lighting is important for student outcomes, although there is debate around best practice in the field. While natural lighting is agreed to be preferable (Earthman, 2004), studies point out the impracticality of relying solely on daylight for learning space illumination (Barnitt, 2003; Benya, 2001).

Those studies that distinguish further between types of artificial lighting tend to favour incandescent lighting over fluorescent lighting (Blackmore et al., 2011; Lackney, 1999), and suggest fluorescent lighting may reduce student focus and increase hyperactivity (see Morris Jr, 2003; Woolner et al., 2007, for a summary of previous findings).

While studies agree on the importance of lighting for student outcomes, there is disagreement on what constitutes best practice lighting, and what features of lighting impact student outcomes. Studies tend to agree that natural lighting is preferable (Earthman, 2004), but point out the impracticality of relying solely on daylight for classroom illumination (Barnitt, 2003; Benya, 2001). Those studies that distinguish further between types of artificial lighting tend to favour incandescent lighting over fluorescent lighting (Blackmore et al., 2011; Lackney, 1999), and suggest fluorescent lighting may reduce student focus and increase hyperactivity (see Morris Jr, 2003; Woolner et al., 2007, for a summary of previous findings). If used, fluorescent lighting must be maintained appropriately, as excessive flickering may cause seizures in students with photosensitive epilepsy (Mitchell, 2008).

The most commonly cited single study of the effect of lighting on student achievement was conducted by the Heschong Mahone Group, and involved a sample group of over 20,000 students (Heschong Mahone Group, 1999). The study concluded that students exposed to higher levels of daylight had higher levels of achievement, and also progressed significantly faster in their learning than other students. The impact of lighting on achievement is supported by a study that measured the achievement levels of students who had transferred schools, and found that those who had transferred to schools with daylight in learning spaces showed a significant gain in achievement (Harrigan, 1999).

Another study of 71 schools found that natural lighting was associated with higher student achievement in reading and science (Tanner, 2009). One study that constructed a multi-level analysis of the effect of built environment on student achievement found that lighting was one of seven significant environmental predictors of achievement (Barrett, Davies, Zhang & Barrett, 2015; Barrett, Zhang, Davies & Barrett, 2015; refer to Barrett, Zhang, Moffat, & Kobbacy, 2013, for the original six factor model). Of the seven factors, lighting explained 21% of the increase in student achievement that was attributed to the environmental factors model. The variable included aspects of both daylighting and controllability.

Both windows and skylights are sources of natural light, but window size and placement has been studied in more detail than skylights, due to the additional potential positive and negative effects of windows on learning. There is disagreement about whether windows affect student learning (see Yarbrough, 2001, for a detailed review). These are important considerations for building schools with innovative learning environments, because a number of recently built schools have deliberately placed windows lower so that students can easily see in and out (Research New Zealand, 2010), and so that the windows have the effect of 'inviting the outdoors inside' (Yarbrough, 2001, p. 41). In contrast, some teachers prefer that windows are placed so that outside activities do not distract students from their learning (AC Nielsen, 2004). One recent study of preschool-aged students found that the presence of exterior windows and natural views were positively related to student engagement (Monsur, 2015).

Māui whakakau, kura whakakau discusses the importance of orienting learning spaces so that they face the sun and receive lots of natural light, which recognises the importance of Tamanuiterā (the sun) in Māori culture and creates links between students and the natural environment outside the learning space.

Some post-occupancy evaluations have found that interior and exterior windows can be distracting for students, and some students may find it difficult to concentrate (Leiringer & Cardellino, 2011). This is particularly true for students that require learning support, such as students with ASD who may be distracted by visual stimuli outside the learning space (McAllister & Hadjri, 2013).

The location of the windows within the learning space can add to their potential to distract. If the windows are behind the teacher, the teacher's face is darker than the surroundings, which can create difficulties for visually or hearing impaired students. Likewise, the activity outside may attract the students' attention away from the teacher (Visser, 2001). However, another study found that looking out the window requires only 'soft' attention, which is less intense than the focus required for other off-task behaviours such as doodling (Grocoff, 1995), and it is therefore easier for students to refocus their attention on their work following time spent looking out the window than for many other off-task behaviours.

There are conflicting views on potential solutions to the downsides of windows, with studies explaining that teacher control over window coverings such as blinds can be used to control against distractions. As a long-term solution, however, it is recognised that this largely negates the benefits of daylighting (McAllister & Hadjri, 2013). There are also differing opinions on the use of clerestory windows (those placed above eye level). Some studies suggested this as an option for preserving levels of natural light while reducing the potential for distraction (AC Nielsen, 2004), while a further study stated that clerestory windows are more prone to creating shifting patterns of light and shade, and that shadow lines can create visual barriers that may cause distress for some students that require learning support (Planning & Building Unit, 2012).

One possible solution is the use of clerestory windows combined with a brise-soleil. A brise-soleil is a permanent sun-shading structure that extends from the facade of the building. This can have the effect of diffusing direct light, and causing consistency in light distribution as it enters the learning space. Louvered windows or frosted glass can also admit an appropriate level of lighting while reducing glare and the potential for distraction.

Other studies emphasise the importance of lighting controllability for both student and teacher outcomes (Lang, 2002). Observational studies and studies containing comments from student and teacher participants have found that lighting preferences are not constant, and vary depending on activity, time of day, and individual student needs. This results in the need for teacher control over lighting to maximise its effectiveness.

Comments typically included frustration with glare, which varied depending on learning space, season, and time of day, and difficulties in tailoring lighting levels to suit particular activities, such as viewing films or PowerPoint displays (AC Nielsen, 2004). Glare and solar heat gain through large window areas continue to be issues in recently built schools, suggesting that maximising the benefits of natural lighting while minimising the downsides is an area that needs further thought during the design stage (Research New Zealand, 2010).

One study, however, cautions against reducing the number of windows as a strategy for reducing glare, describing this as 'a negative approach to design' (Scott, 2009, p. 39). It is also important that users of learning spaces do not inadvertently reduce daylight levels by covering windows with displays of student work or similar (Montazami, Gaterell & Nicol, 2015).

Heating

Studies are generally consistent about the link between student achievement and engagement outcomes and learning spaces being maintained at an appropriate temperature (see McGuffey, 1982; Schneider, 2002, for a review of findings). A multi-level analysis of the effect of built environment on student achievement found that temperature explained 12% of the increase in student achievement that was attributed to the environmental factors model (Barrett et al., 2015).

One review concluded that heating and indoor air quality (IAQ) were the most important single features of facility design and quality for improved student outcomes (Earthman, 2004). However, findings are less consistent about what the optimal temperature range should be, suggesting that it is affected by factors such as humidity, the type of activity being performed, and individual needs and preferences (BRANZ Ltd, 2007b). Studies measuring teacher outcomes as well as student outcomes have concluded that inappropriate learning space temperatures result in negative teacher outcomes in addition to negative student outcomes (Lackney, 1999).

Similar to lighting, studies emphasise the importance of the controllability of heating as central to student and teacher outcomes. Student comments emphasise the importance of a learning space that is 'not too hot or too cold' (BRANZ Ltd, 2007b), while teachers emphasise the importance of having control over heating as being central to overall comfort and student outcomes (AC Nielsen, 2004; Heschong Mahone Group, 2002; Lowe, 1990; Woolner et al., 2007). By having control over the temperature of the learning environment, teachers can consider the comfort of students with lower activity levels, or different mobility needs.

This is particularly important if there are students who may not be able to communicate distress due to temperature extremes, meaning that teachers or paraprofessionals need to be able to monitor the student closely, and adjust the temperature accordingly (Department for Children, Schools and Families, 2008).

Some students may not have the same activity rates as other students in the class, and so temperatures may need to be slightly higher than if all students were engaging in the same level of physical activity (Department for Children, Schools and Families, 2008; Gathorne-Hardy, 2001).

Traditional radiator heating systems provide direct heat and may be a health and safety risk for students (Department for Children, Schools, and Families, 2008). However, current school design practices are moving away from such systems, meaning that this will be less of a consideration in a new build context (BRANZ Ltd, 2007b). In a New Zealand setting, boilers have been used for providing heat, but may be unsuitable if there is no system that can be used to actively cool the learning space in addition to heating it.

Ventilation

Many studies have reviewed the impact of adequate ventilation on indoor air quality (IAQ), and conclude that poor IAQ is related to adverse student outcomes (see Daisey, Angell, & Apte, 2003, Schneider, 2002, for a review), including issues such as dizziness, headaches and asthmatic symptoms. Volatile organic compounds are released from some furniture materials (Hall, 2009; Stewart, 2010), and this lowers IAQ and may cause health issues such as asthma or allergic reactions (Smedje, Norback, & Edling, 1997). Students with high levels of health needs are usually the most vulnerable to poor IAQ (Abend, 2001).

The majority of studies on IAQ do not measure student achievement as a variable, and instead tend to infer that health problems are more likely to result in increases in absenteeism or inattention in class, and that these issues will indirectly affect achievement. The impact of IAQ on student health outcomes is supported by a study that 'cleaned' the air in two daycare centres, and found that absenteeism decreased as a result (Rosen & Richardson, 1999).

One large-scale study that constructed a multi-level analysis of the effect of built environment on student achievement found that temperature explained 16% of the increase in student achievement that was attributed to the environmental factors model (Barrett et al., 2015). In one United States study that measured achievement, the presence of air conditioning in the learning space explained 1.6% of the total variance in performance in 3rd Grade English (students are 8 – 9 years old), 2.8% for 5th Grade English (10 – 11 years old), and 4.8% for 5th Grade Technology (Lanham, 1999).

Other studies show findings consistent with the above, but many are not directly applicable as they include climate control and ventilation as a single variable, and may also measure achievement based solely on a single in-class task (see Yarbrough, 2001, for a review).

Heating and ventilation are often considered interrelated, and some systems, such as heat recovery systems, have both heating and ventilation features. However, other heating systems such as standard heat pumps that recycle indoor air without introducing new air do not provide the benefits of ventilation that lead to improved IAQ (BRANZ Ltd, 2007d).

Acoustics

One New Zealand study found that teachers and students did not think that acoustics were as important as other core features of flexible learning spaces (AC Nielsen, 2004). Similar to ventilation, most studies list the negative outcomes of poor acoustics in terms of student health or engagement outcomes, and indirectly infer their influence on student achievement (Higgins et al., 2005; Schneider, 2002).

Learning space acoustics are affected by three interrelated factors:

- Poor signal-to-noise ratio: the teacher's voice compared to background noise.
- Excessive sound reverberation: measured by reverberation time or how long the sound 'bounces' or 'echoes' in the room.
- High levels of ambient noise: the noises present in the learning space when empty

(American Speech-Language-Hearing Association, 2005).

Studies suggest that poor acoustic quality can adversely affect student outcomes by causing them to miss or misinterpret part of the teacher's lesson, which may lead to them tuning out altogether (Johnson, 2001). One study found that teacher pauses during bursts of external noise could lead to a reduction in teaching time of up to 11% (Rivlin & Weinstein, 1984). Some students may also find noisy environments distracting or distressing. Strategies to minimise or eliminate sudden loud noises can support the benefits of an appropriate acoustic environment. Quality acoustics such as insulation materials that reduce sound transmission, and carpeting in circulation areas can create a calmer environment.

Reviews of teacher outcomes show that poor acoustic quality can lead to adverse effects for teachers also, including annoyance, less patience, less inclination to repeat information, and increased fatigue (Morris Jr, 2003; Tanner, 2000). A study comparing the two groups found that external noise was more disruptive for teachers than for students (Lucas, 1981).

One British study found that learning space noise level negatively impacted all students, but particularly students that require learning support (Allcock, 1997). Case studies reflect that improvements to acoustics increase the extent to which students who are deaf or hard of hearing are able to hear adults and peers (Department for Education and Employment: School Buildings and Design Unit, 2001). Acoustics are also important to consider for students short-term hearing loss from ear infections or allergies (Abend, 2001).

Some students may find it difficult to concentrate in a noisy environment, or may find sudden or unexpected noise distressing. Strategies to minimise or eliminate sudden loud noises can support the benefits of an appropriate acoustic environment for these students. For example, rather than have school bells set to ring at a volume that may upset some students, a visual signal accompanying the bell will assist students who are deaf or hard of hearing, and will allow the bell to be rung at a lower volume (Education Law Centre, 2005; Erkilic & Durak, 2013). Quality acoustics such as insulation materials that reduce sound transmission (using sound baffle materials such as Autex, for example) and carpeting in learning spaces and in circulation areas such as corridors creates a calmer environment and lessens stress for noise-sensitive students.

Technology in the form of a sound-field amplification system can also be used to increase the volume of the teacher's voice, and therefore improve the signal-to-noise ratio. A New Zealand study using sound-field amplification for students with Down Syndrome found that the students were able to perceive significantly more speech when the teacher's voice was amplified by 10 decibels (Bennetts & Flynn, 2002).

Furniture, fittings, and equipment to support core features

Comfortable furniture is a key consideration for both students and teachers, with both groups emphasising the negative impact of uncomfortable furniture more than the positive impact of comfortable furniture (AC Nielsen, 2004). A discussion of beneficial features for common items of school furniture is included as Appendix B. Discomfort with seating was more likely to be raised as an issue in a secondary setting because students are larger and heavier than primary students, and need to transport more equipment from class to class (AC Nielsen, 2004).

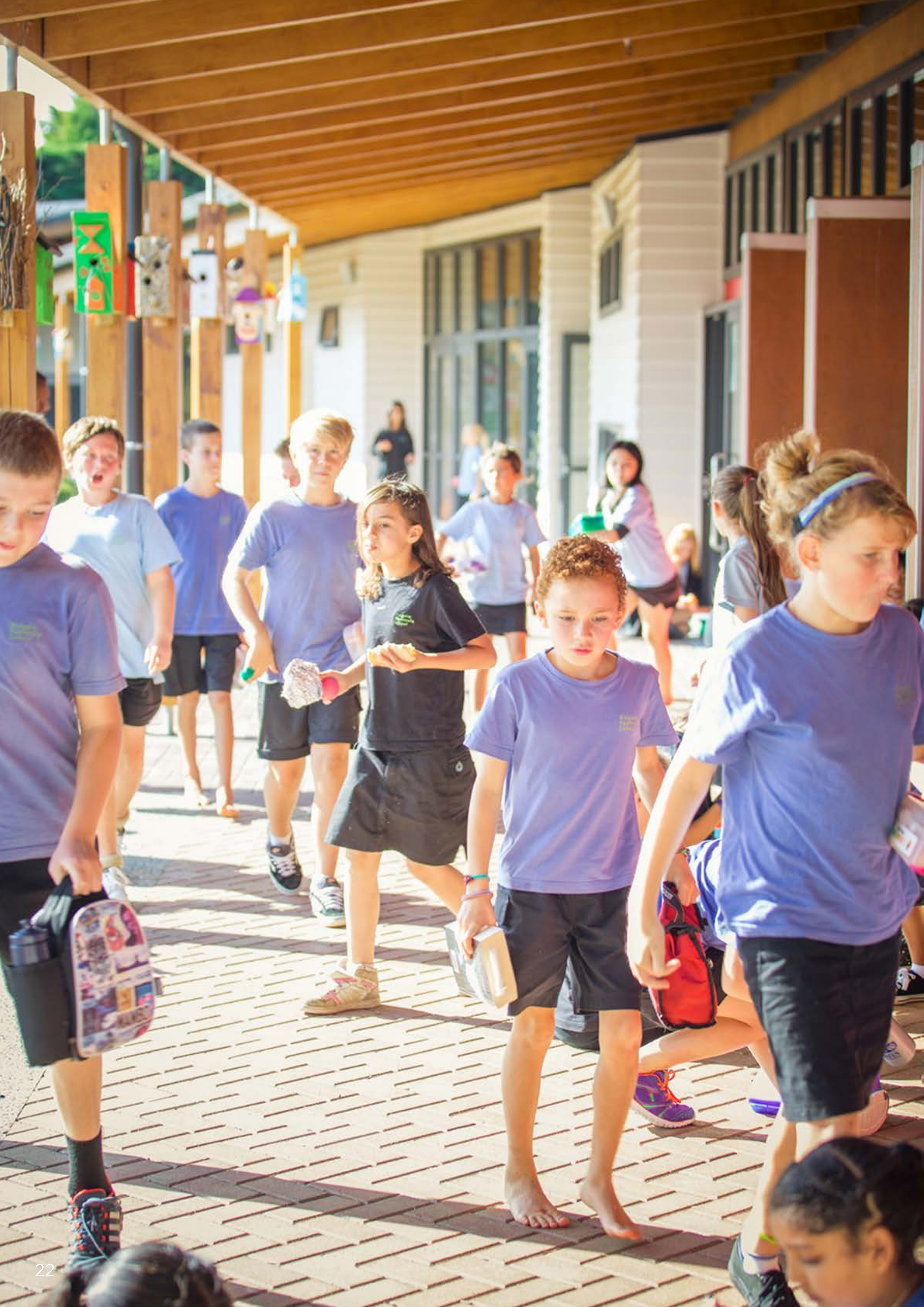
Many studies consider furniture comfort in the context of whether the furniture (particularly chairs) is ergonomically designed and suitable for users of different sizes and physical builds (for an overview of findings from studies comparing ergonomic furniture with non-ergonomic furniture, see Higgins et al., 2005). Some studies advocate one style of chair that is ergonomically designed to suit a wide range of users, while others suggest a range of differently sized chairs, or chairs of an adjustable height.

Decisions on learning space furniture will depend on the specific school and context. That is, ergonomic furniture may be more important in learning spaces where students will be focussing for longer periods of time than for furniture that will be used more casually (such as chairs and tables in the library or cafeteria), or in classes such as art or science where students will be moving around more frequently (Rydeen & Sorenson, 2005).

Ensuring comfort is an important element of expressing manaakitanga (hospitality) to manuhiri (guests), and so furniture provided should be suitable and comfortable for adults of a range of heights and sizes. This is particularly important where they will be expected to be seated for a long time, such as during an assembly, ceremony or performance (refer to *Māui whakakau, kura whakakau* for further discussion on cultural considerations for furniture, fittings, and equipment).

Adjustable furniture or furniture of different sizes may lead to increased comfort and wellbeing, and may appear to enhance the flexibility of the learning space. However, it may actually restrict flexibility by requiring students to relocate their personalised desks and chairs in order to move to a different part of the learning space, or to switch between learning activities. Some types of adjustable furniture may also compromise health and wellbeing goals by being more difficult to keep clean (LS3P Research, 2012), or by being difficult or dangerous for students to adjust (Cornell, 2002).

It is important to consider that special adaptations to furniture and equipment, such as wheelchair seating in an assembly hall or lowered lab stations in a science learning space should be readily accessible by students that require learning support or additional physical support, and centrally located within the teaching space. In this way, students can be included in the learning space activity alongside their peers, while still using equipment that is appropriate to their needs (Abend, 2001).



Moderate and advanced features of flexible learning spaces and potential links with student outcomes

This section considers the types of learning spaces that should be present in a school, and how their configuration is linked to student outcomes. This includes aspects of design for those spaces, such as how learning spaces should be designed to support a variety of teaching and learning activities that meet the learning needs of all students. It also reviews the literature on outdoor spaces, physical access and circulation, and storage, all of which are aspects of flexible learning spaces drawn from the assessment tool. The literature recognises two further design aspects that are not specifically captured in the assessment tool but are discussed in this section, which are the use of technology and colour.

For schools embarking on a redevelopment or a build, meaningful and ongoing engagement with students, whānau and community from the conceptual design phase is essential for building buy-in and developing an inclusive design that meets the aspirations of the community. This is discussed in more detail in *Māui whakakau, kura whakakau*, and experts who contributed to that report believed communities tend to be influenced by the school environments that they themselves were familiar with. The contributors therefore believed that consultation achieves more effective outcomes when communities are given an opportunity to learn about different possibilities for innovative teaching and learning pedagogies and environments.

Types and configurations of interior spaces

This covers primary and secondary data relating to non-specialist interior spaces. This includes learning spaces, break out rooms, teacher spaces, and toilet facilities. It also covers how interior spaces can be configured in relation to one another to afford different teaching and learning possibilities, and the use of visual transparency.

Flexible learning spaces

Learning spaces were traditionally designed and configured to support teacher-directed pedagogies, resulting in cellular or box-like designs. As education practices evolve and change, learning spaces need to be designed so that they can keep pace with these changes. The term 'flexible learning spaces' does not specify a particular spatial typology, but rather refers to spaces that are of sufficient size and flexibility to support different teaching and learning pedagogies. The term 'flexible learning spaces' reflects the adaptable nature of the space and that the provision of smaller, break out spaces is also important. This section considers key features of a flexible learning space, and how these spaces differ from traditional cellular designs.

Flexible learning spaces are intended to support the adaptable delivery of teaching and learning programmes to meet the learning needs of all students. In order for teachers to maximise the potential of these learning spaces, the space must be explicitly considered as part of planning and delivery. This should not be limited to the space influencing which pedagogies will be most effective, but should also recognise that teachers can actively configure or utilise the space to support the learning programme being planned (Hughes, 2014).

When teachers do not use teaching and learning practices that are suited to the learning space, flexible learning spaces are less successful (Gislason, 2009a). Studies show that using flexible learning spaces effectively require teachers to implement teaching and learning practices suited to the space, and to continue to develop these practices (Gislason, 2009b; Woolner et al., 2007). A study of student outcomes suggested that flexible learning spaces impact positively on student outcomes where pedagogy is aligned to the physical space (Gifford, 2002). The ability to implement culturally responsive pedagogies in flexible learning spaces is discussed in further detail in *Māui whakakau, kura whakakau*.

Input from teachers during the design of learning spaces helps to address concerns and prepare them for teaching in a new environment (Higgins et al., 2005). One study found that there were links between changes to teacher pedagogy and involvement in the design of flexible learning spaces (Lippincott, 2009). Literature suggests that teachers are particularly open to experimenting with different pedagogical approaches when failure is viewed as part of the teacher's development process (Blackmore et al., 2011). To avoid defaulting to previous pedagogical methods, teachers need to be well prepared and supported throughout the transition (Thomson, 2010), particularly if teachers have a perceived lack of efficacy over their physical environment (Lackney & Jacobs, 1999).

Environmental competence is the ability of the individual to manipulate the physical environment to achieve their desired outcomes (Steele, 1980). It firstly requires an awareness of the properties of the physical environment, and then requires the ability to control or change the environment. Lackney (2008) suggested that a lack of environmental competence may lead to teacher-directed pedagogies persisting in flexible learning spaces. However, understanding the influence of the environment tends to come from direct experience, rather than formal training (Horne-Martin, 2002) and one recent study found that teachers' self-discoveries in a flexible learning space are extremely valuable in building confidence (Frith, 2015).

There may be implications for timetabling also, with studies suggesting that there is a time as well as space component to the effective use of flexible learning spaces (Gifford, 2002). Many of the pedagogies used in flexible learning spaces require longer instructional blocks of time compared to traditional teacher-centred pedagogies (Arnot & Reay, 2007). There is some process loss in time when students move from one learning activity or learning centre to another, but this is commensurate with the time that would be taken to move between learning spaces in a traditional secondary setting (Gislason, 2009b).

One important feature of flexible learning spaces is that they should be of a sufficient size to accommodate a variety of different learning activities. This should include a range of different groupings, such as whole classes, mixed classes, small groups, and individual study (Gump, 1987; Innovation Educators Forum, 2000). Larger learning spaces can also support larger numbers of students coming together for activities such as karakia, waiata or Pasifika performing arts without having to move students to a hall or wharenui space.

Thought must be given during the design phase to the appropriate size of these learning spaces to support the additional space requirements of students with mobility aids, or who are accompanied by a teacher aide or other support, and to providing suitable space for students whose needs mean they are unable to be in close proximity with other students (Clark, 2002; McAllister & Hadjri, 2013).

Flexibility is not a feature of size alone, as the spaces must also be equipped so that they can be easily reconfigured to suit the needs of all the students using the space for a variety of activities. This may mean that parts of the room are able to be separated off to support smaller group activities, or that furniture, fittings and equipment are thoughtfully chosen to support flexibility and inclusive learning practices. Flexible learning spaces should have minimal fixed partitions, furniture, fittings or other equipment (Department for Children, Schools and Families, 2008; Planning & Building Unit, 2012). This allows the learning space to be reconfigured to support different activities and to address different student needs.

Within the spaces, there is flexibility in the location of individual students, with students given more opportunity to choose the type of configuration that is most suited to their learning needs (Kennedy, 2010; Rydeen & Sorenson, 2005). One study found that students' maths achievement improved when students were able to choose their own work space within the learning space (Hirano, 1993).

One large-scale study that constructed a multi-level analysis of the effect of built environment on student achievement found that flexibility explained 17% of the increase in student achievement that was attributed to the environmental factors model (Barrett et al., 2015). Flexibility included the ability to reconfigure the learning space to support different learning activities, and having different zones within the learning space for different types of learning.

The size and configuration of a traditional cellular classroom support a teacher-centered style, with direct instruction occurring from the front of the classroom. Within cellular classrooms, the configuration and location of furniture, fittings, and equipment often enhance this tendency, with the teacher's desk located at the front of the space, accompanied by display media such as a whiteboard, projector screen or interactive whiteboard. In a flexible learning space, physical design supports delivery from multiple locations. This requires careful consideration because chairs, desks and tables will need to be easily moved and reconfigured to give clear lines of sight to wherever delivery is occurring in the room (Innovative Educators Forum, 2000).

Likewise, the location and portability of technology must be considered, with technologies such as interactive whiteboards often permanently mounted to a learning space wall (Smith, Higgins, Wall & Miller, 2005). Projectors were traditionally fixed in ceiling mounts, but now many learning spaces have portable projectors (LS3P Research, 2012). Portable technologies and mobile furniture in combination with a flexible learning space allow the 'front of the classroom' to be anywhere (LS3P Research, 2012, p. 2).

One recent quasi-experimental study re-configured a number of traditional classroom spaces by using furniture, fittings, and equipment to create spaces that supported a wider range of pedagogies. Findings showed significant self-reported increases to student learning experience and engagement, in addition to increases on measures of achievement (Byers, Imms, & Hartnell-Young, 2014). Focus groups with teachers from those learning spaces showed shifts from traditional teacher-directed pedagogies towards more collaborative and student-centred pedagogies.

Post-occupancy studies recognise that spaces must be designed and furnished to support students being able to see and hear clearly in order to benefit from direct instruction or group discussion activities, and that teachers should be able to supervise students easily within the space (Deaker, 2007).

Break out spaces

While flexible learning spaces can be configured to provide a variety of different spaces, it is also important to have smaller spaces located off the learning space. Break out spaces add another area that supports different types of instruction or learning, such as a teacher taking a small group of students, or a group of students working together on a project. These spaces are generally accessible from the learning space, or from a central area in close proximity to the learning space, so that students using the room are not isolated from activity in the larger space.

In addition to these functions, these spaces are also valuable for students who need a quiet space to calm down and re-focus (Education Law Centre, 2005), or for a teacher to take a student to as a preventative measure, in order to diffuse a potential behavioural outburst (Planning & Building Unit, 2012; Visser, 2001). The proximity of the room to the learning space is important not just because of creating easy accessibility, but because it may add to a student's distress to have to transit to the room over a longer distance where they may be observed by others (Education Law Centre, 2005). In addition, for the student to remain included in the class, they should remain in close proximity to the learning space, while still having their individual learning needs addressed (Scott, 2009).

Teacher spaces

The secondary literature did not address the configuration of teacher spaces and workspaces specifically. Some schools favour individual teacher workspaces connected to the learning space, and some prefer a larger shared space. The reasons given for this were that a shared space promotes collegiality, and enhances informal professional discussions and collaboration. Participants likewise differed in their views on whether teacher relaxation spaces should be in close proximity to the learning spaces and shared with students, or whether they should be exclusively for the use of teachers. Some participants spoke of a shift towards shared recreation spaces, with students and staff using communal kitchen spaces. Staff would tend to use the space during their breaks, and students would use the space as part of curriculum delivery, to learn food preparation and cooking skills.

In contrast, some participants prefer the staffroom to be located away from student spaces so that teachers and other staff are able to have a total break from students. If the staffroom location overlooks the playground or other student areas, teachers may be drawn back to help with student behaviour management during lunchtime and other breaks. Studies on emotional labour within teaching recognise both the importance of teachers displaying the appropriate positive and negative emotions, and that this depletes teachers' emotional resources (Näring, Canisius, & Brouwers, 2011; Ogbonna & Harris, 2004). Within-work breaks are one method for replenishing emotional resources, and thus decreasing the risk of negative consequences such as emotional exhaustion or burnout (Trougakos, Beal, Green, & Weiss, 2008).

Configurations of other spaces

Groupings of learning spaces (sometimes called instructional neighbourhoods) should include learning spaces, small and large group areas, spaces for teacher planning, wet areas and bathrooms (Genevro, 1992). These are generally arranged surrounding shared spaces which may be called learning streets, whānau spaces or common areas, and which maximise the effective use of space by limiting or eliminating corridors. For considerations and guidelines relating to cultural spaces, refer to Māui whakakau, kura whakakau.

While there is a growing body of research considering the impact of other interior spaces on student outcomes, this generally focuses on the tertiary sector (see Painter et al., 2013, for a review). One recent study suggests that informal or common spaces should be designed so that they have a symbiotic relationship with more formal learning spaces, thereby promoting a smooth transition between spaces and maximising learning opportunities (Ellis & Goodyear, 2016). One recent study found that the ability for all areas to be used as potential learning spaces increased flexibility and supported student-centred pedagogies (Bisset, 2014).

Post-occupancy studies show that users value the ease of access to different types of spaces within the grouping, and believe that it leads to more variation in teaching type and configuration of student groups (Research New Zealand, 2010). Likewise, tthe literature on design for students that require learning support or additional physical support advocates for a configuration in which spaces can be easily and directly accessed, and where the spaces most commonly used in conjunction with one another are located in the closest proximity.

One study that measured a number of facility design features found that instructional neighbourhoods was one of four significant design features that influenced achievement, and that it explained 3.1% of the variance in student achievement (Tanner, 2008). The same study found that having large group meeting places available explained a further 1.8% of variance in achievement. In contrast, a study with a slightly older age group (10 – 11 years compared with 8 – 9 years) found large group spaces explained 3.1% of variance in achievement (Yarbrough, 2001), and instructional neighbourhoods 0.5% - 0.8% of achievement for 3rd graders and 5th graders.

Visual transparency

Flexible learning spaces often include a higher level of visual transparency than traditional cellular classrooms. Post-occupancy evaluations listed the advantages of transparency as an increase in natural light, the ability for the teacher to observe students discreetly, and increased safety for students and teachers (Research New Zealand, 2010). Visual transparency allows both teachers and students to observe and learn from teaching and learning occurring in other learning spaces, and to be observed in return (Osborne, 2013). Participants felt that it supported a more collaborative and shared style of teaching, as teaching practice is also observable by those passing by the learning space.

Although there is a chance that students may become distracted by what is going on in other spaces (Leiringer and Cardellino, 2011), one New Zealand pilot study of flexible learning spaces did not find students were distracted by being able to see other activities taking place through internal glass (Ministry of Education, 2012). Natural light is preferable in these environments, and consideration must be given to contrast, so that the teacher's face can be easily seen against the background.

Outdoor spaces

One study of 39 features of facility design and quality found positive outdoor spaces to be one of the four main predictors of student achievement in a mainstream setting (Tanner, 2000). Positive outdoor spaces were described as well-maintained and designed 'places which are defined; may be surrounded by wings of buildings, trees, hedges, fences, fields, arcades or walkways' (Tanner, 2000, p. 320). These features were distinct from outdoor rooms, and green areas, which were separate features.

Another study showed that outdoor areas were more strongly linked to achievement for 3rd graders (explaining 3.2% of achievement variance) than for 5th graders (0.6%) (Yarbrough, 2001). There are numerous options for outdoor spaces, including a play area, a sensory garden, or natural environment study areas. Outdoor areas need to consider appropriate spaces and equipment for all students.

There are numerous options for outdoor spaces, including play areas, sensory gardens, or natural environment study areas. A play area needs to provide appropriate play equipment for all students that can be easily accessed by students with impaired mobility (Abend, 2001; Department for Children, Schools and Families, 2008).

In the case of sensory gardens and gardens with planting areas for students, careful consideration should be given in the design stage to spacing the planting beds appropriately and providing a sufficient mix of hard and soft landscaping (Abend, 2001; Planning & Building Unit, 2012). Native plants and trees can be used to reflect the interaction between culture and the natural environment. A further connection can be made between student culture and the environment by using plants such as harakeke that can be harvested for weaving, and trees that can have the bark stripped for dyeing or other artworks (refer to *Māui whakakau, kura whakakau* for further discussion). For a detailed review of options for meaningful outdoor learning environments, see Mozaffar and Mirmoradi (2012).

Some students do not have the same understanding of danger and physical limits, and so may deliberately or unintentionally leave school property or stray into other areas of the school when outdoors (McAllister & Hadjri, 2013; Scott, 2009). The ability for adults to observe students unobtrusively adds to the safety of the outdoor area (Scott, 2009), and so there should not be areas within the outdoor space which are hidden from view (Planning & Building Unit, 2012).

Physical access and circulation

Innovative learning environments are social, pedagogical and physical environments that are sufficiently flexible and adaptable to support the effective delivery of different learning programmes. The physical component of an innovative learning environment (ie flexible learning spaces) can be used to support or facilitate an inclusive environment that addresses the differing learning needs of students. The intentions of flexible learning spaces are reflected in the Universal Design principle of flexibility in use, specifically that the design accommodates a range of student preferences and abilities (Mitchell, 2010).

To ensure best practice in physical access and circulation, many design guidelines show the influence of Universal Design and Universal Design for Learning. Universal Design aims for 'products and environments to be usable by all people, to the greatest extent possible, without the need for subsequent adaptation or specialised design.' (Centre for Universal Design, as cited in Mitchell, 2010, p. 199). The principals of Universal Design are shown in Table 3 below.

Table 3 Principles of Universal Design (The Center for Universal Design)

PRINCIPLE	DESCRIPTOR
Equitable use	• The design is useful and marketable to people with diverse abilities.
Flexibility in use	• The design accommodates a wide range of individual preferences and abilities.
Perceptible information	• The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
Tolerance for error	• The design minimises hazards and the adverse consequences of accidental or unintended actions.
Low physical effort	• The design can be used efficiently and comfortably and with a minimum of fatigue.
Size and space for approach and use	• Appropriate size and space is provided for approach, reach, manipulation and use regardless of user's body size, posture, or mobility.

One New Zealand study of inclusion asked participants to select up to 10 barriers from a list of 27 that they felt represented barriers to schooling for students that require additional support. 19% of parent participants selected the physical environment of the learning space as a barrier, and 16% selected the physical environment of the school (Kearney, 2009). It is worth noting that none of the participants selected either of these as their top-rated barrier, but many of the barriers that were selected as the top would benefit from, or be reduced by, an inclusive physical environment.

Access

It is important to have suitable access for picking up and dropping off students, particularly if many students arrive by car. This can cause traffic congestion, which may be lessened if schools were to have kerbing that was either ramped from road to footpath, or where the road and footpath were flush. If students in wheelchairs or with limited mobility arrive or depart in cars, but cannot enter or leave the car until it can draw up to an area with suitable kerbing, then congestion could result despite there being a large pull-up area for cars and other vehicles. The pick-up and drop-off area should be covered and sheltered from the wind and rain.

The literature specified a number of different features for doors (internal and external) to be safe and appropriate for student use, although most studies did not specify whether doors should be automatic or manual. One study specified that external doors, particularly to the main entrances, should be automatic (Department for Children, Schools and Families, 2008).

Access for students that require additional support is commonly considered in the literature in terms of ramps and lifts, with the importance of these for physical access and an inclusive environment explained by a staff member of a special education facility as ‘we are very lucky … you can take a wheelchair anywhere, or take the children anywhere’ (Kearney, 2009, p. 154). Some of the literature suggests that if these forms of access are not available, students with mobility needs should attend classes on the ground floor of school buildings (Erkilic & Durak, 2013). While there are obvious health and safety benefits to this, it raises the question of whether a school that cannot give equitable access throughout its buildings to students with special education needs or disabilities can offer a truly inclusive environment for those students.

Students wthat require additional support who participated in another study of the barriers to accessing education listed a number of other physical barriers to access such as kerbs or thresholds, and heavy doors (Pivik McComas & Laflamme, 2002). It is important to ensure that doors are wide enough and there are no unnecessary thresholds between inside and out, between a change in floor coverings, or created by runners for sliding doors. It is also important to consider physical access to all spaces within the school, as although overall access might be good within a school, design groups sometimes overlook ramp access to specialist areas (eg stage within a performing arts area).

Some students spoke of restricted access due to a lack of manual dexterity, such as lockers or science equipment that required two hands to operate or required a level of manual manipulation that posed challenges for the students (Pivik et al., 2002). This conflicts with the UD principle of designing environments to require low physical effort on the part of the user (Mitchell, 2010).

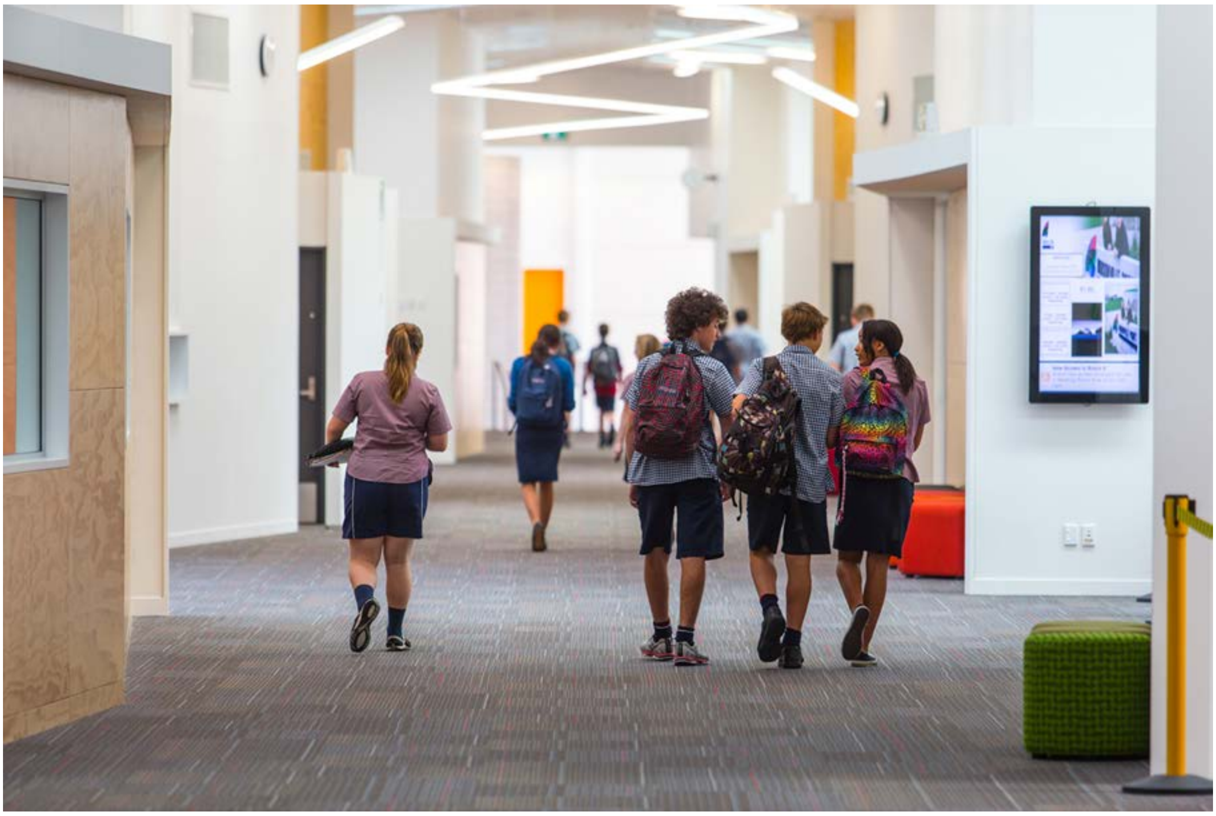
Circulation

Circulation around the school is also an important design feature. The distances that students will be required to travel are largely dependent on the configuration of the learning and other associated spaces, and should be minimised wherever possible. Long or complex routes can be physically demanding, but may also be overwhelming for some students (McAllister & Hadjri, 2013), and will be less able to be mentally imaged by students with visual impairments (Erkilic & Durak, 2013). Routes should be direct and logical, and students can be assisted using methods such as colour and sign-posting to mark routes (McAllister & Hadjri, 2013). Participants emphasised the importance of considering whether corridors and pathways were open or enclosed, so that students with limited mobility or high health needs were not unnecessarily exposed to the elements during bad weather or cooler temperatures.

Tanner’s (2000) study of 39 facility design and quality features found that pathways were linked to student outcomes. Pathways were described as ‘clearly defined areas for freedom of movement’ (Tanner, 2000, p. 319). This may link with the finding that crowding and density within schools has been associated with adverse student achievement and engagement outcomes (Wohlwill & Vliet, 1985). One study found that movement and circulation explained the highest level of variance in student achievement (6.9%) of the four significant design features (Tanner, 2008). Another study with students in the same age group found that movement and circulation explained 3.5% of variance in student achievement (Yarbrough, 2001).

Corridors and other circulation spaces must be sufficiently wide to accommodate students with mobility aids such as wheelchairs or walking frames, or who may be accompanied by an adult (Erkilic & Durak, 2013). The design phase needs to take into account furniture or equipment that may be stored in the corridor, because if a corridor is filled with student bags and other belongings, the functional width of the corridor will be reduced (Erkilic & Durak, 2013). This includes consideration of the school facility in all seasons, as heavier winter clothing and wet weather gear such as raincoats and umbrellas can further restrict corridor space (Pivik et al., 2002). This is also an important consideration for the placement of lifts, because lifts located within the main corridor area can create congestion due to students (particularly those with mobility aids) waiting to access the lift and narrowing the functional width of the corridor.

Corridor width must also be taken into account for students who require more personal space than other students who will be using the space (Follows, 2003). For example, students



with ASD frequently become uncomfortable or distressed by other students being in close proximity to them (Humphreys, 2005; Whitehurst, 2006). It is also important for students who are deaf or hard of hearing to have sufficient room to carry on a sign language conversation while in the corridor. Crowded corridors can also make students vulnerable to bullying from other students (Clark, 2002), whereas areas that allow freedom of circulation increase student safety by making it easier for teachers to supervise student activity (Moore & Lackney, 1995). Along main routes, quiet spaces off to the side can act as passing bays, can give students a place to congregate in a small group, or can give students time to calm down and regroup if needed (Department for Children, Schools and Families, 2008). This is particularly important given that corridors will have times of high congestion as students shift between classes, and arrive or leave school for the day.

Emergencies

An important design consideration with regard to exiting the school is the provision for students that require additional support in the event of an emergency. Whatever security provisions are put in place to prevent students leaving the school grounds must not restrict exit in the case of an emergency (Planning & Building Unit, 2012). There are physical barriers that students may experience in entering and leaving the school, or in travelling around the school unrestricted. Fire doors in particular may tend to be so heavy that students often could not open them unaided, and students were fearful of being trapped in the event of a fire (Pivik et al., 2002). One student reported that all wheelchair-bound students were required to wait in a designated upstairs learning space for assistance during a fire drill. While this a practical solution, it signals to students the value that the school places upon them: 'if the fire alarm goes off, we are told to meet in a room upstairs and just wait. You can't do anything but sit and wait and hope they remember about you' (Pivik et al., 2002, p. 101).

Storage and accessibility

One study of best practice school design made frequent mention of the importance of adequate and thoughtfully designed storage facilities (AC Nielsen, 2004). A post-occupancy evaluation listed storage as both a positive and a drawback of the schools evaluated, with teachers appreciating the storage space available, while still feeling that more storage space would be useful (Research New Zealand, 2010).

Thoughtful inclusion of learning space storage led to more lesson time being available to spend on learning (see Woolner et al., 2007, for specific findings). Consideration needs to be given to the best storage method for the object being stored, and where this storage is best located for the people using it. The location will depend on how often the resources need to be accessed, and by whom, in addition to any restrictions on access (Department for Children Schools and Families, 2008).

Under desk storage can reduce thigh clearance, which impacts on student comfort (Wadsworth, 2000). It may also mean that students are less able to move from area to area within the learning space, unless they are bringing their desk with them into a new configuration (Butin, 2000). One study found that eliminating under desk storage led to more flexibility in movement around the learning space, but made the room more untidy as resources tended to be placed on the desks or on the floor (Kane, Pilcher, & Legg, 2006).

Storage of both personal belongings and school equipment also needs to be considered with reference to any needs of students that require additional support. For example, a number of design guides suggest that equipment should be stored in closed systems such as cupboards or drawers rather than on open shelves (Department for Children, Schools and Families, 2008; Tufvesson & Tufvesson, 2009). Open storage systems are reported to have a negative effect on student concentration (Tufvesson & Tufvesson, 2009), and so appropriate concealed storage systems can minimise distraction from this source (Department for Children, Schools and Families, 2008). Some students are particularly attracted to computers and computing equipment, and therefore having this equipment stored in a concealed manner is preferable (Planning & Building Unit, 2012).

Students with Emotional and Behavioural Disorders (EBD) will feel less anxiety about being separated from personal possessions if they are confident that the storage is secure (Clark, 2002; Visser, 2001). Providing secure and appropriate storage assists these students in the learning space by minimising a potential source of distraction, and by more clearly delineating between learning space behaviour and out-of-school activities (Visser, 2001). For example, students with EBD are often attached to bulky outdoor clothing, which can limit mobility in the learning space, and can distract the student from focussing on the class (Cole, Visser, & Upton, 1998).

It is preferable to minimise built-in storage and instead use mobile cabinets and storage units (LS3P Research, 2012). These cabinets can then be moved to wherever their contents are required, as well as defining spaces and providing acoustical isolation (Hassell, 2011). Taller storage units can also double as vertical display spaces (LS3P Research, 2012), and smaller units can be used for horizontal display (Wadsworth, 2000). It should be noted, however, that there are considerations with the height and weight of storage units. If units are too large they become too heavy to move (LS3P Research, 2012) and are prone to tipping (Cornell, 2002).

Likewise, some smaller units such as planners' drawers tend to become heavy due to their contents (Watson, Wadsworth, Daniels & Wonnacott, 1998). Heavier types of storage should be fitted with lockable castors to prevent units tipping or moving accidentally if bumped or in an emergency (Wadsworth, 2000).

This can also be extended to using mobile caddies or trolleys to transport teaching resources between and within learning spaces (LS3P Research, 2012). A combination of fixed and flexible storage can make it easier to transport resources or equipment from a storage area to the appropriate part of the learning space by using compatible storage bins or trays. If a number of students will need to access resources from a storage space at the same time, consideration should be given to storing those resources in a location that will not become easily congested (Watson et al., 1998).

It can also add flexibility to the room if rubbish bins are placed on castors, making it easier to transport the bin to the area needing to be tidied rather than carry a heavy bin or make multiple trips to the bin (Watson et al., 1998).

An issue related to storage that is covered in the literature is the physical discomfort and health impact of students carrying heavy bags or equipment to, from and around school (see Legg & Jacobs, 2008; Trevelyan & Legg, 2006, for comprehensive reviews of previous findings), with some students carrying up to 30% of their body weight (Negrini, Carabalona, & Sibilla, 1999). One review suggested schools should be considering storage for student belongings that minimises both the weight of their bags, and the time spent carrying them (Trevelyan & Legg, 2006). This is particularly important for students that require additional support who may need to transport multiple mobility aids, assistive devices or other equipment around the school.

Technology

The available literature on the impact of technology in the learning space is necessarily limited by the speed of change of the availability and cost of technology. There were elements, however, that remain applicable, and the main finding can be summarised as technology having a positive influence on student outcomes as long as it is embedded within a teacher's pedagogy, or 'owned' by the teacher (Higgins & Hall, 2002).

The use of current and future technology should be able to be seamlessly integrated into teaching and learning. Post-occupancy studies show an emphasis on design that allows for future-proofing in the area of technology (AC Nielsen, 2004). Future-proofing needs to consider the types of network requirements for all students to be using electronic devices, as well as hard-wired charging requirements.

Careful advance consideration of how technology will be used in a learning space is necessary to make sure that the aim of supporting technology does not conflict with the principle of flexibility. At the fittings level of design, this relates to careful placement of wiring and cabling so that learning spaces do not need to be retrofitted in the future. Wiring should be accessible so that any necessary upgrades are minimally intrusive (Butin, 2000), and may include wiring for voice, video and data capabilities (Butin, 2000). Future-proofing in this area should include consideration of the impact of wireless systems.

Learning spaces may include charging stations fitted to furniture, such as desks or chairs with power supplies, or furniture with wireless charging capabilities (LS3P Research, 2012). How desktops, laptops, tablets and other devices will be used in the learning space should be considered when choosing desks and other workstations.

The increasing presence of electronic technology also affects other aspects of physical design, such as the impact on heating and ventilation of a large number of laptops or workstations, in addition to security and maintenance implications (Butin, 2000).The additional heat generated by having large numbers of electronic devices in a space can be used effectively by having a heating or ventilation system that distributes this heat into surrounding spaces that would otherwise have to be heated (JISC, 2006).

Colour

Colour can be important for both psychological and functional purposes. There is a need to balance the benefits of colour in assisting those with visual impairments while avoiding overstimulating students who may be sensitive to environmental stimuli (Department for Children, Schools and Families, 2008; Planning & Building Unit, 2012). Bright colours and patterns may overstimulate some students, particularly patterns that can give a strobe effect (Department for Children, Schools and Families, 2008; Greville, 2009).

Examples of the effective use of colour are different coloured doors for different learning spaces, different coloured chairs to correspond with each learning space, and a variety of coloured pendant lights in the hallway. More subdued pastel colours can be soothing on the mood (Department for Children, Schools and Families, 2008), and so a neutral or subdued colour palette is commonly used in special education environments (Pauli, 2006; Scott, 2009). This allows teachers to introduce bright colours through the display of student work or other strategies, depending on the sensitivities of students in the class (Department for Children, Schools and Families, 2008). Choice of colour should also be considered alongside other physical features such as light sources and the whole colour palette. For example, bright colours against a background of darker colours can appear to glare, and may reduce visibility.

Colour can be used as a visual cue, such as to identify spaces, navigate around the school, or to signal a change in activity from one part of a learning space to another. Colour can also assist students with visual impairments, such as layering colour to define objects, or using contrasting colours to define important objects such as step edges (Department for Children, Schools and Families, 2008; Greville, 2009). It is important for this purpose that there is a contrast between wall and floor colouring (Planning & Building Unit, 2012).

Furniture, fittings, and equipment to support moderate and advanced features

Appropriate furniture, fittings, and equipment (FF&E) is of central importance in ensuring that a space's potential for flexibility is supported. Learning spaces should minimise fixed and built-in furniture, and use moveable furniture where possible (LS3P Research, 2012). This is because fixed furniture decreases flexibility and limits possible layouts (AC Nielsen, 2004).

This may mean that different areas of the learning space are configured in different ways (LS3P Research, 2012). Learning spaces might be set up with different types of seating in addition to different configurations, such as soft seating for small meetings, or bean bags for quiet reading and individual work (Kennedy, 2010). It may also mean that chairs, desks and tables are themselves easily moveable to create different configurations throughout the period or the school day (Rydeen & Sorenson, 2005).

It is important to consider the effect of lighting when designing different learning areas, or when designing a learning space where FF&E will be reconfigured for different learning activities. Lighting levels are very rarely consistent at all points in a learning space, and there may be some areas where a lower level of lighting is more appropriate to the activity (Lei, 2010). Likewise, desks tend to produce glare when the level of light on them is too high (Winterbottom & Wilkins, 2009), and so if desks will be shifted within the learning space it is important that the light does not create glare which would cause certain locations or configurations to be unworkable.

Complete flexibility in learning space configuration can be mentally tiring, and that teachers may eventually revert to a single configuration rather than taking the time to rearrange the learning space more frequently (Cornell, 2002; Henshaw, Edwards, & Bagley, 2011). Posting suggested room layouts can support teachers to maximise the potential of a learning space's flexibility (Cornell, 2002).

Configurations and the FF&E used give meaningful visual and spatial cues to students about how resources or areas can be used (Saltmarsh, Chapman, Campbell & Drew, 2015). It is also important to consider the reciprocal interaction of students and teachers with the FF&E, and that students interacting with FF&E may result in pedagogical, structural or organisational opportunities not originally anticipated by the teacher (Yeoman, 2015).

In order to support this level of adaptability furniture must be durable enough to last despite frequent rearranging (Rydeen & Sorenson, 2005). It must also be lightweight enough for students to easily move it around the learning space (LS3P Research, 2012). Much of the literature suggests that furniture should be made more mobile by being on castors. This is particularly the case for heavier or more awkward pieces of equipment such as shelving or tables (Breithecker, 2005). While enhancing flexibility, this must be considered in the context of student wellbeing, particularly if furniture could move or tip over during usage or in the event of an earthquake (Cornell, 2002). The floor coverings of the rooms in which FF&E will be used should also be considered, as different types of castors work less effectively on carpets compared with hard flooring (Wadsworth, 2000).

Some seating configurations can cause discomfort for students if they struggle to see the teacher, the whiteboard, or other visual aids (BRANZ Ltd, 2007e). If students are seated in clusters, they may have difficulty seeing the teacher, whereas students seated in rows will have trouble seeing other students speaking (Van Note Chism, 2002). In addition to considering line of sight, it is also important to consider the distance between students and the teacher, whiteboard or other visual aids, to ensure that visibility is not compromised (Niemeyer, 2003).

A review of previous findings on the advantages and disadvantages of different seating arrangements found that different arrangements support different styles of learning (Wannarka & Ruhl, 2008). Students working on an individual task displayed higher levels of on-task behaviour when seated in rows, and this finding was more pronounced for disruptive or easily distracted students (Wannarka & Ruhl, 2008). Rows of desks are thought to increase student achievement by increasing the amount of time spent on-task (Galton, Hargreaves, Comber, Wall, & Pell, 1999).

It is theorised that this relationship is also mediated by teacher interactions, and that being seated in rows may increase achievement indirectly by minimising the number of negative interactions that the teacher had with students (Higgins et al., 2005). This is because students sitting in rows are better able to concentrate and are therefore less likely to attract negative attention from the teacher. One study found that students produced the same quality of work when seated in clusters as in rows, but produced a greater quantity of work when seated in rows (Bennett & Blundell, 1983).

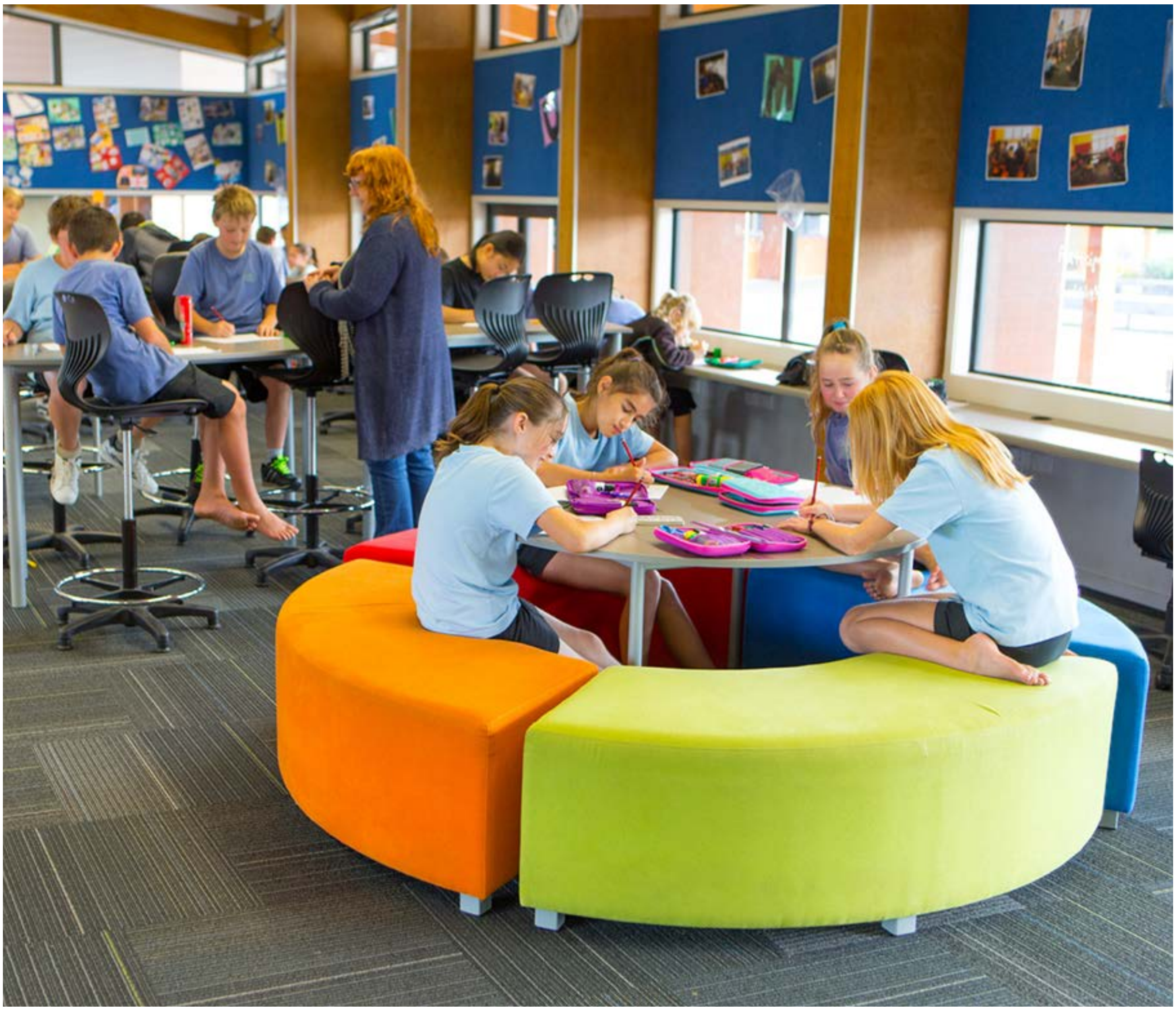
Despite these findings, studies asking teachers their learning space arrangement preferences tend to find that teachers prefer clusters to rows (Patton, Snell, Knight, & Gerken, 2001). This is consistent with another review of findings that concluded that horseshoes or clusters were more effective than rows for supporting group activities or collaborative tasks (Wheldall & Bradd, 2010). Psychologically, seating arrangements may signal to students that a certain type of learning expected of them, such as tables arranged in clusters suggesting collaborative learning (Cornell, 2002). It is therefore important that learning spaces are configured so that individual and group learning areas are clearly distinguished (Guardino & Fullerton, 2010).

Seating arrangements that minimise the distance between the teacher and the students are more acoustically effective for activities that involve direct teacher instruction, because the teacher does not have to raise his or her voice, and the students can clearly hear what is being said (Siebein, Gold, Siebein & Erbann, 2000). Studies suggest that the proximity to the teacher and the ability to easily see and hear other students are the main advantages of a horseshoe shape (Galton et al., 1999), and more questions are asked by students overall when seated in a horseshoe arrangement than in rows (Marx et al., 2000). However, this arrangement has also been criticised for being too teacher-centric (Horne-Martin, 2002).

There are other considerations for learning space design to support different learning activities without students feeling crowded or as though their personal space is being violated. If students are working individually, the distance between them and another individual would generally range from 1.2 – 2 metres. However, if students are working together on a collaborative activity, then they will have a lower personal space requirement, and can be expected to work comfortably at distances of between 0.6m and 1.2m from other students without feeling crowded (Graetz & Goliber, 2002).

Collaborative activities in which students are active and are seated in closer proximity to each other will lead to increases in temperature, meaning that it is important to be able to easily lower the temperature in the learning space to keep the temperature at an appropriate level for the activity taking place (Graetz & Goliber, 2002).

Reviews of findings in the area of seating arrangements conclude that the best seating arrangement is dependent on the task that students are being asked to complete. Activities involving collaboration and communication will be more suited to arrangements where students are in closer proximity to one another, and activities involving concentrated individual work are more suited to an arrangement that doesn't encourage interaction (Wannarka & Ruhl, 2008; Wheldall & Bradd, 2010). However, one review also points out that there are a lack of recent studies on this topic (Wannarka & Ruhl, 2008). The different learning areas able to be offered in a flexible learning space may support different opportunities for students to choose to work individually in a quiet area of the learning space, rather than the teacher configuring an arrangement of rows.




TAMORA PIERCE

Conclusion

By addressing a variety of different learning needs and activities through their size and malleability, flexible learning spaces can support the adaptable delivery of teaching and learning programmes to meet the learning needs of all students.

In order for teachers to maximise the potential of these learning spaces, they must be supported to develop their pedagogical repertoire while also being encouraged to explicitly consider the role of the physical environment as part of the planning process. Schools should consider development to assist both teachers and students to perceive and act upon the range of opportunities offered by the learning environment.

In terms of philosophical intent, innovative learning environments can be seen as a tool to support the strengthening of a school's inclusive environment. Inclusive education involves creating a school environment in which all students can be socially and educationally involved in a way that meets their individual needs. Just as effective teaching can occur in any physical setting, so too can schools offer an inclusive environment and culture regardless of the physical features of the school buildings and facilities.

The current report has summarised the potential links between core, moderate and advanced features of flexible learning spaces and student achievement and engagement outcomes. Many of the studies contained in this review demonstrate links between physical environment and student outcomes, but the vast majority do not include measures of other possible influencing factors such as teacher effectiveness or student self-belief. This review strongly recommends that the visioning and design process considers these potential links in association with the wide range of other variables that may influence student outcomes.

References

Abend, A. C. (2001). Planning and designing for students with disabilities. Retrieved from http://files.eric.ed.gov/fulltext/ED454699.pdf

AC Nielsen. (2004). Best practice in school design: Ministry of Education.

Al-Bustami, H. (2014). Impact of Classroom Plants on Students' Comfort and Performance in UAE. The British University in Dubai. Retrieved from http://bspace.buid.ac.ae/handle/1234/663

Allcock, J. (1997). Report of FM Soundfield study, Paremata School 1997. Retrieved from www.oticon.org.nz/pdf/OTICONParamataresearchreport.pdf

American Speech-Language-Hearing Association. (2005). Acoustics in educational settings: Technical report.

Arnot, M., & Reay, D. (2007). A sociology of pedagogic voice: Power, inequality and pupil consultation. Studies in the Cultural Politics of Education, 28(3), 311 - 325.

Barnitt, H. (2003). Lighting for the Future. Building Services Journal: The magazine for the CIBSE, 25(1), 38 - 39.

Barrett, P., Zhang, Y., Moffat, J., & Kobbacy, K. (2013). A holistic, multi-level analysis identifying the impact of classroom design on pupils' learning. Building and Environment, 59, 678 - 689.

Barrett, P., Davies, F., Zhang, Y., & Barrett, L. (2015). The impact of classroom design on pupils' learning: Final results of a holistic, multi-level analysis. Building and Environment, 89, 118-133.

Barrett, P. S., Zhang, Y., Davies, F., & Barrett, L. C. (2015). Clever classrooms: Summary report of the HEAD project. Manchester: University of Salford.

Bennett, N., & Blundell, D. (1983). Quantity and quality of work in rows and classroom groups. Educational Psychology, 3(2), 93 - 105.

Bennetts, L. K., & Flynn, M. C. (2002). Improving the classroom listening skills of children with Down syndrome by using sound-field amplification. Down Syndrome Research and Practice, 8(1), 19 - 24.

Benya, J. R. (2001). Lighting for Schools: National Clearinghouse for Educational Facilities.

Bishop, R. (2001). Designing for special educational needs in mainstream schools. Support for Learning, 16(2), 56 - 63.

Bisset, J. A. (2014). The move to modern learning environments in New Zealand secondary schools: Step forward or smokescreen? (Unpublished doctoral dissertation). Unitec Institute of Technology.

Blackmore, J., Bateman, D., Loughlin, J., O'Mara, J., & Aranda, G. (2011). Research into the connection between built learning spaces and student outcomes. Melbourne, Australia: Education Policy and Research Division: Department of Education and Early Childhood Development.

BRANZ Ltd. (2007a). Designing quality learning spaces: Acoustics: Ministry of Education.

BRANZ Ltd. (2007b). Designing quality learning spaces: Heating and Insulation: Ministry of Education.

BRANZ Ltd. (2007c). Designing Quality Learning Spaces: Lighting: Ministry of Education.

BRANZ Ltd. (2007d). Designing quality learning spaces: Ventilation and Indoor Air Quality: Ministry of Education.

BRANZ Ltd. (2007e). Designing quality learning spaces: Introduction and interior design, function and aesthetics: Ministry of Education.

Breithecker, D. (2005). "The educational workplace": What the "classroom of the future" will look like. Wiesbaden: Bundesarbeitsgemeinschaft für Haltungs und Bewegungsförderung.

Bullock, A. A., & Foster-Harrison, E. (1997). Making the best decisions: Designing for excellence. Schools in the Middle, November/ December, 37 - 39, 60 - 61.

Burchett, M., Torpy, F., Brennan, J., & Craig, A. (2010). Greening the great indoors for health and wellbeing. Sydney, Australia: Horticulture Australia.

Butin, D. (2000). Classrooms. Retrieved from http://files.eric.ed.gov/fulltext/ED446421.pdf

Byers, T., Imms, W., & Hartnell-Young, E. (2014). Making the case for space: The effect of learning spaces on teaching and learning. Curriculum and Teaching, 29(1), 5-19.

Cash, C. (1993). A study of the relationship between school building condition and student achievement and behavior. Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Cash, C., & Twiford, T. (2009). Improving student achievement and school facilities in a time of limited funding. International Journal of Educational Leadership Preparation, 4(2), 1 - 9.

Chan, T. C. (1996). Environmental impact on student learning. Valdosta, Ga: Valdosta State College.

Clark, H. (2002). Building education: the role of the physical environment in enhancing teaching and learning - issues in practice. London: Institute of Education.

Cleveland, B., & Fisher, K. (2014). The evaluation of physical learning environments: A critical review of the literature. Learning Environments Research, 17(1), 1-28.

Cole, T., Visser, J., & Upton, G. (1998). Effective schooling for pupils with emotional and behavioural difficulties. London: David Fulton.

Cornell, P. (2002). The impact of changes in teaching and learning on furniture and the learning environment. New Directions for Teaching and Learning, 92, 33 - 42.

Daisey, J. M., Angell, W. J., & Apte, M. G. (2003). Indoor air quality, ventilation and health symptoms in schools: An analysis of existing information. Indoor Air, 13, 53 - 64.

Daly, J., Burchett, M., & Torpy, F. (2010). Plants in the classroom can improve student performance. National Interior Plantscape Association.

Deaker, M. (2007). An appraisal of recently built or remodelled learning environments in New Zealand schools. Wellington: Ministry of Education.

Department for Children, Schools and Families. (2008). Designing for disabled children and children with special educational needs: Guidance for mainstream and special schools Building Bulletin 102. London: The Stationery Office.

Department for Education and Employment: School Buildings and Design Unit. (2001). Inclusive School Design: Accommodating pupils with special educational needs and disabilities in mainstream schools Building Bulletin 94. London: The Stationery Office.

Doxey, J. S., Waliezek, T. M.. & Zajicek, J.M. (2009). The impact of interior plants in university classrooms, on student course performance and on student perceptions of the course and instructor. HortScience, 44, 384 - 391.

Dudek, M. (2000). Architecture of schools: the new learning environments. Oxford: Architectural Press.

Earthman, G. I. (2004). Prioritization of 31 Criteria for School Building Adequacy. Retrieved from http://www.schoolfunding.info/policy/facilities/ACLUfacilities_report1-04.pdf

Earthman, G. I., & Lemasters, L. (1996). Review of research on the relationship between school buildings, student achievement, and student behavior. Paper presented at the Council of Educational Facility Planners International, Tarpon Springs, Florida.

Earthman, G. I., & Lemasters, L. (1998). Where children learn: A discussion of how a facility affects learning. Paper presented at the Virginia Educational Facility Planners, Blacksburg, Virginia.

Education Law Centre. (2005). Long range facilities planning and design implementation for students with disabilities: A guide for New Jersey school districts. Retrieved from http://www.edlawcenter.org/assets/files/pdfs/publications/LRFP_Disabilities.pdf

Edwards, M.M. (1992). Building conditions, parental involvement, and student achievement in the DC Public School System (Unpublished masters dissertation). Georgetown University, Washington, D.C.

Ellis, R. A., & Goodyear, P. (2016). Models of learning space: integrating research on space, place and learning in higher education. Review of Education. Advance online publication. doi: 10.1002/rev3.3056.

Erkilic, M., & Durak, S. (2013). Tolerable and inclusive learning spaces: an evaluation of policies and specifications for physical environments that promote inclusion in Turkish primary schools. International Journal of Inclusive Education, 17(5), 462 - 479.

Fjeld, T. (2002). The effects of plants and artificial daylight on the well-being and health of office workers, school children and health-care personnel. Paper presented at the International Plants for People Symposium, Floriade, Amsterdam.

Fletcher-Campbell, F., & Kingston, A. (2001). Links between special schools and mainstream schools: A follow-up survey. Journal of Research in Special Educational Needs, 1(3).

Follows, B. E. (2003). Creating and funding school buildings that promote the inclusion of pupils with behaviour problems. Emotional and Behavioural Difficulties, 8(4), 303 - 315.

Frith, K. (2015). Are your school interiors giving you a pedagogical edge? Mapping learning environment evaluation across the design and education landscape, 20 - 31.

Galton, M., Hargreaves, L., Comber, C., Wall, D., & Pell, A. (1999). Inside the primary classroom: 20 years on: Routledge.

Gathorne-Hardy, F. (2001). Inclusive design in schools. Support for Learning, 16(2), 53 - 55.

Genevro, R. (1992). New Schools for New York: Plans and Precedents for Small Schools. New York, New York: Princeton Architectural Press.

Gifford, R. (2002). Environmental Psychology: Principles and practice (3 ed.). Colville, WA: Optimal.

Gislason, N. (2009a). Building paradigms: Major transformations in school architecture (1798 - 2009). The Alberta Journal of Educational Research, 55(2), 230 - 248.

Gislason, N. (2009b). Mapping school design: A qualitative study of the relations among facilities design, curriculum delivery, and school climate. The Journal of Environmental Education, 40(4), 17 - 34.

Graetz, K. A., & Goliber, M. J. (2002). Designing collaborative learning places: Psychological foundations and new frontiers. New Directions for Teaching and Learning, 92, 13 - 22.

Greville, E. (2009). Including pupils with special education needs in Ireland. Retrieved from http://www.oecd.org/education/country-studies/centreforeffectivelearningenvironmentscele/42168831.pdf

Grocoff, P. N. (1995). Electric lighting and daylighting in schools: Council of Educational Facility Planners, International Issue Track.

Guardino, C., & Fullerton, E. (2010). Changing behaviors by changing the classroom environment. Teaching Exceptional Children, 42(6), 8 - 13.

Gump, P. V. (1987). School and classroom environment. In D. Stokols & I. Altman (Eds.), Handbook of environmental psychology (Vol. 1, pp. 691 - 732). New York, NY: John Wiley & Sons.

Hall, J. (2009). Healthful Choices. American School & University, 81(7), 25 - 28.

Han, K.-T. (2009). Influence of limitedly visible leafy indoor plants on the psychology, behaviour and health of students at a junior high school in Taiwan. Environment and Behaviour, 41(5), 658 - 692.

Harrigan, M. (1999). Plugging into energy savings. The American School Board Journal, 186(1), 12 - 16.

Harris, C., & Straker, L. (2000). Survey of physical ergonomics issues associated with school children's use of laptop computers. International Journal of Industrial Ergonomics, 26, 337 - 347.

Hassell, K. (2011). Flexible Classroom Furniture. American School & University, 84(2), 18 - 21.

Henshaw, R. G., Edwards, P. M., & Bagley, E. J. (2011). Use of swivel desks and aisle space to promote interaction in midsized college classrooms. Journal of Learning Spaces, 1(1).

Heschong Mahone Group. (1999). Daylighting in schools: An investigation into the relationship between daylighting and human performance. San Francisco, California: Pacific Gas and Electric Company.

Heschong Mahone Group. (2002). Re-analysis report: Daylighting in schools, additional analysis. Sacramento, California: California Energy Commission (CEC Contract to New Buildings Institute number 400-99-013).

Higgins, S. E., & Hall, E. (2002). Embedding Computer Technology in Developmentally Appropriate Practice: Engaging with early years professionals' beliefs and values. Information Technology in Childhood Education Annual (1), 293 - 312.

Higgins, S. E., Hall, E., Wall, K., Woolner, P., & McCaughey, C. (2005). The impact of school environments: A literature review: The Centre for Learning and Teaching, School of Education, Communication and Language Science, University of Newcastle.

Hirano, A. (1993). Opun supesu no katsuyo [Utilizing open space]. In Kyoikukaihatsukenkyujo (Ed.), Opun supesu sukuru dokuhon [Handbook of open space school] (Vol. 40 - 45). Tokyo: Kyoikukaihatsukenkyujo.

Horne-Martin, S. (2002). The Classroom Environment and its Effects on the Practice of Teachers. Journal of Environmental Psychology, 22(1 - 2), 139 - 156.

Hughes, S. J. (2014). Teachers as placemakers: how primary school teachers design, manage and maintain learning spaces as part of their daily workflow (Unpublished doctoral dissertation). University of Southern Queensland.

Humphreys, S. (2005). Autism and architecture. Autism London Bulletin, February/March, 7 - 8.

Innovative Educators Forum. (2000). Designing a school for the future. Paper presented at the Innovative Educators Forum.

Jensen, E. (2003). Environments for learning. San Diego: CA: Brain Store.

JISC. (2006). Designing spaces for effective learning: A guide to 21st century learning space design. University of Bristol: Higher Education Funding Council for England.

Johnson, E. (2001). Let's Hear it for Learning. American School and University, 73 (11), 28.

Kane, P. J., Pilcher, M., & Legg, S. J. (2006, 10 - 14 July). Development of a furniture system to match student needs in New Zealand schools. Paper presented at the 16th International Ergonomics Association World Congress (IEA2006), Meeting Diversity in Ergonomics, Maastricht, The Netherlands.

Kearney, A. C. (2009). Barriers to school inclusion: An investigation into the exclusion of disabled students from and within New Zealand schools. Ph.D., Massey University.

Kennedy, M. (2010). In position to learn. American School & University, 82(6), 20 - 22.

Knight, G., & Noyes, J. (1999). Children's behaviour and the design of school furniture. Ergonomics, 42(5), 747 - 760.

Koskelo, R., Vuorikari, K., & Hänninen, O. (2007). Sitting and standing postures are corrected by adjustable furniture with lowered muscle tension in high school students. Ergonomics, 50(10), 1643 - 1656.

Krueger, R. A., & Casey, M. A. (2000). Focus Groups. A Practical Guide for Applied Research (3rd ed.). Thousand Oaks, CA: Sage Publication.

Lackney, J. A. (1999). The relationship between environmental quality of school facilities and student performance: Environmental Energy Study Institute.

Lackney, J. A. (2008). Teacher environmental competence in elementary school environments. Children, Youth and Environments, 18(2), 133 - 159.

Lackney, J. A., & Jacobs, P. J. (1999). Teachers as placemakers: Investigating teachers' use of the physical setting in instructional design: Council Educational Facility Planners.

Laeser, K. (1997). The effect of computer workstation design on student posture and computer task performance: Children grades six and eight. Master's of Science, Cornell University, New York.

Lai, K.-W. (2000). Health risks with teachers' computer use: some New Zealand observations. Journal of Information Technology for Teacher Education, 9(3), 303 - 318.

Lang, D. C. (2002). Teacher interactions within the physical environment: How teachers alter their space and/or routines because of classroom character. Seattle: University of Washington.

Lanham, J. W. (1999). Relating building and classroom conditions to student achievement in Virginia's elementary schools. (Ph.D.), Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Legg, S. J. (2007). Ergonomics in schools. Ergonomics, 50(10), 1523 - 1529.

Legg, S. J., & Jacobs, K. (2008). Ergonomics for Schools. Work, 31, 489 - 493.

Legg, S. J., Pajo, K., Sullman, M., & Marfell-Jones, M. (2003, 24 - 29 August). Mismatch between classroom furniture dimensions and student anthropometric characteristics in three New Zealand secondary schools. Paper presented at the 15th Congress of the International Ergonomics Association, Ergonomics for Children in Educational Environments Symposium, Seoul, Korea.

Lei, S. A. (2010). Classroom physical design influencing student learning and evaluations of college instructors: A review of literature. Education, 131(1), 128 - 134.

Leiringer, R., & Cardellino, P. (2011). Schools for the twenty-first century: School design and educational transformation. British Educational Research Journal, 37(6), 915 - 934.

Lemasters, L. K. (1997). A synthesis of studies pertaining to facilities, student achievement, and student behavior. Blacksburg, Virginia: Virginia Polytechnic and State University.

Lippincott, J. K. (2009). Learning spaces: Involving faculty to improve pedagogy. Educause Review, 44(2), 16 - 18.

Lohr, V. I., Pearson-Mims, C. H., & Goodwin, G. K. (1996). Interior plants may improve worker productivity and reduce stress in a windowless environment. Journal of Environmental Horticulture, 14, 97 - 100.

Lowe, J. M. (1990). The interface between educational facilities and learning climate in three elementary schools. (Ph.D.), Texas A&M University, College Station, Texas.

LS3P Research. (2012). Furniture for 21st century schools. Retrieved from http://www.ls3p.com/wp-content/uploads/2013/08/21C-Schools_Furniture.pdf

Lucas, J. (1981). Effects of noise on academic achievement and classroom behavior. Sacramento, California: California Department of Health Services.

Marshall, H. H. (1981). Open classrooms: Has the term outlived its usefulness? Review of Educational Research in Occupational Stress and Well Being, 51, 181 - 192.

Maxwell, L. E. (1999). School building renovation and student performance: One district's experience. Scottsdale, Arizona: Council of Educational Facility Planners.

McAllister, K., & Hadjri, K. (2013). Inclusion and the special educational needs (SEN) resource base in mainstream schools: physical factors to maximise effectiveness. Support for Learning, 28(2), 57 - 65.

McDaniel, E. A., Sullivan, P. D., & Goldbaum, J. L. (1982). Physical proximity of special education classrooms to regular classrooms. Exceptional Children, 49(1), 73 – 75.

McGuffey, C. (1982). Facilities. In H. Walberg (Ed.), Improving educational standards and productivity: The research basis for policy. Berkeley, Califormia: McCutchan Pub. Corp.

Merriam, S. B. (1988). Case study in education: A qualitative approach. San Francisco: Jossey-Bass.

Ministry of Education. (2012). Learning studio pilot review.

Ministry of Education. ILE School Assessment tool. Retrieved from http://www.education.govt.nz/school/property/state-schools/design-standards/flexible-learning-spaces/

Mitchell, D. (2008). What really works in special and inclusive education: Using evidence-based teaching strategies. Abingdon, Oxon: Routledge.

Mitchell, D. (2010). Education that fits: Review of international trends in the education of students with special education needs: University of Canterbury.

Molenbroek, J. F. M., Kroon-Ramaekers, Y. M. T., & Snijders, C. J. (2003). Revision of the design of a standard for the dimensions of school furniture. Ergonomics, 46(7), 681 - 694.

Monsur, M. (2015). Does Childcare Architecture Matter? Investigating how Indoor-Outdoor Spatial Relations Influence Child Engagement and Teacher Motivation (Unpublished doctoral dissertation). North Carolina State University.

Montazami, A., Gaterell, M., & Nicol, F. (2015). A comprehensive review of environmental design in UK schools: History, conflicts and solutions. Renewable and Sustainable Energy Reviews, 46, 249-264.

Moore, G. T., & Lackney, J. A. (1993). School Design: Crisis, educational performance and design applications. Children's Environments, 10(2), 99 - 112.

Morris Jr, R. F. (2003). The relationships among school facility characteristics, student achievement, and job satisfaction levels among teachers (Unpublished doctoral dissertation). University of Georgia.

Mozaffar, F., & Somayeh Mirmoradi, S. (2012). Effective Use of Nature in Educational Spaces Design. Organization, Technology & Management in Construction: An International Journal, 4(1), 381-392.

Murphy, S., Buckle, P., & Stubbs, D. (2004). Classroom posture and self-reported back and neck pain in schoolchildren. Applied Ergonomics, 35(2), 113 - 120.

Näring, G. W. B., Canisius, A. R. M., & Brouwers, A. (2011). Measuring emotional labor in the classroom: The darker emotions. In A. Caetano, S. Silva & M. J. Chambel (Eds.), New challenges for a healthy workplace in human services (pp. 127 - 139). Munich: Rainer Hampp Verlag.

National College for School Leadership. Co-location, continuity and community: Vignettes. Retrieved from http://dera.ioe.ac.uk/2088/1/download%3Fid%3D132913%26filename%3Demerging-patterns-of-leadership.pdf Negrini, S., Carabalona, R., & Sibilla, P. (1999). Back pain as a daily load for school children. Lancet, 354(9194), 1974.

Niemeyer, D. C. (2003). Hard facts on smart classroom design: Ideas, guidelines, and layouts: Rowman & Littlefield.

Ogbonna, E., & Harris, L. C. (2004). Work intensification and emotional labour among UK university lecturers: An exploratory study. Organization Studies, 25(7), 1185 - 1203.

Osborne, M. (2013). Modern learning environments. Retrieved from http://www.core-ed.org/sites/core-ed.org/files/Modern-Learning-Environments-v.1.pdf

Painter, S., Fournier, J., Grape, C., Grummon, P., Morelli, J., Whitmer, S., & Cevetello, J. (2013). Research on learning space design: Present state, future directions. The Perry Chapman Prize: Society for College and University Planning.

Patton, J. E., Snell, J., Knight, G., & Gerken, K. (2001). A survey study of elementary classroom seating designs. Paper presented at the Annual meeting of the National Association of School Psychologists, Washington, DC.

Pauli, D. (2006). Contact through colour. Special Children, 173, 30 - 33.

Pivik, J., McComas, J., & Laflamme, M. (2002). Barriers and facilitators to inclusive education. Exceptional Children, 69(1), 97 - 107.

Planning & Building Unit. (2012). Planning & design guidelines: Primary & post primary school specialist accommodation for pupils with special educational needs (Vol. School Design Guide TGD-026).

Research New Zealand. (2010). New Zealand new school post occupancy evaluation: Key learnings report. Wellington.

Rivlin, L G, & Weinstein, C S. (1984). Educational Issues, School Settings and Environmental Psychology. Journal of Environmental Psychology, 4, 347 - 364.

Rosen, K.G., & Richardson, G. (1999). Would removing indoor air particulates in children's environments reduce rate of absenteeism - a hypothesis. The Science of the Total Environment, 234(3), 87 - 93.

Rydeen, J. E., & Sorenson, K. A. (2005). Beyond the seat. American School & University, 77(7), 29 - 30.

Saltmarsh, S., Chapman, A., Campbell, M., & Drew, C. (2015). Putting "structure within the space": spatially un/responsive pedagogic practices in open-plan learning environments. Educational Review, 67(3), 315-327.

Schneider, M. (2002). Do school facilities affect academic outcomes? : National Clearinghouse for Education Facilities.

Scott, I. (2009). Designing learning spaces for children on the autistic spectrum. Good Autism Practice, 10(1), 36 - 59.

Shibata, S., & Suzuki, N. (2004). Effects of an indoor plant on creative task performance and mood. Scandinavian Journal of Psychology, 45(5), 378 - 381.

Siebein, G. W., Gold, M. A., Siebein, G. W., & Ermann, M. G. (2000). Ten ways to provide a high-quality acoustical environment in schools. Language Speech and Hearing Services in Schools, 31(4), 376 - 384.

Smedje, G., & Norback, D. (2001). Irritants and Allergens at School in Relation to Furnishings and Cleaning. Indoor Air, 11, 127 - 133.

Smedje, G., Norback, D., & Edling, C. (1997). Asthma among secondary schoolchildren in relation to the school environment. Clinical and Experimental Allergy, 27, 1270 - 1278.

Smith, H. J., Higgins, S. E., Wall, K., & Miller, J. (2005). Interactive whiteboards: boon or bandwagon? A critical review of the literature. Journal of Computer Assisted Learning, 18(4), 91 - 101.

Steele, F. (1980). Defining and developing environmental competence. In C. P. Alderfer & C. L. Cooper (Eds.), Advances in Experimental Social Processes 2 (pp. 225 - 244). New York: Wiley.

Stewart, D. (2010). Maximising investment. American School & University, 82(9), 26 - 29.

Stricherz, M. (2000). Bricks and Mortarboards. Education Week, 20, 30 - 32.

Tanner, C. K. (2000). The influence of school architecture on academic achievement. Journal of Educational Administration, 38(4), 309 - 330.

Tanner, C. K. (2008). Explaining relationships among student outcomes and the school's physical environment. Journal of Advanced Academics, 19(3), 444 - 471.

Tanner, C.K. (2009). Effects of school design on student outcomes. Journal of Educational Administration, 47(3), 381 – 399.

The Center for Universal Design. Universal Design Principles. Retrieved from http://www.ncsu.edu/ncsu/design/cud/about_ud/udprinciples.htm

Thomson, P. (2010). Whole school change: A literature review: Creativity, Culture & Education.

Trevelyan, F. C., & Legg, S. J. (2006). Back pain in school children - Where to from here? Applied Ergonomics, 37, 45 - 54.

Trougakos, J. P., Beal, D. J., Green, S. G., & Weiss, H. M. (2008). Making the break count: An episodic examination of recovery activities, emotional experiences, and positive affective displays. Academy of Management Journal, 51, 131 - 146.

Tufvesson, C., & Tufvesson, J. (2009). The building process as a tool towards an all-inclusive school. A Swedish example focusing on children with defined concentration difficulties such as ADHD, autism and Down's syndrome. Journal of Housing and the Built Environment, 24, 47 - 66.

Van Note Chism, N. (2002). A tale of two classrooms. New directions for teaching and learning, 92, 5 - 12.

Visser, J. (2001). Aspects of physical provision for pupils with emotional and behavioural difficulties. Support for Learning, 16(2), 64 - 68.

Wadsworth, A. (2000). Furniture and Equipment in Schools: A Purchasing Guide (Vol. 7). England: The Stationary Office.

Wannarka, R., & Ruhl, K. L. (2008). Seating arrangements that promote positive academic and behavioral outcomes: A review of empirical research. Support for Learning, 23(2), 89 - 93.

Watson, L., Wadsworth, A., Daniels, R., & Jones, A. (1996). Design and technology accommodation in secondary schools: A design guide. London: Department for Education and Employment.

Watson, L., Wadsworth, A., Daniels, R., & Wonnacott, G. (1998). Art accommodation in secondary schools: A design guide. London: Department for Education and Employment.

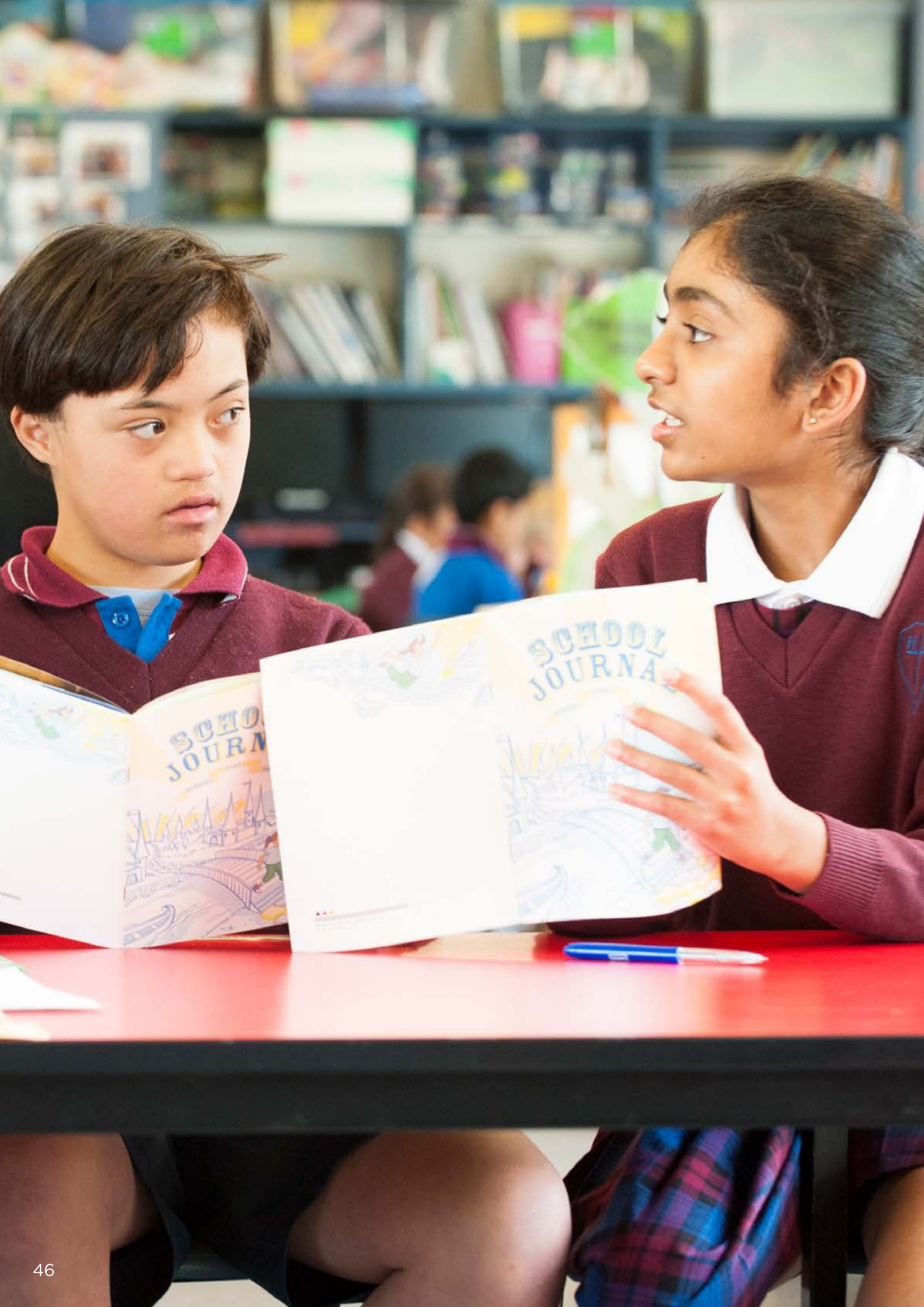
Wheldall, K., & Bradd, L. (2010). Classroom seating arrangements and classroom behaviour Developments in educational psychology (2nd ed.). London: Routledge.

Wohlwill, J. F., & Vliet, W. van. (1985). Habitats for Children: The Impacts of Density. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Woolner, P., Hall, E., Higgins, S. E., McCaughey, C., & Wall, K. (2007). A sound foundation? What we know about the impact of environments on learning and the implications for Building Schools for the Future. Oxford Review of Education, 33(1), 47 - 70.

Yarbrough, K. A. (2001). The relationship of school design to academic achievement of elementary school children (Unpublished doctoral dissertation). University of Georgia.

Yeoman, P. J. (2015). Habits and habitats: An ethnography of learning entanglement (Unpublished doctoral thesis). The University of Sydney.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Appendix A

Design considerations for learning support co-location

Co-location on site with another school

There are a number of different models for co-location, but to offer social development and inclusion benefits to students, the schools should have at least some shared facilities and resources.

It is important to consider the relative travel distance to access those shared facilities, and to design an appropriate route for students that require additional support to move between purpose-built learning spaces and shared facilities (Department for Children, Schools and Families, 2008). The design process should also take into account the differing levels of mobility of the students at each school, and should plan routes that will be appropriate for both groups of students. This may involve design elements such as quiet spaces located to the side of the route, wider areas for passing, and visual cues such as signage, symbols or colour (Department for Children, Schools and Families, 2008).

Case studies show that co-location offers a number of possibilities for both formal and less formal collaboration across the two schools. One model which has a formal collaborative relationship jointly employs a specialist staff member, and staff members at each school have led professional development activities for staff at both schools (National College for School Leadership). The two schools also share property facilities, such as a greenhouse, dining room and media suite (National College for School Leadership).

Another co-location has a 'twinned classrooms' approach, meaning that many of the students that require additional physical support or learning support attend both schools during the course of their schooling (National College for School Leadership, p. 22). The two schools share facilities, as well as using each other's facilities. This is valuable for students that require additional support enrolled at the mainstream school accessing specialist spaces and resources at the special education school. There are financial advantages to the sharing of property and teaching resources, as long as this can be appropriately negotiated and agreed upon by both schools (Bishop, 2001).

Satellite provision integrated with a partner school

Consideration should be given to the location of the satellite provision in relation to the remainder of the partner school buildings. For students that require additional support, the benefits of inclusion in a partner school are maximised by the purpose-built satellite spaces not being isolated from other buildings, or clustered in a single area in the building (Abend, 2001). If satellite provision is physically isolated from the partner school, then it cannot offer the same level of inclusiveness as more physically integrated provision (Bishop, 2001; Greville, 2009; Visser, 2001). One study of 273 special education classrooms within mainstream schools found that 36% of the classes were either partly isolated (such as being down the hallway) or entirely isolated from mainstream classes (McDaniel, Sullivan & Goldbaum, 1982).

Satellite provision that was physically isolated from the other classes was described by participants as making satellite students feel as though they weren't part of the partner school learning community, whereas provision that was physically adjacent to other classes gave students from satellite and partner school more opportunities to interact and learn from one another.

It should be noted that when satellite provision is retrofitted to an existing school site, there are logistical and space restrictions that would not be present if satellite provision were being constructed at the same time as the partner school. Students in satellite provision remain in that classroom for a much longer period of time than students in the partner school, meaning the satellite provision has to be located to give those students access to both the junior and senior facilities of a partner primary school. In a construction situation, there are more opportunities for siting satellite provision so that students are located in the same areas of the school as peers of a similar age. For example, there could be a satellite classroom in the junior section of the school, and a separate satellite classroom in the senior section of the school.

For students to feel that they belong and are valued in the same way as partner school students, access to satellite provision classes should be through the same main entranceway to the school as for partner school students (Greville, 2009), while keeping in mind the mobility and space needs of these students in what can be a crowded and fast-paced part of the school (Department for Children, Schools and Families, 2008). Considering travel distances, the satellite provision would ideally be located in reasonable physical proximity to the school's main entrance (Planning & Building Unit, 2012). However, if students find the size and busyness of the main entrance overwhelming, the satellite provision should also have an alternate entrance located in a less busy area of the school (McAllister & Hadjri, 2013).

This must be balanced with the likelihood that satellite students may be physically accessing the school site through different methods of transport, and consideration needs to be given to ensuring that students arriving via taxi and other forms of wheelchair access are adequately provided for, while making sure that the picking up and dropping off of students with mobility issues does not cause traffic congestion issues for other students using the school entrance.

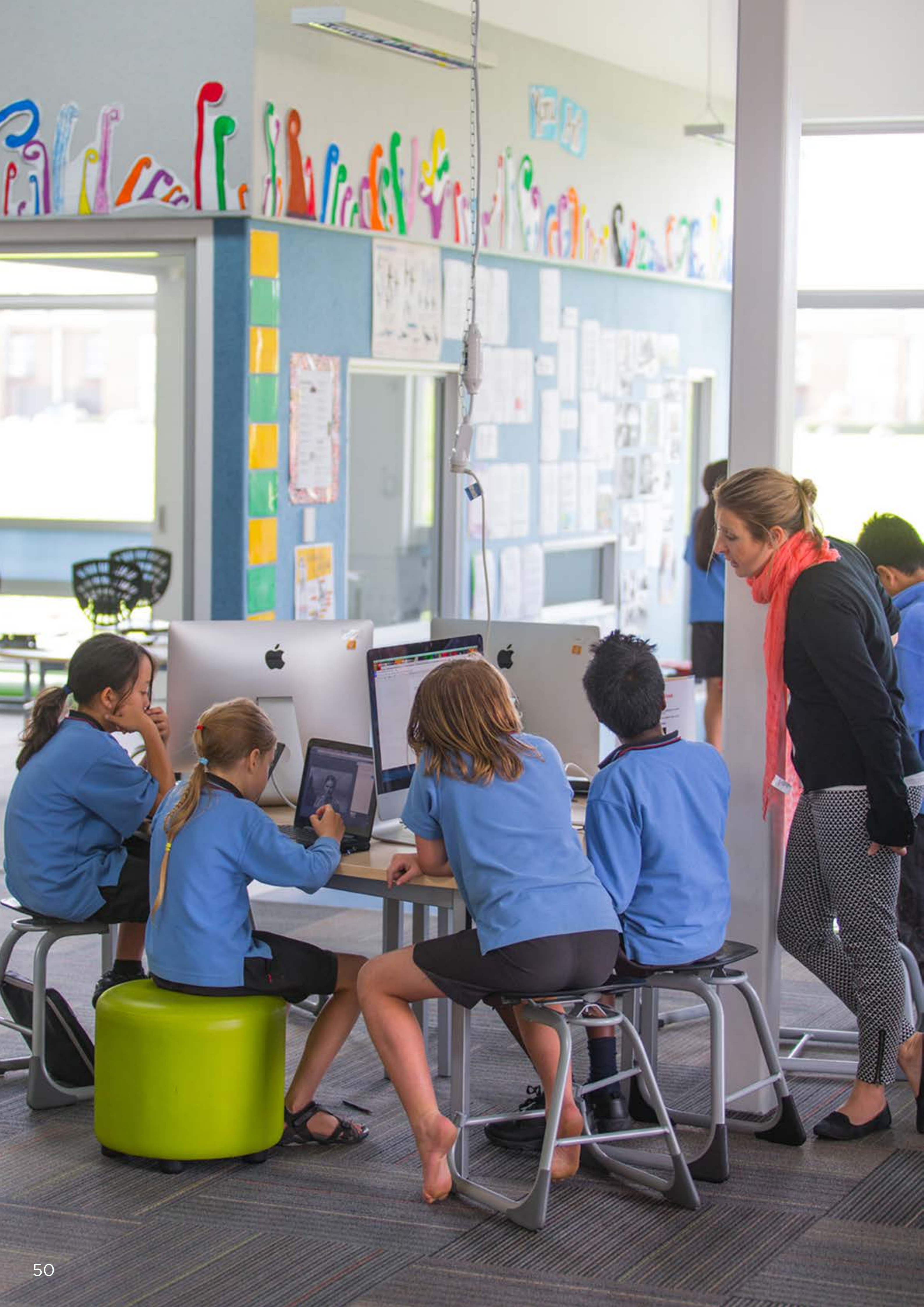
It is important to have regard to travel distances and routes when designing satellite provision that is dispersed throughout the partner school (Abend, 2001). Likewise, it is important to think about the structuring of shared spaces or opportunities for interaction, so that interaction can be beneficial for students rather than cause students from the satellite classes to feel uncomfortable or vulnerable (McAllister & Hadjri, 2013).

In addition to location and opportunities for integration in the wider partner school, it is important to recognise the visual cues that students attending the satellite provision will get that will inform them about their value relative to partner school students. Similar to sharing the same entrance, layout of classrooms and other spaces in the satellite provision should be of the same design and build quality as those in the partner school.

It is also important to consider access to quieter spaces and contained outdoor spaces that are safe for students at both the satellite provision and the partner school (Department for Children, Schools and Families, 2008). Participants spoke of the benefits of having multiple outdoor spaces, such as a playground shared with the partner school that gives opportunities for social interaction with peers, in addition to a separate playground specifically for satellite provision students.

Co-location and satellite provision may give the option for dual placement arrangements, where students from the special education school can access different facilities or learning areas at the mainstream or partner school that may not be able to be offered at the special education school (Fletcher-Campbell & Kingston, 2001). There are also possibilities for 'reverse inclusion', where students from the mainstream or partner school access resources within the special education school or satellite provision (Greville, 2009; Planning & Building Unit, 2012).

Dual placement options can be a lot more manageable for students with special education needs or disabilities due to the shared site, as the environment is familiar, and there is always the possibility of returning easily to the special education school or satellite class if they feel overwhelmed or uncomfortable (National College for School Leadership).



Appendix B

Furniture, fittings and equipment (FF&E) considerations

Chairs

Chairs should be comfortable, ergonomically designed, lightweight, durable and easily moved. One study found that 96% of students in the three New Zealand secondary schools studied were seated in furniture that was not suitable for their size (Legg, Pajo, Sullman, & Marfell-Jones, 2003). If chairs are too high, students cannot rest their feet on the floor, which creates pressure on the back of the thighs (Kane et al., 2006), and affects blood circulation (BRANZ Ltd, 2007e).

A number of studies deal with ergonomic topics such as the mismatch between student size and chair size (for a summary, see Legg, 2007; Trevelyan & Legg, 2006), which can be a contributing factor to musculoskeletal disorders and lower back pain (Trevelyan & Legg, 2006). Rather than chairs being suited to different overall heights, the literature suggests that chairs should be fitted to students' popliteal height (Knight & Noyes, 1999). Popliteal height is the height from the underside of the thigh at the knees to the underside of the foot. This is suggested as the more appropriate measurement to use because popliteal height can vary considerably, even among students of the same overall height (Molenbroek, Kroon-Ramaekers, & Snijders, 2003).

The three main options to overcome this are to provide a range of chair sizes to suit different sized students (Kane et al., 2006), to provide adjustable chairs (BRANZ Ltd, 2007e), or to provide footrests (Wadsworth, 2000). There are advantages and disadvantages to each of these options. It is also worth noting that non-adjustable, uniform height plastic chairs do not comply with any of these options and yet have the logistical advantages of being easily stackable and lightweight for being moved around the learning space (Watson, Wadsworth, Daniels, & Jones, 1996), as well as being more affordable.

In contrast, different sized chairs would possibly need to be stacked separately, meaning that the room may be less flexible in its configurations. The chairs could be coded so that students can select the correct height (Kane et al., 2006). Students in one study that used such a system reported higher levels of comfort, and teachers reported higher levels of on-task behaviour (Kane et al., 2006). The study did not discuss how chairs could be distributed so that students in each learning space could be assured of getting a chair that fitted them, given that there would not be the same number of students of each chair size in each class which uses a learning space.

There are compromises in flexibility if numerous chairs need to be provided in each learning space, and it seems likely to create further challenges if students cannot be guaranteed the correct size seat. This would be more challenging in a secondary setting, where students move more frequently from one learning space to another. In a primary setting, students could be assigned a chair which they move within the learning space from one activity to another.

The most common adjustable chairs have either a gas lift or screw thread to raise and lower height. Gas lifts can be problematic for primary aged students, as they may not be heavy enough to activate the lift (Wadsworth, 2000). Screwthread adjustable chairs overcome this problem, but take longer to adjust (Wadsworth, 2000). Having chairs that can swivel helps to overcome the issue of students having to strain to see the teacher or other students from different places in the learning space (Henshaw et al., 2011). These chairs can be combined with castors to be both mobile and easily adjusted (Stewart, 2010).

Adjustable chairs may be preferable to chairs of different sizes, as they can be adjusted to fit different learning activities on different surfaces, such as ensuring the correct line of sight for students using laptops or desktops (Wadsworth, 2000). Ideally, chairs for use with laptops or desktops should have adjustable backs, so that line of sight is at the appropriate angle as well as the appropriate height (Watson et al., 1996). A study of an intervention with students switching to adjustable chairs and desks found better posture, less back pain, and a possible positive effect on student achievement outcomes (Koskelo, Vuorikari, & Hänninen, 2007).

The benefits of adjustable chairs are only attained when the chairs are adjusted correctly to each user, and there is some evidence that this does not always occur, even when users have received training (Kane et al., 2006).

The third option is to provide footrests when students cannot touch the floor with their feet (Watson et al., 1996). Foot rests are easy to store and transport, but users must be trained in how and when to use them, and students can be resistant to their use (Wadsworth, 2000). It is important that chairs are available to suit each working height, such as stools for standing height desks (Watson et al., 1996).

Because students will be unable to rest their feet on the ground when sitting on a stool, consideration should be given to using stools with either a built-in footrest, or supplying a separate footrest (Wadsworth, 2000). In addition to the height of chairs, seats can cause discomfort by being too shallow, with a New Zealand study finding that 48% of the seats tested were too shallow for their secondary-aged users (Legg et al., 2003). Seats should be deep enough to support the thigh, but with a gap at the back of the knees (BRANZ Ltd, 2007e). A rounded or 'waterfall' edge rather than a right angle seat edge minimises pressure on the back of the legs where legs meet the seat (Cornell, 2002; Wadsworth, 2000).

A study considered the different postures assumed by students during the course of a school period, and found that fixed shell chairs (with a fixed seat and back) do not support all student posture requirements (Murphy, Buckle, & Stubbs, 2004), which can lead to increased fidgeting and movement as students try to alleviate discomfort (Breithecker, 2005). This can be overcome by having chairs with a pivoting shell that tilts forward as students lean forward to write on their desks, and tilts back as students lean backwards. However, chairs that 'recline' in a single shell have the effect of lifting the front of the seat, effectively lifting the height of the chair (Kane et al., 2006). Chairs with separate adjustable backs and seats can overcome this issue, but it is important that the chair backs are robust enough to accommodate larger students (Cornell, 2002). Seats that tilt back to accommodate student movement are thought to decrease behaviours such as rocking back on the chair, which is generally perceived as disruptive, and can cause accidents and damage furniture over time (Breithecker, 2005).

Some research indicates that students are not able to focus on learning for longer periods of time if chairs are not cushioned (Bullock & Foster-Harrison, 1997), although cushioned chairs are harder to clean and maintain (Wadsworth, 2000). The use of cushioned chairs and other soft furnishings should be considered in association with the acoustics of the room in which they will be used (BRANZ Ltd, 2007a), as soft furnishings will have the effect of dampening reverberation within the learning space. This has implications for IAQ, as soft furnishing can attract dust, which lowers air quality (Smedje & Norback, 2001), and cushions and other soft furnishings made with synthetic foams may release volatile organic compounds, which also affect IAQ.

Desks, tables and workstations

Many similar considerations apply to desks and tables as apply to chairs. To maximise flexibility tables and desks should be mobile and lightweight, and to maximise student comfort they should be of an appropriate height and size for the student and the learning activity. Consideration should also be given to accommodating students in wheelchairs or with standing frames. The literature suggests that desks and tables be on castors if they will be reconfigured frequently (LS3P Research, 2012).

Appropriate desk or table height must be determined in association with the chair with which the desk or table will be used, with a minimum clearance of 20mm between the top of the students' thighs and the underside of the desk or table (BRANZ Ltd, 2007e). If chairs are adjustable, then they should be matched with adjustable desks or tables (Breithecker, 2005).

It is important to consider that if desks and tables are to be adjusted to the height of individual students, then there are implications for desks or tables intended for use by more than one person. Adjustable tables are unlikely to be able to be adjusted to suit all students in a group (Wadsworth, 2000), while adjustable single desks configured into a cluster arrangement may cause difficulties depending on the collaboration required. A cluster of desks of different heights would not impact upon a discussion exercise, but would cause difficulties for students attempting to share resources or work on a collaborative practical activity (Wadsworth, 2000; Watson et al., 1998).

Different height adjustable tables will have different ranges within which they can be varied. If the room will be used for activities that require standing, such as art, science or technology, then it may be worth considering tables that can be raised high enough for students to use them while standing (Breithecker, 2005). The correct height will depend on the activity because some standing activities require downwards pressure, such as sanding wood or manipulating clay (Wadsworth, 2000).

If desks are to be reconfigured easily and flexibly, then they should be geometrically shaped (such as trapezoids) to be able to easily fit into a variety of groupings (LS3P Research, 2012). They should also be sufficiently durable to sustain frequent moves and frequent contact with other desks or tables. This has a particular impact on the edge of the desk or table (Watson et al., 1998). Heat and water resistant surfaces are important for some activities, but could be considered for all desks and tables to maximise flexibility of use (Watson et al., 1998).

There are additional considerations for desks and tables that will be used as workstations for laptops. The practice of 'daisy chaining' involves the connecting of desks or tables to one another to allow services to be run through built-in trunking. This gives flexibility for routing services to different parts of the room, but cuts down on the ability to reconfigure desks for a short time period (Wadsworth, 2000). Built-in trunking can also have the advantage of lessening trip hazards if cabling would otherwise run across the floor (Wadsworth, 2000).

Research suggests that ergonomically suitable workstations and computers lead to higher levels of comfort and increased task performance (Laeser, 1997). An adjustable keyboard support for desktops will mean that students do not need to bend their wrists while typing (BRANZ Ltd, 2007e; Wadsworth, 2000), however this is not possible for laptops, which usually have the screen fixed to the keyboard. The user is able to adjust the viewing angle of the laptop screen, but cannot position the keyboard independently unless external equipment is used. This can mean that if the screen is at the right height and angle, the keyboard is too high for a user to type without bending their wrists (Harris & Straker, 2000). It is ergonomically better to place the laptop on a lower surface, or in the user's lap, so that the wrists can be kept straight while typing (Kennedy, 2010). The screen should then be tilted to minimise neck flexion (see Harris & Straker, 2000, for a discussion of recommended angles).

A large-scale New Zealand study found low usage rates of furniture purpose-built for computer usage, with usage of adjustable computer desks and foot supports particularly low (Lai, 2000). This study is mentioned as no large scale New Zealand studies on this topic have been published since this time; however it is important to note that the situation may have changed since the study was conducted.

Plants

Some suggested benefits of indoor plants are related to basic features of flexible learning spaces, including increasing IAQ by reducing volatile organic compounds in the environment, improving ventilation by absorbing carbon dioxide, or even improving acoustics through buffering. However, other benefits cited are more psychological, such as plants being calming or aesthetically pleasing. One study listed indoor plants as one of the ten top ways to increase student achievement with a minimal financial investment (Cash & Twiford, 2009), and a study of workplaces found that a single plant increased productivity over approximately 10 square metres (Jensen, 2003). There is a comparatively larger body of research on the effect of plants in the workplace (see Burchett, Torpy, Brennan, & Craig, 2010, for a brief review) than in educational settings.

There are a small number of studies on the effect of plants on tertiary students, which have found such effects as increased performance (Shibata & Suzuki, 2004), and lower stress levels (Lohr, Pearson-Mims, & Goodwin, 1996). Another study of tertiary students did not find an increase in achievement, but found that students in learning spaces with plants reported higher levels of satisfaction with their lecturer, and rated their lecturer as being more organised and enthusiastic than students in spaces without plants (Doxey, Waliezek & Zajicek, 2009). This may mean that increased student wellbeing causes students to have more positive perceptions of the teacher, or that the presence of plants increases teacher wellbeing and satisfaction, leading to them teaching more effectively.

A small-scale Taiwanese study found that students in the experimental learning space, which had six plants placed at the back of the room, had lower levels of absence due to sickness, fewer disciplinary incidents, and higher (although not statistically significant) levels of achievement (Han, 2009), and a Norwegian study found a decrease in sickness-related absences (Fjeld, 2002).

One recent study found an increase in student achievement when a 'green wall' was installed in a classroom (Al-Bustami, 2014). The study found that IAQ, carbon dioxide levels and temperature improved, but concluded that the changes were not sufficiently large to account for the increase in student achievement. Based on survey data from students, the study concluded that the increase was partially attributable to the plants' positive effect on student wellbeing and comfort.

A larger Australian study found increases in student achievement for students in the learning spaces with plants at two of the three participating schools (Daly, Burchett, & Torpy, 2010). The researchers theorised that the third school did not show a difference in performance because students were already exposed to nature through the school's active gardening programme (Daly et al., 2010). This suggests that the positive influence of indoor plants may be negated if students already attend a school where they can access positive outdoor spaces, which are themselves a predictor of achievement (Tanner, 2000).

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