

Research into the connection between built learning spaces and student outcomes

Literature review

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Foreword

The Department of Education and Early Childhood Development recognises that school design can influence both innovative teaching practices and student outcomes. In recent years, through state investment and the Commonwealth's Building the Education Revolution (BER), many government schools in Victoria have been rebuilt or refurbished. As well, we have seen the development of the Ultranet as a virtual learning space for Victorian government schools, and the spread of ICT devices.

We need to ensure that strong evidence is gathered to ascertain links with these inputs and student learning outcomes. However, both in Australia and internationally, there appears to have been little research with this specific focus.

This literature review was commissioned by the Department to identify the current state of research into the connections between learning spaces in schools and student learning outcomes. It systematically reviews recent local and international literature, and presents a conceptual framework of four temporal phases (design, transition and implementation, consolidation, and sustainability/re-evaluation) to map current research in relation to practitioners, learners and spaces.

The review reveals gaps in the literature, in that most research on learning spaces focuses on the design phase, rather than on the later phases or on the people that use the space – practitioners and learners.

The Department has recently conducted research in schools as part of the OECD Centre for Educational Research and Innovation (CERI) project on Innovative Learning Environments (ILE). The Department is also participating in the OECD Centre for Effective Learning Environments (CELE) research, investigating the planning and design of educational facilities.

I hope this review will encourage deeper thinking about how spaces are designed and used for learning, as well as inform the Department's ongoing research and evaluation program on learning spaces.



Chris Wardlaw

Deputy Secretary

Office for Policy, Research and Innovation

Executive summary

This literature review asked the question of the current literature on built environments: *To what extent does the literature show connections between learning spaces and student learning outcomes in schools?* The report presents information on:

- theoretical and empirical connections made between learning spaces and student learning outcomes;
- gaps in extant research; and
- emergent themes.

A critical desktop review identified over 700 primary documents from a wide range of sources including peer-reviewed periodicals, magazines, reports (governmental, non-governmental and advocate groups), books, conference proceedings, national newspapers, dissertations and websites.

Built environment was understood to include both external and internal spaces, shared community facilities and landscapes as well as associated technologies. Learning outcomes broadly include the social, affective, physical and cognitive changes in students.

Learning outcome indicators covered:

- attainment as measured by standardised test scores;
- pedagogical effects as indicated by improved engagement in learning;
- perceptions of improved quality of student/teacher, teacher/ teacher and student interactions;
- evidence of increased student interpersonal competencies, engagement and team work;
- individuals' perceptions of belonging and inclusion, self esteem and self confidence;
- wellbeing in terms of physical comfort, health, and sense of safety; and
- behavioural indicators related to engagement, retention, vandalism, absenteeism, suspensions, expulsions, disciplinary incidents, violence, disruption in class, lateness, racial incidents, and smoking.

Claims in the literature about the possible effects of various aspects of learning spaces on student learning are often not substantiated empirically. The review is therefore as much about what is missing from the research as it is about synthesising evidence to support connections between learning spaces and student outcomes.

This report is organised around a conceptual framework that was developed from an analysis of the literature. The framework identifies four temporalities in the research addressing connections between learning spaces, teacher practice and student learning. These temporalities are the:

- design phase;
- implementation and transition phase;
- consolidation phase; and
- sustainability/re-evaluation phase.

However, the review identified very little empirical evidence associating any of the above phases with specific regard to student learning outcomes. Much of the literature focuses on the quality of conditions, perceptions or tangibles rather than educational practices or intangibles in terms of how space is perceived, used, and with what effect. The research literature is concentrated in the design phase. While informed by both contemporary architectural and educational research as to what is best design and best practice, there is little empirical research that considers what happens once in the space. Little attention is paid to the following areas, which provide a basis for research questions to guide future work:

- the processes and preparation required to transition into new spaces ;
- the types of practices that emerge in new spaces (e.g. groups, teaming, social interactions) and how these may change over time;
- the organisational cultures and leadership that facilitate or impede innovative pedagogies in new spaces;
- the relationships between, and significance for learning in particular spaces;
- the relationships between indoor and outdoor spaces and flows, and their role in all potential learning activities;
- how design of furniture or outdoor space relates to pedagogies and learning; and
- relationships between virtual and built environments.



Background and context

The focus on better understanding the connections between built learning environments and student learning outcomes has emerged out of a concern as to whether the pedagogies, curriculum, assessment and organisational forms necessary to develop the capacities in students for the 21st century require particular built environments and usage. Issues of environmental sustainability, the integration of Information and Communication Technologies (ICT) to enhance learning, industry and university partnerships, educational inequality and neighbourhood regeneration are still being explored. In addition, the restructuring of school organisation and governance to broaden curriculum provision and provide integrated services provide the foreground to how built and natural environments relate to communities, teaching, student engagement and learning outcomes.

The key question or focus of this review is: *To what extent does the literature show connections between learning spaces and student learning outcomes in schools?*

Review methodology

This literature review identifies:

- theoretical and empirical connections made between learning spaces and student learning outcomes;
- gaps in extant research; and
- future research trajectories, theoretically and methodologically.

A critical desktop review identified over 700 primary documents from a wide range of sources including peer-reviewed periodicals, magazines, reports (governmental, non-governmental and advocate groups), books (both printed and in digital formats), conference proceedings, national newspapers, dissertations and websites.

In this style of a 'best evidence synthesis' (Alton-Lee, 2002), quantitative and qualitative studies are included as are case studies that identify further research. Whereas quantitative studies tend to focus on direct links between outcomes and learning spaces, qualitative research provides greater understanding as to how this has occurred and why. The search was initially broad as learning outcomes were often a passing reference rather than the focus of a particular study. What counted as evidence of impact on learning outcomes was sometimes unreliable and often not systematically evaluated or analysed.

The research approaches used were varied and overall their quality was variable. To gain greater breadth, searches were based on different criteria (significance/quality of journal, case study/quantitative study). These were mapped onto the conceptual framework outlined in Table 1. This framework became the organiser for this literature review.

Table 1: Conceptual framework for literature review

	Practitioners		Learners		Spaces	
Design phase	Consultation in design	26	Personalised needs	74	Principles and philosophical aspects of design (includes physical environment and influences on well-being)	312
	1st generation users	6	Voice through consultation	50	Specialist use of space	135
	Preparation for pedagogical change	30	Access/availability to resources	44	Contemporary approaches and trends within education broadly	97
	Availability of resources	14	Social Achievement	60 101	Policy Infrastructure Furniture Time	77 35 52 13
Implementation and Transition Phase	Orientation to space	44	Needs of different learners	41	Governance	7
	Rethinking practices for teaching	50	Gendered spaces	9	Community-shared spaces	9
	Professional learning	22	Reorienting/ positioning as learner within space	34	Access	5
	Adoption of space Challenges of space	42 38	Privacy and safety	18	Security	19
Consolidation Phase	Changes in pedagogy	41	Engagement in learning	57	Management	7
	Responses to space	35	Quality in learning experiences	33	Maintenance	6
	Collaborative planning and teaching	33	Collaborative learning experiences	42	Flexibility	9
	Enacted curriculum	20	Personalised learning	26	Fitness of purpose	12
	Privacy and ethics	19				
Sustainability/ Re-evaluation phase	Creativity and learning design	5	Creativity and problem-solving	7	Possibilities of redesign	10
					Virtual within the virtual	4
					Innovations	7
					Sustainability	16

A graphical representation of the patterns of the research literature in the above table (see Appendix 1) demonstrates the following:

- The focus of research has been in the design phase, not the implementation and transition phase, with little research on the sustainability/re-evaluation phase.
- In the implementation and transition phase, the research literature focused on practitioners and not students or spaces. This moved to a focus on learners in the consolidation phase.

A wide range of data sources were searched using various combinations of keywords (see Appendix 2). The review targeted the most recent literature (2000-2010) that made some reference to learning spaces and outcomes, relying on recent systematic reviews for the period pre-2000 where possible, and including frequently cited key references in the bibliography. The annotated bibliography is available on line at: <http://www.education.vic.gov.au/researchinnovation/default.htm>.

Theoretical position

This literature review is premised upon the perspective that space (natural and built environments) 'shapes' social relations and practices (Lefebvre, 1991; Massey, 1994). Social practices, formal instruction and informal social interactions change the nature, use and experience of space. Learning spaces mediate the relationship and social practices of teaching and learning, and are only one factor among many in the complex relationships of teaching that inform learning outcomes (Oblinger, 2006). There is not a linear relationship between learning spaces, their use, and student learning outcomes, although this is depicted as such in much of the literature as exemplified in Lackney (1993, see Appendix 3A). But while learning spaces do produce conditions and mediate relationships that can improve student learning along a range of indicators (physical and mental wellbeing, as well as cognitive), relationships can be made more complex by the blurring of real and virtual space, as indicated in the diagram in Appendix 3B.

There is also a temporal dimension to the production, use and effect of learning spaces. Education systems have spatial and temporal orders (Nespor, 2004). Changes in the use of physical spaces are often related pedagogically and organisationally to changes in schedule organisation and space use. For example, personalised learning, individual pathway planning, team teaching, inquiry approaches, teamwork, problem solving, rich tasks and community based service learning, as well as organising multipurpose, open and flexible spaces, often require longer instructional time 'blocks' than teacher-centred transmission pedagogies (Arnot & Reay, 2007). Temporality is a key factor in how organisations, teachers and students respond to new learning spaces over time (Bruckner, 1997). Organisational and pedagogical change takes time, and education has long and short-term effects on students and their learning (Paechter, 2004). Therefore, we consider school environments to include not only social, cultural, temporal and physical aspects, but also built and natural, as well as real and virtual environments (McGregor, 2004).

Learning outcomes

Difficulties arise in particular around learning spaces and built environments in determining the factors that actually contribute to student learning. Physical wellbeing, affective, cognitive, and behavioural characteristics of individuals are pre-conditions that can impede or enhance learning. They are also desirable learning outcomes. Built environment is one factor of many impacting on student learning outcomes. Hattie's (2009) meta analysis of school effect sizes indicates that after family and socio-economic status (SES) background, teacher-student interactions are the greatest predictor of learning outcomes in standardised tests, with peer influences, prior learning, and social mix having some influence particularly in the adolescent and post-compulsory years (Woolley & Grogan-Taylor, 2005, cited in Bowen, 2008; Alton-Lee, 2002; Bowen et al., 2008). School leadership indirectly contributes by providing conditions conducive to learning including resources and teacher professional development (Mulford, 2005). Yet school effect, improvement and effectiveness studies often neglect built environment, location, context and school profile as well as relying on limited measures of outcomes.

Increasingly evidence indicates learning is affected if students are disengaged, alienated, absent or feel excluded. Disengagement results from multiple factors, many out of a school's control. These include familial violence, poor health and wellbeing, discrimination or bullying (Blackmore & Kamp, 2008; Bandura, 1997). Parental involvement in students' learning is also seen to impact on student learning, particularly early literacy (Bowen et al., 2008). Coinciding with managing new built environments, teachers and principals manage multiple curriculum and assessment reforms that are intended to focus on student learning, but that can have contradictory demands on time and space. Poorly designed and maintained schools, often found in areas of lowest educational achievement, can also have a detrimental impact on teacher and student morale and engagement, and impact negatively on aggregate student outcomes (Filardo, 2008). Collectively, these factors impact on teachers' work, attitudes and behaviours, and in turn have flow on effects on student learning (see Appendix 3B).

Learning outcome indicators are dealt with variously throughout the literature as:

- attainment as measured by standardised test scores (e.g. Iowa Basic Skills Tests, PISA) and teacher observations;
- pedagogical effects as indicated by improved engagement in learning (proxies such as time on task, self-management);
- social in terms of perceptions of improved quality of student/teacher, teacher/teacher and student interactions, and evidence of increased levels of student interpersonal competencies, engagement and team work;
- affective as indicated by individual's perceptions as to a sense of belonging and inclusion, self esteem and self confidence;
- wellbeing in terms of physical comfort, health, and sense of safety; and

- behavioural changes related to engagement, retention, vandalism, absenteeism, suspensions, expulsions, disciplinary incidents, violence, disruption in class, lateness, racial incidents, and smoking.

The connection between learning outcomes and built environment and use of learning spaces is thus mediated by tangibles (e.g. quality of air, light, spatial density) and intangibles (school and classroom culture, sense of belonging and self-efficacy) as well as teacher-student relationships among other mediating variables.

Sources

The extant research focuses on the tangibles connecting learning spaces and outcomes rather than the intangibles, or how teachers and students respond to and use space pedagogically in ways that improve learning.

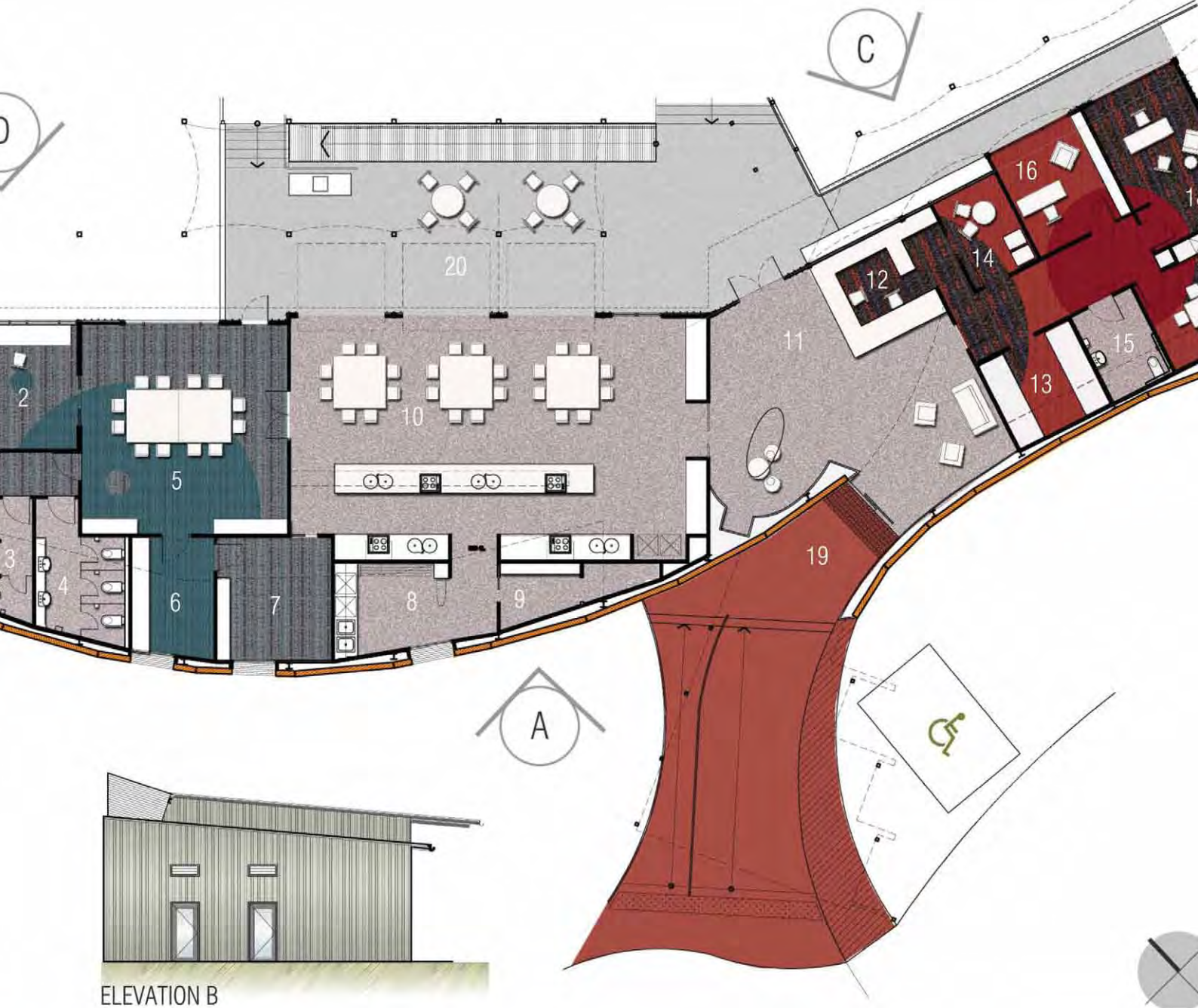
The literature on learning spaces was primarily from the United States of America (US) and the United Kingdom (UK), as well as Australia. US research tended to be quantitative research that sought direct causal links, but the sample sizes varied as did levels of correlation. European, UK and Australian research, while qualitative, indicated the complexity of indirect links between learning spaces and outcomes, but provided a greater depth of understanding about what happens in learning spaces (Fisher, 2002).

The learning spaces literature drew from the fields of sociology, environmental studies, psychology, health, architecture and design, and within-field specialisms—educational philosophy, curriculum and learning theory (including brain science), occupational health, health and wellbeing, indoor and furniture design, landscaping, ergonomics, environmental psychology and environmental sustainability.

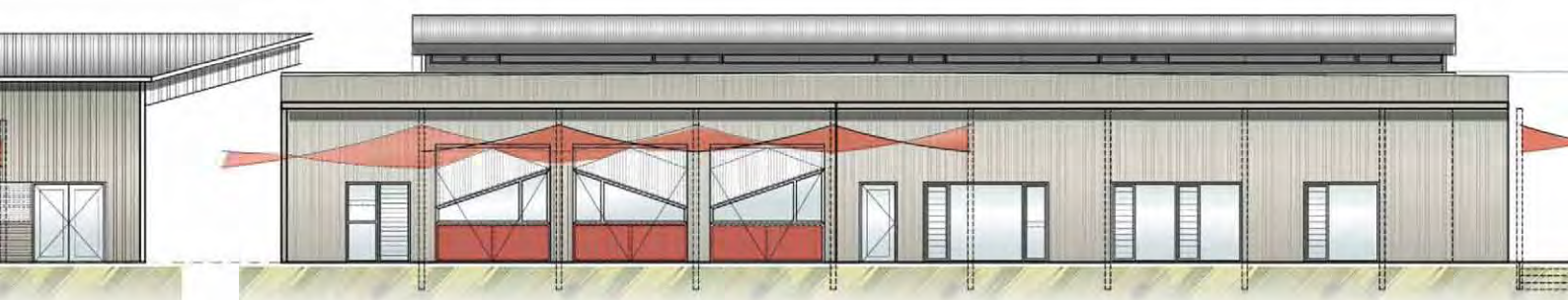
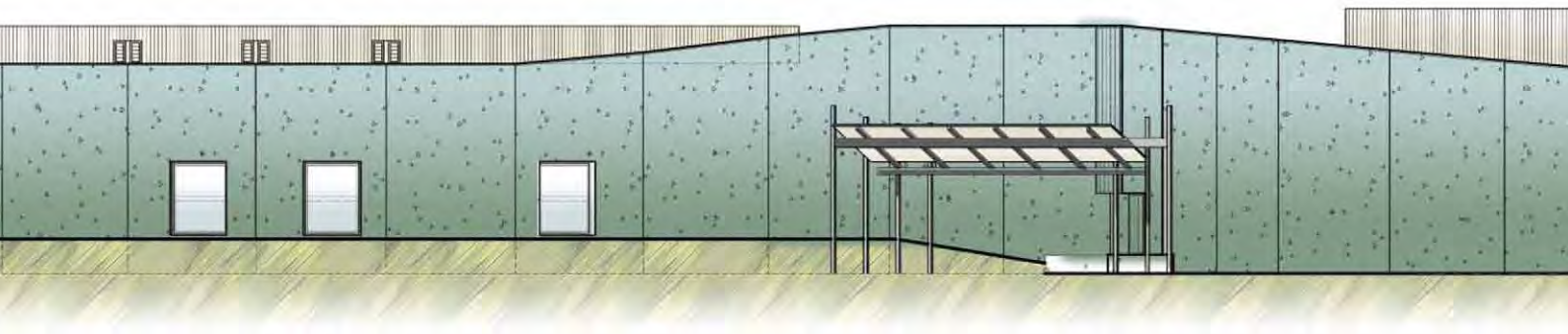
Findings

Overall, there are many sweeping claims about the possible effects of various aspects of learning spaces on student learning that are not substantiated empirically (Tanner, 2000). In many articles, the methods used to gather data are unclear. Specific instruments tend to measure student and teacher responses to learning spaces rather than academic outcomes. This review, therefore, is as much about what is missing from the research as it is about evidence to support connections between learning spaces and student outcomes.

The conceptual framework (Table 1) indicates four overlapping temporal phases with respect to learning spaces: design, transition and implementation, consolidation and re-evaluation/sustainability. Table 1 and the graph in Appendix 1 also indicate the uneven distribution of the research literature. The coding indicates that most research literature is located in the design phase, a little on transitioning into new spaces, more on consolidation; and little on issues of re-evaluation/sustainability. There is little empirical evidence associating any phase with specific regard to student learning outcomes. Much of the literature focuses on the quality of conditions or perceptions and not educational practices or how space is used and to what effect.



ELEVATION B



ELEVATION D

Design phase

The design phase indicates a focus upon sound architectural principles and/or contemporary educational philosophies and principles that have been taken as best practice from other fields of research (e.g. learning theory, identity theory, and environmental sustainability). From this, design principles have been developed as exemplars of the redesign process. Particular elements of design are linked to desirable student outcomes and teacher pedagogies, leading to claims that some spaces can be more conducive to intellectual, physical and emotional wellbeing, and therefore have flow on effects to student learning.

Design principles

Three assumptions underpin the design principles:

- educational objectives and practices have fundamentally changed from the teacher-centred 20th century factory model. Therefore, learning spaces must address the educational needs of learners in the 21st century (Chism, 2006; Fisher, 2002; Temple, 2007). The relationship between space and identity formation is embedded historically in environmental psychology principles (e.g. Good & Adams, 2008; Carter, 2006; Ferrer-Wreder et al., 2008), and more recently around issues about notions of personalisation.
- design principles are open to re-interpretation according to the cultural context of the school. Typical school buildings and classroom layouts symbolise culturally specific understandings and philosophies of education, as well as resource distribution (Bateman, 2009). An example is the Reggio Emilia notion of the physical environment as 'the third teacher' (New, 2007; Rinaldi, 2006).
- changing learning spaces based on the above principles is likely to have subsequent effects in influencing teacher pedagogies and student learning (Oblinger, 2006; Sanoff, 1995; DEECD, 2009; Flutter, 2006). That is, building design has flow on effects on teacher and student behaviours, morale and practices, and therefore learning outcomes.

These assumptions are largely anticipated rather than empirically justified claims.

The focus of the design phase literature is on built environment and space oriented to perceived student needs, as reflected in the following outline:

The design of individual spaces within an educational building needs to be:

- flexible to accommodate current and evolving pedagogies;
- future proofed to enable space to be re-allocated and reconfigured;
- looking beyond tried and tested technologies and pedagogies;
- creative to energise and inspire learners and tutors;
- supportive to develop the potential of all learners; and
- enterprising to make each space capable of supporting different purposes.

(JISC, 2006: 3)

A more focused and learner centred approach to the design of facilities includes:

- designing learning spaces around people;
- supporting multiple types of learning activities;
- enabling connections, inside and out;
- accommodating information technology;
- comfort, safety and functionality; and
- reflection of institutional values.

(Oblinger, 2005)

Seven guiding principles to augment rather than replace existing design principles are:

- design space for multiple use concurrently and consecutively;
- design to maximise the inherent flexibility within each space;
- design to make use of the vertical dimension of facilities;
- design to integrate previously discrete campus functions;
- design features and functions to maximise teacher and student control;
- design to maximise the alignment of different curricular activities; and
- design to maximise student access to and use/ownership of the learning environment.

(Jamieson et al., 2000: 6-7)

The dominant theme is that learning spaces need to be flexible, pedagogically and physically, in ways that reflect the nuances of different knowledge areas and specialisms (e.g. Butin, 2000). Much of the literature on furniture design and classroom settings focuses on ideal patterns and designs characterised by flexibility and mobility of structures, the grouping of desks, computer pods and display boards in order to facilitate multimodal pedagogies that accommodate individual learner's needs, and personalisation of space. Multiple exemplars exist as to ideal classroom settings (Fisher, 2005) and enacted designs (DEECD, 2009; JISC, 2006; Bateman, in press), but with little evidence as to their impact on learning.

Elements of design and student outcomes

Across the design literature, there is emerging an interest in the specific aspects of design that may impact on teacher practice and student learning outcomes. These claims can be organised into a number of key themes, which are outlined below.

Environmental impacts

Temple (2007) and Higgins et al. (2005) refer to a number of sources that describe the ways in which specific environmental conditions impact upon student learning. The environmental conditions described are factors such as noise, temperature, air quality, ventilation and lighting (Keep, 2002; Higgins et al., 2005; Lackney & Jacobs, 2004; Earthman, 2004; Sundstrom, 1987; McNamara & Waugh, 1993; Weinstein, 1979). Generally, these conditions are considered as basic yet optimal conditions in which students are best able to perform. However, there is much debate over the relative significance of specific elements such as air quality, colour, aesthetics and furniture. Colour and physical presentation of space are highly contested elements (Sundstrom, 1987; Temple, 2007; Higgins et al., 2005). Good (2008) and Rinaldi (2003) argue that aesthetics, access to resources and opportunities can work in different ways to accentuate student learning outcomes, differing from Fisher (2005; 2002) and JISC (2006). The issue of additional resources that may enhance learning spaces is not addressed. Furniture, plants, presentation devices and audio systems are resources often not factored into costs. While arguably part of design, there is no evidence to indicate whether the effect is more on comfort than learning (Heluish, 2009; Lomas, 2005; Nair, 2005). By increasing comfort for students and teachers, it is assumed that teachers and students will be able to ‘concentrate on the task at hand’ (Bateman, in press).

A large proportion of the design literature in early years and primary (e.g. Bullard, 2010) is based on design possibilities in higher education with regard to ICT and flexibility. Simon et al. (2007) conclude that much research linking school building quality to child development suffers from conceptual and methodological problems because it ignores both the quality of old and new buildings and children’s responses to new buildings. There is little research on specific design requirements for age cohorts.

Design process

An emergent theme is the significance of the design process (Jamieson et al., 2000; Morgan, 2000; Radcliffe, 2008; Higgins et al., 2005; Fisher, 2005). Traditionally, learning spaces have been designed by architects and interior designers – not teacher-practitioners. They generally mirror contemporary architectural rather than educational imaginaries, often leading to the reproduction of the industrial model of classrooms. Some notable exceptions to this are Reggio Emilia, Montessori and Dewey, where the designs are derived from particular educational philosophies (Jamieson et al., 2000; Abbasi, 2009; Ceppi & Zini, 1998).

More recent design literature suggests that a participatory or ‘generative design’ process will improve teacher practices and in turn will benefit students’ learning experiences (Temple, 2007; Higgins et al., 2005; DEECD, 2008; Fisher, 2002). The trend of both the architectural and educational literature is towards user-friendly spaces and personalised learning (Chism, 2005). Design takes up the insider, practitioner, student or pedagogical perspective as they are ‘able to articulate a distinctive vision for their school and then work with designers and architects to create integrated solutions’ (Higgins et al., 2005, p. 3; Fisher, 2002; Morgan, 2000; JISC, 2007).

This trend towards participatory decision-making is mirrored in the research literature on school improvement with closer attention being paid to listening to teachers and students (Thomson, 2009). The input of teachers in design is said to be critical (Temple, 2007; Higgins et al., 2005; Sanoff, 1995) because staff morale (Higgins et al., 2005) and teacher attitudes and behaviours affect the use of space and learning outcomes. Their lack of involvement could lead to a negative orientation to new spaces (Temple, 2007; Fisher, 2002; Wolff, 2008). Participation in the design process and investment in their environment, Loi (2006) argues, indicates to teachers they are valued. Moreover, the prospect of a new environment heightened through participation will motivate teachers (Morgan, 2000; Oblinger, 2005; Temple, 2007). In providing a flexible facility, it is anticipated that teachers will increase and refine their repertoire of teaching strategies (Radcliffe et al., 2008).

Anticipated effects and design processes

Much of the design phase literature is aspirational: that is, it assumes or anticipates changes in teaching and learning will occur as a result of learning space design. There is limited empirical evidence provided to support claims connecting the design process to learning outcomes.

Gaps in the design phase literature

The design phase literature, while informed by both sound architectural and educational principles:

- is dominated by philosophical positions without empirical evidence;
- indicates little recognition of the significance of context for each school;
- does not use primary sources about use and effect (student/teacher/parent/community interview or other data) that can be replicated; and
- fails to consider student perceptions of relationships between neighbourhood social disorganisation, safety, school buildings and neighbourhood culture (Bowen et al., 2008).



Implementation and transition phase

The focus in the implementation and transition phase is on transitioning into the new school buildings, organising services, resources and space, the nature of system supports, developing new organisational arrangements, and establishing rules and protocols of use. All of these in turn impact on, and are affected by, school cultures, teachers' work, and the pedagogical practices most likely to affect learning outcomes in the short term. Barrett and Zhang (2009) state:

Every effort should therefore be made in the design stage to create the ideal conditions for learning to take place. However, a variety of teachers with specific and very different groups of pupils will subsequently inhabit and inherit these spaces. Each teacher and each group of pupils is different, and teachers must develop the generalised environment for specific purposes and groups. When a new building is complete and is handed over to the teachers, the school can only be a 'finished beginning' in which adaptations will occur. Only when spaces are seen to support learning and create a positive experience, can we say it was designed successfully (p. 4).

Much of the literature assumes that students and staff move into 'finished buildings' rather than being phased into occupancy over months if not years, which is more often the norm, with building still ongoing on the site (Blackmore et al., 2010). There is little research on the immediate effects of occupancy on student learning other than a few US case studies. Buckley et al. (2003) indicate positive effects on aggregate student assessments once installed, except in a strictly regulated school environment where a highly regulatory school culture meant there was no improvement in outcomes.

The implementation and transition phase raises specific issues around security and access, temporary accommodation, changing perceptions, adaptation, managing transition, school size and learning communities, curriculum, organisational culture and space, and group work.

Security and access

Unfinished building sites produce unexpected (and un-costed) problems such as no power or water, lack of security, safety issues with builders on site, frequent movements of staff and students, transport costs between new and old sites, building faults, and furniture, etc. Emerging evidence suggests these impact on initial interactions between teachers and students and with communities in shared spaces such as libraries. Blackmore et al. (2007-10) identified teacher and community anxiety over shared facilities with regard to potentially fraught interactions between different age cohorts and the loss of community facilities as a local library was moved onto a school site. Shared spaces (e.g. sport facilities) can require relocation as they can be difficult to access. The process of design therefore extends into occupancy as space needs to become usable.

Temporary accommodation

While school systems see combinations of temporary and permanent buildings providing system-wide flexibility, permanent school buildings are linked positively to shaping community growth patterns, and in particular enrolments (Taylor, Vasu & Vasu, 1999). Chan (2009) found no significant impact on teacher perception, morale, job satisfaction, student achievement and behaviour with the use of portables. Negative correlations between health and safety and relocatable classrooms are no worse than with inadequate permanent buildings. Therefore, the issue is quality not permanence. Relocatable classrooms may impact more on community perceptions than student learning. Portables do raise management and resource issues, however, around implementation strategies, maintenance schedules, relocation and replacement plans.

Changing perceptions

A few US studies indicate that the location and appearance of schools, in addition to environmental sustainability, attract particular student cohorts as schools are central to wider patterns of spatial residential segregation and educational outcomes (Baker & Foote, 2006). Some evidence indicates new schools can attract and retain good teachers and a different social and academic mix of students that tends to benefit lower achievers most (Darling-Hammond, 2002).

Qualitative evidence from Flutter's (2006) projects indicates intangible effects. Students like a 'good working environment', resources and buildings that are 'inspiring' and 'exciting', with little noise or distracting behaviour. Many students with low expectations of schooling see it as an 'exchange relationship' in which schools have to offer something tangibly better in terms of relationships and environment (such as the quality of buildings) to indicate that they are valued (Flutter, 2006). Bullock (2007) found a positive relationship between new and renovated buildings and student academic achievement based on academic tests in Virginia. Similarly, a review of the Building Schools for the Future (BSF) program in England, that saw the creation and refurbishment of buildings in schools across the country, found that students in schools where the new buildings had been completed had a more positive attitude about their school environment and buildings than students in schools currently being built (PricewaterhouseCoopers, 2010).

Appearance of the school is important in terms of the negative or positive messages students receive about themselves. Students internalise any reflections on the buildings or school on themselves as they and their teachers identify with their school, its image and reputation. Evidence from Victorian research indicates that students see new uniforms as part of the 'make over' associated with new buildings as they gain a sense of pride (Blackmore, 2007-10). Likewise, parental and local community participation have positive but intangible outcomes as the physical environment of the school reflects the culture and aspirations of the community and indicates it is respected and valued (Flutter, 2006). Therefore, being in a new building in itself could be expected to have an immediate effect in terms of local perception and positive student responses. The UK BSF program was found to have a positive impact on school engagement with local communities. Eighty-four per cent of head teachers from schools within the program indicated that the new or refurbished buildings created during the program are enabling their schools to improve relationships with parents, and many also expected that the new buildings would positively engage the wider community in educational and cultural activities (PricewaterhouseCoopers, 2010).

Adaptation

There is a possible dissonance between how teachers and students anticipate and then experience these new spaces. Literature indicates teachers enjoy novel spaces, and are usually encouraged to experiment with student organisation (e.g. individual, groups, whole class) within specific types of physical spaces. Yet there is little recognition of the preparation required for teachers and students to effectively transition into using new learning spaces in terms of pedagogies, as well as setting realistic expectations and contingency planning. If teachers are not well prepared and given leeway for risk taking and failure, particularly if disruption is ongoing, they may revert to 'default pedagogies' or 'the way we used to do things' rather than explore innovative pedagogies (Thomson, 2009). Furthermore, some schools have both traditional and refurbished or new buildings, yet innovative curriculum and pedagogy is expected of teachers in traditional spaces as well as in the redesigned spaces. The issue remains as to how to use a non-ideal space for contemporary pedagogies (Montgomery, 2008). 'Design failures' where spaces just do not work as intended also need to be redesigned.

Managing transition

While there is some research on the benefits of participatory or generative design (Sanoff, 1995) premised upon sound architectural and educational principles in the design phase, there is little research on whether participation in decision making continues to inform processes and structures established to manage the transition into occupancy. According to the UK BSF report, most head teachers took on primary responsibility for managing the project in their school, with deputy and assistant head teachers the next most likely to take on the responsibility. Both groups were heavily involved in the project. Limited literature exists on teacher and student anxiety (Cotterell, 1984) or the type of preparation and strategies required for teachers and leaders as to pedagogical strategies suited to new spatial configurations.

Learning communities and school size

New learning spaces are often a consequence of school restructuring and closures that require new modes of governance (e.g. multi campus, senior/junior level, or K-12). There are few articles considering school organisation and governance. In the US, the trend is for new schools to be smaller than previously (particularly in the early years), or when schools are merged to increase curriculum provision at the senior level, towards 'schools within schools' models in order to develop distinctive learning communities. These communities are often spatially separated in different buildings, organisationally separated into houses with teams of teachers, or across different campuses (Darling-Hammond & Ancess, 2002). But smaller schools in themselves are not enough to have an effect on achievement. Other essential conditions appear to include proper resources in terms of staffing, capacity for personalised units such as mini-schools, redesigned school districts to reduce bureaucracy, greater autonomy for schools and planning time.

Shared resources, mergers or multi-campus formations require new governance arrangements. Darling-Hammond and Ancess (2002) found that smaller US schools improved aspects of achievement of low income and minority students (e.g. Coalition Campus Schools Project in New York). This was indicated by better attendance, lower incident rates, better performance on reading and writing assessments, higher graduation rates and higher college ongoing rates compared to the previous large school, despite serving largely socially disadvantaged students.

Organisationally, changes in class size become an issue in open learning spaces where multimodal approaches to pedagogy are required (e.g. small tutorials, individual learning, mass lectures etc.). Graue and Hatch et al. (2007) in the US found team teaching and class size were linked. A school had to change staffing patterns, programs and space allocation to reduce teacher student ratios to 1:15 or 2:30. Partner classes used tag-team teaching, with one teacher leading and other assisting, but without any professional development most teachers reverted to solo practice. Changing the organisation and structure of space and time does not necessarily lead to changed practices.

Curriculum, organisational culture and space

There is little research considering the relationship between facilities design, curriculum delivery and school ethos, with the exception of a study in a senior public school specialising in environmental studies (Gislason, 2009). The school was organised around 'houses' and teams of teachers who worked in shared open spaces. The 'culture' of the classroom or mini-school gave students a sense of belonging and ownership due to student-teacher interactions within the shared space and not having teacher oriented spaces in separate classrooms. Therefore students felt socially accepted and enjoyed school more than other high schools they had attended. The qualification is that this school was comprised of well-motivated students with good work habits and academic aspirations. This type of setting could be different with less motivated students as noise and traffic could distract them from their learning.

Gislason (2009) argues that school culture is the scaffold for practice (see also change theory literature in the review by Thomson (2009)). Overall, it was the alignment between interdisciplinary curriculum, team teaching and the design and use of learning spaces that then facilitated multimodal pedagogies: combinations of formal lectures, group work and individual work. An essential condition was block scheduling, which allowed for flexible use of space, extensive teacher collaboration and sequencing of instruction. Bruckner et al. (1997) indicate that teachers have to change their practice with block scheduling or they reduce their practices to lengthy lectures or multiple lessons strung together (default pedagogies). Often new spaces involve block scheduling, but this is not necessarily the case.

Collaboration and team teaching is, from the professional learning literature, likely to lead to improved student outcomes (e.g. Darling-Hammond, 2002), but only with significant teacher professional development and supportive school cultures. Collaboration is not without issues — loss of autonomy, tension over work allocation, greater communication and interdependence among teachers and responsibility to others (York-Barr, Ghore & Sommers, 2007). Overall, in York-Barr et al. (2007), the teachers felt that the advantages of team teaching outweighed the disadvantages. They cited inter-disciplinarity, opportunity to pool insights about individual student's learning and personal qualities gained from longer periods of contact as significant positive factors.

Group work

Group work is also not contingent on space and open space does not necessarily lead to group work. Blatchford et al.'s (2006) study in primary schools indicated that group work for 10-11 year olds led to more active and sustained engagement, more connectedness and more higher order inferential joint reasoning. Likewise class sizes of less than 25 were seen to facilitate activities that were task related and increased teacher-student interactions (Blatchford et al., 2005).

Overall, this review supports Higgins, Hall et al.'s (2005) conclusion:

The first thing that will strike you is the relative paucity of research on effective learning environments. Not only is the evidence incomplete, particularly in areas such as the systems and processes and communication approaches that schools need to underpin their physical environment, but the research that has been done seems to be largely predicated on a traditional view of 'chalk and talk' learning in standardised 'one size fits all' institutions (p. 47).

Gaps within the transition phase

Key findings evident from this review are that there is:

- little empirical research that considers how students and teachers as well as communities negotiate and create new relationships, organisational structures and processes in the use of new learning spaces (Jamieson et al., 2000; Barret & Zhang, 2009) i.e. creating decision making structures and processes for ongoing ownership of change;
- an inadequacy to address management of transition such as unexpected costs, dysfunctional spaces, mix of old/new/temporary buildings;
- a failure to explore the significant relationships between organisational planning, school culture and leadership, the use and meaning of learning spaces, and student academic outcomes (standardised test scores). The architectural and environmental psychology literature ignores empirical research from effective schools, school improvement, leadership and educational change (Burch & Theoharis, 2010) which indicate that culture, resources and leadership are critical conditions indirectly influencing student learning. At the same time, the effectiveness and school improvement literature ignores the built environment (see review by Thomson, 2009);
- no recognition of the importance stressed in critical pedagogy and effective schools literature of the need to prepare teachers through ongoing professional learning for use of new learning spaces; and
- little recognition of the affective (feelings/emotions) dimension. The literature equates the affective to feelings in response to the quality of physical conditions and not feelings about the need to change and find new ways of working (i.e. commitment). The literature ignores a significant body of change literature that refers to the need to address the affective dimensions of change, as well as teacher and student anxiety when undertaking fundamental changes in practice (Leithwood & Beatty, 2008; Cotterell, 1984).



Consolidation phase

Consolidation is what happens in practice as buildings are used by teachers and students for the purposes of teaching and learning. There is little research on what practices become institutionalised over time with regard to the use of space and time, and their impact on teaching and learning. Instead, a largely US-based set of quantitative controlled sampling studies focus on post-occupancy evaluations (POE) designed by the building industry and largely completed by architects, principals and head teachers. They take little account of the complexities of teaching and learning or the lived experience of living and working in these buildings. In these evaluations, students and teachers are at best ‘respondents’ (Comber, Nixon et al., 2006). The notion of ‘occupancies’ takes away ownership from the schools and their communities (compare DEECD, 2009).

The conceptual framework sought to move beyond teacher and student responses to identify practices or what is enacted in spaces for quality learning.

Teacher practice

Changes in pedagogy

As noted by Higgins, Hall et al. (2005):

The relationship between people and their environments must be complex, and therefore any outcomes from a change in setting are likely to be produced through an involved chain of events. It is the defining and understanding of these mediating chains that is the key (p. 35).

There are few studies that focus on pedagogical change and those that did were highly general using aggregated outcomes of the whole school. DEECD (2009) research on 162 schools, while having a strong ICT focus, outlines the ways in which these schools have used resources for time, space and ICT to change teacher practice. Lippincott (2009) found that while new — and newly renovated — classroom buildings, libraries, and computing labs were highlights of campus tours for prospective students, the buildings themselves did not result in changes to pedagogical practices or to student learning unless teachers and students were involved in their design. The few observational studies, — such as Sztejnberg and Finch (2006) — a multi-method study in which trainee teachers spatially mapped classrooms, merely confirmed that if traditional seating in rows dominates, so do teacher-centred approaches.

Collaborative planning and teaching

A considerable number of studies focus on increased collaboration when spaces and curriculum are specifically designed for collaborative teaching and learning, (Blatchford, Baines et al., 2006; Tolmie, Topping et al., 2010). Gislason (2009) found that physical design facilitated collaborative, multidisciplinary teaching practices and that the open-plan environment contributed to the creation of social capital. Thorne (2002), in examining schools in Western Australia, found that a wide variety of factors contributed to collaboration, including space. This study emphasised the key role principals take in leading their schools, and the necessity for multiple leaders (often senior teachers or other members of staff) to be fostered in schools undertaking significant curriculum and pedagogical change.

Ability to change space/flexibility

Often spaces need to change their usage over time and a good design initially enables this 'without burdening the taxpayer' (Locker & Olsnen, 2003; Locker, 2007). The requirements placed on a space may vary throughout the school day or year to year with changing demographics and student needs. Herman Miller Inc (2009) explored and found how space can be adapted to multiple functions in support of the learning experience, but no investigation was made as to whether improved satisfaction was connected to improved learning outcomes.

Students

The OECD (2005) argued that governments have a responsibility to invest in quality educational spaces because of the important role of quality spaces in increasing access and equity for all in education, improving educational effectiveness and promoting the acquisition of key competencies, as well as optimising building performance and operation. Little empirical research was cited in this OECD report.

Engagement in learning

Considerable evidence correlates poor conditions with negative outcomes on students and teachers (Price Waterhouse, 2003; Fisher, 2002; Filardo, 2008). Rudd, Reed et al. (2008) and PricewaterhouseCoopers (2010) found that student engagement increased in newer, well-designed buildings. Greene, Miller et al.'s (2004) research noted that student perceptions of classroom structures were important for their motivation, particularly if current class work was instrumental for future success. This included how the curriculum was reshaped in the new buildings. Of the few studies of outside school spaces, Black's (2007) studies of the city as a classroom reported a learning experience that makes education a public activity outside schools with a positive sense of engagement.

Quality learning

Collaborative learning experiences

There is a reasonable body of literature on the facilitation of collaboration through appropriately designed physical spaces. Numerous studies argue for the particular role of libraries in collaborative learning (Bridgland & Blanchard, 2001; Keating & Gabb, 2005; Folkestad & Banning, 2009). Wolff's (2002) systematic analysis of how physical environments support and encourage collaborative project-based learning found that it was extremely difficult to determine the essence of what was important in terms of the design; concluding that it was the interrelationship between the design elements that was significant. Dahey (1994) found that putting students into groups does not necessarily lead to co-operative learning unless there is a shared and common goal leading to positive interdependence, face to face interaction, individual responsibility, social skills and group processing with a clear pedagogical focus. For students in groups that meet the above conditions, Dahey (1994) cites Slavin's study that 63 per cent of those students in co-operative learning groups increased their achievement scores. This has implications for use of space in terms of class size, group size, space, personalisation, comfort, safety and classroom furniture.

Personalisation

Personalisation has various meanings. In the architectural paradigm, personalisation is about making a space feel like home, familiar, a place of one's own, a sense of ownership, implying safety and/or privacy as achieved through photographs, art, physical dividers etc. Much of the literature on personalisation focuses on non-educational workplaces rather than schools. Wells and Thele (2002) found that while psychological studies tend to suggest personalities that are creative have high need for affiliation and low need for privacy, this was not linked to personalisation of space. A person's status and type of workspace are more likely to impact on the level of personalisation.

Open staffrooms can raise issues of privacy, confidentiality and security for teachers. In the educational paradigm, personalisation is about developing good personal relationships with students; about social inclusion by recognising student diversity (gender, race, class, religion, ability); and addressing individual learning needs and preferences. A pedagogical repertoire based on personalisation ranges from individual computer-based instruction to basic skill acquisition through to individual learning plans, e-portfolios and mapping pathways (Jenkins & Keefe, 2001). Strategies of personalised learning include multimodal approaches to teaching and flexibility in classroom settings conducive to learner-centred and project-based interdisciplinary pedagogies. Some examples of this include individual computer assisted skills learning, learning-style-based instruction, self-paced learning, contract learning, guided practice through coaching, co-operative learning in small groups and project based or topic study.

In order to enhance this pedagogical repertoire, multiple activity centres are created to facilitate individual, group and whole-of-class and lecture-style learning. Personalisation is sometimes linked to small classes to facilitate teachers as coaches and advisers able to diagnose student learning characteristics, as well as to a school culture of collegiality, flexible scheduling and pacing (Jenkins & Keefe, 2001). Again, it is implied but not addressed that each strategy requires different types and use of space and time. There is some discussion around early childhood, personalisation and safety (Dahey, 1994). Killeen et al. (2003) examined how the permanent display of student artwork in educational spaces provides a sense of ownership arising from personalisation, sense of control, territoriality and involvement.

Privacy and space

Using ‘booths’ set up for privacy in the classroom, Ahrentzen and Evans (1984) sought to examine the environmental features of elementary school in relation to distraction and privacy. They found that when children wanted to be alone, they prefer to be in secluded study areas or corners, rather than the total privacy of the booth, while maintaining visual contact with others. Visually open and accessible teacher staffrooms also meant changes in ‘staffroom talk’ about student progress (Gordon & Lahelma, 1996).

Spaces

Maintenance

Buckley, Schneider et al. (2004), in a study that focused on teacher retention, observed school conditions—facility conditions and maintenance variables including conditions of lockers, visible graffiti and frequency of cleaned classrooms—in Los Angeles and Milwaukee in the US. They controlled for public and neighborhood socio-economic characteristics, school size and student reported motivation levels. They found higher reading scores among elementary and high schools students in better-maintained schools (p. 65). Poor school buildings had a negative effect on teacher retention.

Assessment of effectiveness

A Canadian study by Roberts (2009) found that engineering assessments of facilities are unrelated to the Quality of Teaching and Learning Environments (QTLE) in schools but that the educators’ assessments of school facilities are systematically related to the QTLE in schools. This highlights the fact that the educational purposes of schools need to be taken into account in order to understand the place and importance of facilities with relation to learning outcomes. A focus on educational relevance is more important than a purely engineering-based assessment. More research needs to be done in order to develop sound tools for measuring school facilities in terms of their educational relevance.

Intangibles

Abdul-Samad and Macmillan (2005) argue for improved understanding of the impact of design on a range of outcomes and new valuation methods (e.g. measures of affect, visual methodologies) for capturing the 'intangible' outcomes. These include engagement, social cohesion and feelings of wellbeing as measures of design quality and desirable outcomes. Eclipse Research Consultants (2005) state that evaluations could be improved if measurements of intangibles as 'an adjunct bundles of value' are included.

Comber, Nixon et al.'s (2006) study examined the redesign of an outdoor area in a low-SES South Australian community 'being improved for someone else and someone else's children' due to gentrification (p. 232). Teachers and children were repositioned from being 'responders' to architectural designs to being the designers of new spaces. Children were involved in collaborative projects that allowed them to become the negotiators, designers, and imaginers of new inclusive spaces. This promoted identity, while also providing tangible material outcomes for the school community. During this project researchers were repositioned from being novices to learning new architectural concepts, vocabularies and practices. In addition, architects had to learn to consult with children as clients rather than informants.

Environmental sustainability: Green schools

A key aspect of new school design is modelling environmental sustainability, as with the UK's Sustainable Schools initiative, yet the link between participation in designing schools and sustainable behaviour is complex (Wheeler, 2008). The design of outdoor spaces is informed by a number of factors such as site and location. This in turn impacts on the scale and type of outdoor area, the natural resources of the school and the commitment to environmental sustainability and outdoor learning. In some instances, the principles of environmental sustainability have been integrated into the school design and are expected to be sustained by having children involved not only in the design but also in the care and use of the outdoor space in teaching and learning. The UK Futurelab's projects such as Fountaineering and Super Sleuths encouraged teams to be involved in problem solving, which was then integrated into classroom work (Lee, 2007). Young people are expected to discuss what it means for community relations and social cohesion and reconcile this with their own consumption and that of friends. Teachers are expected to embed issues of sustainability in and through their pedagogies.

Gislason (2009) found that in a senior environmental college the school's design was a scaffold for the curriculum and interdisciplinary pedagogies. An outdoor pond and outdoor classroom were springboards to curricular units and nurtured a pro-environmental attitude. The students indicated that a 'natural environment' (which included facilities) and applied learning had positive psychological effects over the confines of the classroom.

Information and Communications Technology (ICT)

Much of the most recent literature is driven by the need to incorporate technologies of various forms within learning spaces and how this both demands new teaching practices and creates new possibilities. In 2001, there was little systematic research on how the integration of ICT facilitated or enhanced learning outcomes. Instead the focus was on technical expertise rather than pedagogical use, and on technical prerequisites in the use of space (Blackmore et al., 2001; Morton, 1999). Contemporary computing or other technology education is more ubiquitous since it is integrated across and into the curriculum. Computer use due to mobility of laptops, netbooks and wireless is pervasive and connectivity means blurring the lines between school/leisure/work/home spaces. Spatially, design has moved from enclosed computer labs to computer pods integrated into classroom layouts. Now mobile laptops or netbooks are one of many pedagogical tools producing interactivity and connectivity with other learning technologies such as whiteboards. The issue now is how to facilitate the use of mobile technologies throughout schools, in transition spaces and in internet cafes where educational and social interactions can be encouraged while privacy and safety are addressed (Cilesiz, 2009). Again the focus of the literature is on different configurations that facilitate easy access to ICT and use by individuals and groups, and the integration of ICT into the curriculum (e.g. Moulds & Harper, 2008) with less reference to outcomes.

Libraries as community spaces

Australian research on libraries and space is less systematic and national and is mostly focused on primary schools. There is some indication that library effects reduce in upper secondary levels as students go to the library to play games, read, research, do leisure reading and for privacy (Lonsdale, 2003). Mobile technologies and wireless connectivity have now changed the design of libraries to make them more learner rather than equipment centred and they require only basic infrastructure (i.e. power points, storage and broadband). The issue is how these facilities are used interactively (Lonsdale, 2003; Brook, 2009). Libraries have been remodeled to be sensitive to student behaviour, independent work and problem solving. Lonsdale's (2003) review of literature argues that the changing nature and use of libraries means that a librarian's work is characterised by teaching information literacy, using shared facilities, telecommunications and multimedia, managing digital resources and being web managers. Lonsdale (2003) concludes that a strong well-resourced library program with a strong computer network, a high quality collection and collaborative relationships between teachers and librarians in planning units, which is supported by professional development for teachers, can lead to higher student achievement regardless of the socio-economic or educational levels of the parents.

Outdoor spaces, physical activity, health and wellbeing

The importance of play as pedagogy is foregrounded as important in acquiring social, cognitive and physical skills. Indoor and outdoor spaces need to be designed with play in mind. Critical to outdoor design is student safety and security, as well as privacy. Other issues around physicality of design include:

- scale (i.e. low door handles to welcome smaller children (Meek & Landfried, 1995);
- transitional spaces such as external pathways and internal corridors;
- location of specialist buildings near certain areas e.g. school gardens close to technology or kitchen areas (hospitality) or ponds near science buildings (Tanner, 2000);
- developmental needs in early childhood (e.g. Head Start program in US); and
- access and needs of students with a disability (White Hutchinson, 2010).

There is limited research on effects of these designs in secondary schools, with the primary focus being on early years and preschool (e.g. McNaughton, 1996; 1998). However, research in the UK on playgrounds indicates there are positive effects on learning that playtime and informal use of playgrounds provide. Play contributes to physical, social, emotional and intellectual development as it allows students to practice the skills of conflict resolution, co-operation, sharing and problem solving (Steinhagen & Iltus, 2004; Clements, 2001). Reggio Emilio schools have been developed on this principle (Ceppi & Zini, 1998). But the capacity to gain such benefits depends on the quality of the play environments as well as how they are used and supervised. Conflict or withdrawal is more likely when playgrounds are overcrowded and equipment and materials limited or when there is space but not enough activities, leading to boredom and aggression (Malone & Tranter, 2003). This is particularly the case in secondary schools when there is inadequate seating and where there is territorial domination by older pupils (Titman, 1999).

On a positive note, in primary schools, Susa and Benedict (1994) found that pretend play that correlates with creativity occurs in modular equipment with linked multipurpose structures more often than traditional playgrounds with swings and slides. Where there are a variety of spaces and activities, the intensity of play increases and leads to improved social relationships around respect and responsibility as well as a sense of belonging (Moore & Wong, 1997). Some schools though undervalue their educational use and the importance of playtime as part of children's social world. Free play can be problematised as risky due to concerns about physical safety and bullying rather than seen to have positive benefits (Armitage, 2005). In the US, there is a trend to delete recess due to increased pressures of accountability and curriculum demands, as well as fear of litigation (Thian, 2006).

Built environments can create new play spaces such as bounded spaces, walls for ball games, and open spaces for fast-moving games, although they may also reproduce cultural and gender boundaries (Davies, 2003; Rendell, 2000; OECD, 2009). Studies have indicated that girls tend to sit in groups around the periphery while boys occupy most of the outdoor and indoor playing spaces (gyms) unless there are structured activities or dedicated times allocated for use by girls or less active boys in particular spaces (e.g. basketball courts, ovals, gyms). While boys tend to play longer in more competitive, goal-oriented games, girls tend to undertake a range of games, some of them sedentary and often more co-operative and rhythmic (Shilling, 1991). Girls tend to play active games less as they move into secondary school, particularly in co-educational environments but there is little research on how space may influence these activities (e.g. privacy for older girls).

Furthermore, there is little research on the type and use of space required for sport and physical activity despite significant empirical research linking few extracurricular activities, low levels of physical activity and childhood obesity to poorer learning capacities and often disadvantaged communities; (e.g. Davidson's (2007) review of childhood obesity prevention and Dagkas & Stathi's (2007) study of 52 urban 16 year-olds. Thian (2006) concludes that school playgrounds that support physical, social-emotional and cognitive development have three characteristics:

- developmentally appropriate activities for the age and ability range of students;
- diversity of the types of spaces and range of activities supported; and
- interesting spaces.

There has been a recent trend to develop ways to improve school grounds (e.g. Growing Schools Programme in UK; Boston Schoolyard Funders Collaborative; Seattle's Grey to Green Program). Most recently, many of these initiatives link to environmental education. In the UK, the 120 Forest Schools provide a program modelled on the Scandinavian idea that children's contact with nature is important developmentally. A participative exercise reviewed the program's impact on children and found improvements in the following areas:

- confidence developed with freer time to learn about space and demonstrate independence;
- social skills as children gained greater awareness of actions on peers in team activities;
- communication in terms of language development prompted by sensory experiences;
- motivation and concentration as the woodland led to a keenness to participate; and
- physical skills in terms of stamina and gross and fine motor skills, as well as knowledge and understanding of natural surroundings and respect for the environment.

In addition, teachers gained a new understanding of the students and there were ripple effects as children talked about their experiences at home. Titman's (1994) research found students want a space for doing (to undertake a range of physical activities), thinking (to be intellectually stimulated and enjoy discovery), feeling (to appreciate colour, beauty as well as ownership) and being (to be themselves with some privacy).

Effect of spatial on attitudinal, behavioural, learning, affective outcomes

Environmental psychology has dominated attempts to assess the effectiveness of learning spaces on student outcomes with the emphasis on quasi-experimental reduction models (Weinstein, 1979). Few of these studies show any direct causal link between positive achievement in standardised tests and improved or new learning spaces. Many show negative correlations between specific aspects of building quality and outcomes. Most studies cite that mediating factors are the absent or uncontrollable factors (Tanner & Lackney, 2006; Gifford, 2002; Weinstein, 1979). Dudek's (2000) work on the historical development of educational architecture and design provides the strongest body of evidence to date as proof of the links between space, pedagogy and outcomes. Gifford's (2002) theoretical framework for examining educational settings (based on Weinstein) states:

...the personal characteristics of students (past school experience, attitudes toward learning, age, gender, personality) interact with physical features of the learning setting (its size, noise level, climate, population density and design) and the social-organizational climate (rules, curriculum, teaching style, progressive or traditional orientation) to produce learning-related attitudes (satisfaction with school, dissatisfaction with classroom, commitment to learning) and behaviours (class participation, attention to learning materials, questioning, appropriate or inappropriate activity, persistence, creativity and, of course, learning and performance) (p. 298).

Gifford's (2002) analysis of environmental psychology findings for educational settings indicates that:

- interior architecture has an influence on whether students are distracted or if they retain and recall information;
- aesthetics has a positive effect on grades but this is often subject to gender and age;
- European studies show aesthetic appearance can offer subtle messages to staff and students around the transmission of cultural values as well as stimulate or subdue, aid in creativity, slow mental perception, and cause fear and joy;
- scale of building and structural shape impact on behaviour;
- noise interferes with learning and may be gender specific (girls more affected than boys). Noise also has a negative effect on students with autism;
- incandescent lighting is preferable to fluorescent lighting. Although inconclusive, studies have found adverse effects on learning outcomes from fluorescent lighting;

- performance is best in cool but not humid classrooms. Air flow, temperature and air quality all have implications for learners in terms of health and well being but multiple mediating factors are involved — clothing, culture, home, etc.;
- the amount and arrangement of space is very important for classroom performance and related behaviours. This is directly related to teaching strategies. Open learning spaces have positive effects on outcomes where teacher pedagogy is matched, and there are fewer behavioural problems;
- space also affects teacher and learner feelings. This is specifically related to density, flow and furniture; and
- increased density leads to increased aggression that can be counteracted by pedagogy, layout and programs. Students need a degree of privacy and ownership to feel a sense of belonging.

Research by the 21st Century School Fund (2009) and Schneider (2002) on school facilities provides a substantial body of evidence relating outcomes to the quality of the space. Many of these studies have used regression modelling and in and of themselves are inconclusive but combined give a strong indication of the links. They conclude that the following factors are important design considerations:

- *Indoor air quality (IAQ)* – mould and airborne bacteria have adverse effects on children’s and teachers’ health.
- *Temperature and humidity* – creates conditions which lead to Sick Building Syndrome, relative absenteeism and lowered mental acuity.
- *Ventilation and air flow* – is an occupational health and safety issue because children require more air in proportion to their body weight than adults. Studies indicate that air flow from windows is inadequate in schools to remove or prevent the build-up of carbon dioxide. Poor air flow leads to poor performance of tasks.
- *Thermal comfort* – there is an optimum temperature for learning, retention, task performance and job satisfaction.
- *Lighting* – both natural (day) and artificial lighting have considerable effect on learner performance. Natural light optimises student achievement and aesthetic perception.
- *Acoustics* – good acoustics (quality rather than amount of noise) are fundamental to academic performance.
- *Building age, quality and aesthetics* – affect student and teacher perceptions of safety and well-being. Building age is not as important as the quality of building conditions. Students generally perform better in modernised or new environments but it is difficult isolating mediating factors, and therefore inconclusive.
- *Furniture and carpets* – dampness and pollutants can lead to health problems e.g. asthma.

- *School size* – the trend toward larger schools in some countries has been based on economies of scale. Restructuring for smaller neighbourhood or multi-campus schools and learning communities is having a positive effect on student outcomes and size can be the best predictor of test scores.
- *Class size* – studies are inconclusive due to the variability of methodology rather than lack of findings. Pedagogy, environment (arrangement), age and stage, flow, density, crowding and privacy are mediating factors which are unable to be accounted for in many studies of classroom environments.
- *Classroom design* – issues are around viewing the teacher, board, etc., but again largely focused on obstructions and not linked to specific outcomes. There are indications that overcrowding or high spatial density reduces achievement but not pedagogical strategies, social relationships and outcomes. Research on use of furniture in relation to crowding has been in offices rather than schools.
- *Health and safety* – compliance with health and safety regulations was positively related to academic outcomes.

The Price Waterhouse research report (2003) provides a rigorous and expansive study with 2000 schools in the UK being evaluated for building performance and student outcomes using mixed methods, including three years of quantitative statistical data. However, they highlight the same mediating anomalies in their study that Gifford and others recognise and no measure of teacher practice is included within the data although they recognise that this is a sustaining factor.

Gender and space

Well-established literature discusses how space is gendered historically and experienced in culturally different ways (Massey, 1983; Gordon & Lahelma, 1996). Research indicates that the use of indoor and outdoor spaces is still largely monopolised by boys, particularly for sport activities. Dedicated time/space use is one strategy to balance this out. Weis and Centrie (2002) indicate that whereas schools can represent cultural affirmation and advancement for a cultural group, spaces within schools have the same capacity for recognition of difference and cultural affirmation, e.g. a girls' room or a homeroom for Vietnamese students. There is little contemporary evidence on whether and how culture and gender are factors in the use of space and place attachment (Proshanky et al., 1983), and spatial identity (Fried, 2000) or if there are differential effects in terms of learning outcomes.

Gaps in the consolidation phase

Overall, when it comes to what practices are enabled through new learning spaces and with what effects, Fisher (2005) argues that the existing literature linking learning spaces to student behaviour and learning is overly general and only around the key measures of building conditions. Gifford (2002) outlines the strengths and weaknesses of environmental psychology methodologies by identifying three levels: fundamental processes (perception, cognition and personality), social management of space (personal space, territoriality, crowding and privacy) and the complexity of behaviour within space (working, learning, daily life and community). Perceptual studies utilise methods that include self-reporting, time sampling, behaviour inference, psychophysical estimating and phenomenology. Spatial cognition utilises sketch maps, model construction, distance estimation and observation with the understanding that age and stage biases will affect how this data is presented and collected. The difficulty with perceptual studies is that researchers ‘sacrifice experimental control but in return are able to investigate the perception of real, complex settings that perceivers move through and feel connected to’ (Gifford, 2002, p. 23).

There is little research on the role of the mediating variables of teacher professional development and other intangibles such as pedagogy. Research is lacking in the consolidation phase in the following areas:

Context factors

- What is the relationship between school buildings, effective school environments and complex interacting factors such as location and social mix that impact on learning and outcomes?
- Do changes in student achievement, populations, and social mixes result from new schools rather than new school buildings (i.e. indirect rather than direct effects)?
- What is the relative importance of key determinants in changing pedagogical repertoires — new learning spaces; student needs; imposed versus bottom up reform?

Ownership

- Does the ownership of staff and students over built environments have long term benefits?
- How do teachers and students shape space for themselves pedagogically by using patterns of movement and circulation and patterns of daylight and views?
- Is there a specialised language that empowers people to create multiple spaces?
- What are the relationships between spatial/temporal elements, individual learning, social mix and cultural contexts central to issues of personalisation, ownership, identity and inclusion?
- What are teachers’ and students’ voices about learning spaces and how have they changed attitudes and practices and with what effect?

Relational factors

- What are the relationships between spatial/temporal elements, individual learning, social mix, and cultural contexts that are central to issues of personalisation, ownership, identity and inclusion?
- How does generative or participatory redesign impact on conducive learning environments?
- How do learning spaces work in relation to each other and make a difference in terms of effective practice: 'bundles of value'?
- Do flexible learning spaces improve student behaviour and if so, what are the outcomes?
- How do teachers use innovative pedagogies in traditional classrooms inappropriate for new integrated curriculum and inquiry-based approaches?
- How does the flexibility of space and mobility of technology and furniture impact on the use of space and learning by teachers and students?
- What cultural and gendered messages and values are imparted through built space?
- Does the use of internal and external physical space by boys and girls vary by age, space, and over time?

Structural flexibility

- When testing the value of good design quality on outcomes, does it plateau over time?
- How do we test the impact of innovative design for new ways of teaching and learning, and the interaction of design features?
- How do we understand the relative value of investment in different areas e.g. relative benefits of capital investment in different aspects of school design such as refurbishment, rebuilding and ICT?
- What are the issues around safety and privacy in transitional spaces (indoor/outdoor)?
- What structures and processes sustain the quality of a learning environment (built and socio-cultural)?
- How do structural factors such as space allocated per student, openness of space, size of space and school, building utilisation rates, support facilities (storage) and availability of specialist instructional facilities (labs) impact on learning?

Intangibles

- What are the best ways of assessing how spaces and the relationships between different aspects of the spaces work together, e.g. furniture and activities?
- What are the spatial and temporal factors that assist collaborative learning?



Sustainability/ re-evaluation phase

There is little recent literature that focuses on the long-term effects of new physical spaces and built environments. One exception is a major technical report on the UK's Building Schools for the Future (BSF) program (Price Waterhouse, 2003) and the three annual reports of the program (PriceWaterhouseCoopers, 2006, 2008, 2010). While there is some evidence that new schools can attract and retain students and staff with an initial rise of morale and student attainment, there is no research to indicate whether this is ongoing. In addition, while the standardised templates of school design used in some building programs may be cost effective relative to student outcomes, Critchlow (2007) suggests the short-term cost gains of standardisation are lost in the long-term if buildings are not a good fit.

Langer (2005) indicates in US studies that a lack of ongoing funding for 'green schools' means many sustainable strategies (e.g. reduced energy bills, less emissions, improved indoor quality) are limited, thus compromising both the design and opportunities to make schools into 'living labs'. Likewise, lack of maintenance and care for appearance has a negative effect in the long run.

One of the few longitudinal studies on the effects of neighbourhood, schools, peers and families on school success for middle years students was done by Bowen et al. (2008). They found that longitudinal data of 4,071 student perceptions on social environments (people and places) indicated improvement in school engagement, trouble avoidance and grades.

After buildings are made adequate (and what that means is contestable), is there a limit to which the built environment factor alone may affect student and learning outcomes? The literature suggests that improvement would plateau but again there is little evidence. It also depends on what element(s) of design are being considered—light, air quality, scale, and usage—in relation to what outcomes (social, affective or cognitive) for what students.

Overall, there is a lack of evidence of the various research paradigms (engineering architectural, psychological, critical pedagogy) talking with and learning from each other, even though all are concerned about improving student learning.

Gaps in the sustainability/re-evaluation phase

There is little to no research on the sustainability/re-evaluation phase in the following areas:

Design

- What types and degrees of participation in serial redesign are most beneficial?
- What are the patterns of use impacted on by outside/inside visual and spatial links?
- What are the budget considerations of building programs' impact on schools' capacity to maintain and upkeep learning spaces: i.e. furniture, technologies and general improvements?
- What design features have the greatest impact— aesthetics, technology, physical quality, or age of building?
- How do socio-spatial features of school design work together and with what tangible and intangible effects? Some examples include transitional spaces (indoor/outdoor), anthropological and social aspects of design, sensory stimulation, context, schools within schools, harmony, views and vistas, functional zones, circulation patterns and supervisable spaces.

Community

- How do shared spaces such as libraries and leisure facilities change community relations and perceptions over time?
- Do shared community spaces (libraries, sporting centres etc.) increase the type of parental involvement which may affect student learning outcomes?

Student Outcomes

- What are the learning outcomes arising from the pedagogical practices in new learning spaces, such as how playgrounds or leisure facilities are utilised, new technologies, etc.?
- How do practices in schools built to model environmental sustainability translate into student learning (i.e. raising environmental awareness)?
- How does classroom design, furniture and pedagogical use interrelate and with what effects on student learning?
- How long is learning improvement due to buildings sustained over time?
- How does the changing role of libraries in schools impact on outcomes, e.g. information literacy?
- Which building investments are most likely to lead to improvements in social, affective and/or cognitive student outcomes? Is it outdoor spaces, indoor spaces, refurbishment, informal social space, or new buildings in general?

Teachers

- How is teacher professional identity affected by new physical spaces?

Emergent themes

While there are multiple fields of research (architectural, interior design, pedagogical, organisational, psychological, environmental) exploring the connections between learning spaces and behaviour, each provides a different paradigmatic perspective that frames what is significant in the relationship and how one evaluates effects on student learning. Despite this, the different paradigms are converging on agreement as to the need to focus on the relationships between contextual, organisational, pedagogical and social practices of different learning spaces. Woolner et al. (2007) states that ‘while the research indicates the parameters of an effective environment, there is overall a lack of empirical evidence about the impact of individual elements of the physical environment which might inform school design at a practice level to support student achievement’ (p. 47).

In alignment with this approach, new conceptual frameworks provide a range of possibilities. First, the emergent literature suggests that if educational systems listen to and work with children and teachers they can transform both learning spaces and pedagogical approaches, creating possibilities for rethinking all aspects of school design through the focus on spatial pedagogies (Comber et al., 2006). Although not supported by longitudinal studies, this review indicates that design is ongoing (serial redesign) (Blackmore, 2008). Higgins et al. (2005) found the ‘process of user involvement must be continually refreshed and iterated to support ongoing change’ (p. 3). This puts the focus onto school organisation, whole school culture, as well as teacher and student practice.

Second, buildings alone are not enough; it is about relationships and changing cultures and practices. Higgins et al. (2005) and others argue that participatory or generative design involving students and teachers needs to continue throughout all phases—from design to evaluation—in order to achieve sustainable impact within a rapidly changing context. Temple (2007) suggests that locally governed processes of change and engagement are also necessarily dependent on a process of renewal as staff and students move on. Higgins et al. (2005) conclude:

It is important, therefore to beware of ‘architectural determinism’ of plans for renewal and development that do not allow for both local variation and ownership and of programs which do not budget for an ongoing investment in and iteration of school environments (p. 6).

This review suggests key interconnected elements necessary to sustain innovation and ongoing improvement of student learning in relation to the spatial dimensions of schooling, including:

- the school organisation and whole school processes and practices that inform an ethos or culture of inquiry and learning; and
- sustaining teacher, community and student voice gained through participatory design, and embedding participation into everyday practice and decision making, thus enhancing teachers’ and students’ sense of self efficacy and agency

Third, the review highlighted the critical role of teacher professional learning and pedagogy as key mediating factors. Unless teachers are prepared and are provided with the necessary professional skills, tools and resources to change their practices, then new built spaces will not move them to innovative pedagogies.

The first generation of teachers or initiators who may have been part of the design process tend to feel ownership over the space and pedagogical initiatives; the second generation entering schools with new learning spaces are expected to sustain and improve any initiatives in practice; and the third generation of teachers transitioning from pre-service teacher education expect to find redesigned pedagogies, schools and classrooms to be the norm but may be confronted in reality with wide variability. Teacher educators, therefore, have to be prepared to address how new pedagogies can be mobilised across a range of classroom and school design patterns.

Fourth, researchers need to explore the differentiating aspects of spatial pedagogies that recognise the complexity of teaching and learning and the difficulties of creating permanent structures and processes. This requires a new grammar of socio-spatial practice that gets beyond the tangibles to consider the intangibles, such as going from the language of occupancy to that of ownership, or from student and teacher response to student and teacher agency. Overall, where there is research, it is largely based on aggregate school outcomes and quality of buildings and lacks any specificity in regard to:

- differential use of specialist/generalist spaces by students and teachers; and
- different needs and use of space for each age cohort or social group.

Finally, the significance of different relationships for teaching and learning need to be explored between physical and virtual learning spaces; context, system supports, and organisational factors (culture, patterns of communication, resource use, professional support); in and out of classroom settings; and formal and informal social interactions.

Heppell et al. (2004) argue that ‘no one knows how to prevent ‘learning-loss’ when you design a space ‘pedagogically’, whereas we know lots about designing for minimum ‘heat loss’. Not only is the evidence incomplete, particularly in areas such as the systems, processes and communication approaches that schools can use to underpin how they organise and use their physical environment, but the research that has been done seems to be largely predicated on a traditional view of ‘chalk and talk’ learning in standardised ‘one size fits all’ institutions (Higgins et al., 2005). The social practices of teaching and learning are closely associated with issues of identity, ownership and agency in relation to use of space and time as well as the intangibles that include the affective, cognitive, and social aspects of teaching and learning, and organisational change.

These emergent frames will inform future research on learning spaces and student outcomes, giving the Department a sound basis for planning its research program.

The Department has adopted an overarching research question to guide its research into learning spaces:

What are the benefits, challenges and unintended consequences of new learning space design in relation to pedagogy, school organisation and student learning outcomes?

To view the Department's learning spaces publications, please visit our website:
<http://www.education.vic.gov.au/researchinnovation/resources/default.htm>

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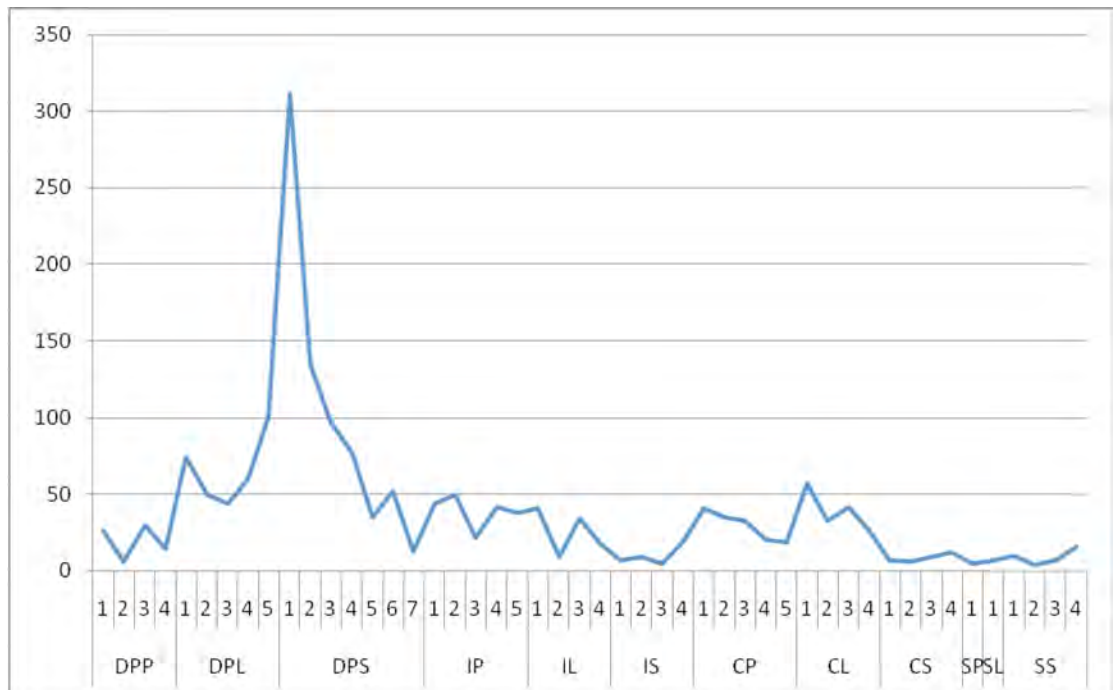
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Appendices

Appendix 1

Below is a graphical representation of Table 1.



Coding Terms	Practitioners		Learners		Spaces	
Design	Consultation in design	DPP1	Personalised needs	DPL1	Principles and philosophical aspects of design (includes physical environment and influences on well-being)	DPS1
	1st generation users	DPP2	Voice through consultation	DPL2	Specialist use of space	DPS2
	Preparation for pedagogical change	DPP3	Access/availability to resources	DPL3	Contemporary approaches and trends within education broadly	DPS3
	Availability of resources	DPP4	Social	DPL4	Policy	DPS4
			Achievement	DPL5	Infrastructure	DPS5
					Furniture	DPS6
					Time	DPS7
Transition	Orientation to space	IP1	Needs of different learners	IL1	Governance	IS1
	Rethinking practices for teaching	IP2	Gendered spaces	IL2	Community-shared spaces	IS2
	Professional learning	IP3	Reorienting/ positioning as learner within space	IL3	Access	IS3
	Adoption of space	IP4	Privacy and safety	IL4	Security	IS4
	Challenges of space	IP5				
Consolidation	Changes in pedagogy	CP1	Engagement in learning	CL1	Management	SP1
	Responses to space	CP2	Quality in learning experiences	CL2	Maintenance	SP2
	Collaborative planning and teaching	CP3	Collaborative learning experiences	CL3	Flexibility	SP3
	Enacted curriculum	CP4	Personalised learning	CL4	Fitness of purpose	SP4
	Privacy and ethics	CP5				
Sustainability/ Re-evaluation phase	Creativity and learning design	SP1	Creativity and problem-solving	SL1	Possibilities of redesign	SS1
					Virtual within the virtual	SS2
					Innovations	SS3
					Sustainability	SS4

Appendix 2

Databases such as ERIC, Ebscohost, SAGE, Science Direct, Inforword, ISI Web of Knowledge, Newsbank, national and international libraries, government (local, national, international) and Google scholar. Subject/discipline areas searched were Education, Health, Architecture, Urban Planning, Social Policy, Brain Science, and ICT

Websites of most use include:

National Clearinghouse for Educational Facilities	www.edfacilities.org
Learning through Landscapes	www.ltl.org.uk
Design Share	www.designshare.com
Educational Design Institute	www.edi.msstate.edu
Council of Educational Facilities Planners International	www.cefpi.com
Commission for Architecture and the Built Environment	www.cabe.org.uk
Futurelab Innovation in Education	www.futurelab.org.uk
Educause	www.educause.edu
Space Management Group	www.smg.ac.uk
American Institute of Architects	www.aia.org
Centre for Teaching: Learning Spaces	www.vanderbilt.edu/cft

Keywords & Themes:

Design

aesthetics
architectural models
between spaces
building design
buildings
classroom design
classroom diversification
classroom practice
ecology
environmental psychology
environmentalism
environmental models
environments
flow
furniture
hallways
indoor
intangibles
learning spaces
open planning
outdoor
school design
sustainability
transitions
water tanks

Planning

classroom plans
classroom strategies
curriculum planning
lesson planning
pedagogy

Specialised Spaces

art classroom design
computer laboratories
gymnasium
multipurpose
performing arts spaces
science laboratories
specialist spaces
technology spaces

Student interaction

co-operative learning
extracurricular activity
learning outcomes
personalised learning
student engagement
student mobility
student responses
student space
student teamwork

Teacher interaction

collaboration
collaborative teaching
professional learning
teacher education
teacher mobility
teacher responses
teacher space
teacher strategies
teacher teamwork

Technology

ICT
interactive
smartboards
technological design
technologies
whiteboards

Time-Space

asynchronous
temporality
schedules
spatiality
synchronous
time-tabling
time-use

Usage of Space

building sharing
building usage
community spaces
external environment
forest spaces
green spaces
flexible environment
learning environment
physical environment
physical space
outdoor spaces
shared spaces
sharing spaces
space
utilisation of learning space

Well-being

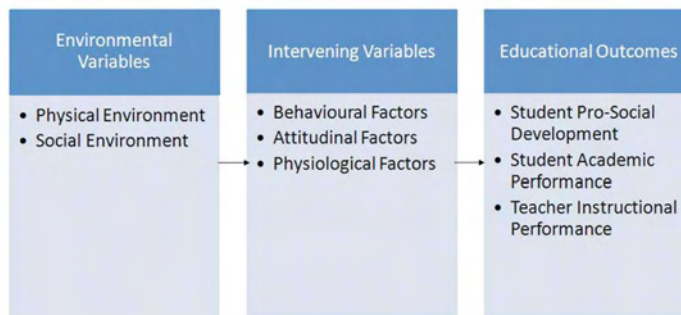
emotional safety
physical safety
well-being

Other

relationship

Appendix 3

A)



Adapted from Lackney, 1999

B)



Adapted from Lackney, 1999

Appendix 4

Principles of Learning Space Design (Fisher, 2005)	
PRINCIPLE 1 Individual settings	Describes types of spaces and spatial qualities that support individuals and research that are essentially for self-directed learning. Student home-base, individual pod.
PRINCIPLE 2 Group settings	Describes types of spaces and spatial qualities that support groups. Movable furniture allows spatial organisation to be controlled, facilitates small group collaborative and cooperative learning activities such as collaboration incubators, presentation spaces, display spaces
PRINCIPLE 3 Activity rich settings	Describes types of spaces and spatial qualities that support activity. These spaces will be technologically enhanced and contain a range of services and other resources according to the studio space type. Project space plus wet areas, specialised focus laboratory.
PRINCIPLE 4 Informal learning settings	Describes types of spaces and spatial qualities that support informal learning: problem-based learning and collaborative team-based activities in non-timetabled spaces scattered across the campus in corridors, verandas, cafeteria and library... outdoor learning, break out spaces
PRINCIPLE 5 Staff settings	Describes types of spaces and spatial qualities that support activity that should not be isolated from students. Adult learning approach supports staff taking time out... teacher meeting, resources, in a supply plus school

Appendix 5

Fisher's (2005) synthesis of assessment tools

Transition phase:-

- *Sannoff's Assessment Tool (2001)*

This tool includes a six factor *school building checklist* which is a post occupancy evaluation walk-through. This looks at the key elements of *context, massing, interface, wayfinding, social space and comfort*. There is also a *School Building Observation Form* which allows first time visitors in particular to give initial impressions of the buildings and spaces. The third element of the process is a *School Building Rating Scale* which is qualitative assessment tool which rates physical features, outdoor areas, learning environments, social areas, media access, transition spaces and circulation routes, visual appearance, and safety and security. It uses 55 statements which can be rated by students, staff and community. There are also photo questionnaires and interviews in which users can assess positive and negative reactions or feelings regarding each space using a *Space Rating Scale*. Also included is a poem template for students to respond called *I Wish My School...* Finally a facilitated dialogue between stakeholders using *Relating Objectives for Learning to Education (ROLE)*.

- *BREAMM Building Evaluation Assessment Method*— a computer generated post-occupancy evaluation tool which requires specialist training and analysis but adaptable to include use by students. It looks at management, health & wellbeing, energy, transport, water, materials, land use, ecology and pollution. The focus of this tool is on conditions and not outcomes or pedagogy, but could be adapted to develop projects associated with environmental sustainability and health.

Consolidation phase:-

- *OECD/PEB EQES (Evaluation of Quality in Educational Spaces) 2009*—asks 5 broad research questions regarding the 22 Quality Performance Objectives (QPO). These are:
 - Which *QPOs* are considered important in the *educational mission* of the school or (if it exists) in the *design brief* for the school?
 - Which *QPOs* are effectively met in the *everyday functioning of the school*?
 - What *school-related factors* are affecting the ability of the school to meet its performance objectives?
 - What *local factors* are affecting the ability of the school to meet its performance objectives?
 - What (*national or regional*) *policy-related factors* are affecting the ability of the school to meet its performance objectives?

QPO are agility (flexibility), openness to the community, accessibility for people with disabilities, external/internal accessibility, student current and future capacity, teacher space, support spaces, furniture, internal/external noise, lighting, temperature/humidity, maintenance, symbolism, appearance, learning resource, healthy environment, safe environment, social spaces. The tool itself is used in conjunction with teacher, student and community interview data, and student achievement data and measured against policy and socioeconomic contexts.

- *Fisher's Matrix Linking Pedagogy and Space* links pedagogical activity and attributes to spatial constructs and layouts, process and behavioural steps. While developed to inform design it could be used to reflect on and evaluate space.
- *Wolff's Problem Based Design Model* : 32 design features of learning spaces which can support individualized and collaborative learning using space, furniture, layout, technology that adhere to best practices around flow, physical conditions, interaction, privacy, flexibility and functionality. Addresses issues around group size, physiological and psychological support, furnishing, adjacencies, functional spaces and structural aspects.

Sustainability phase:-

- *DesignShare Awards Criteria* — 6 design criteria are predicated on three main conditions that *learning is a lifelong process, design is always evolving, and resources are limited*.
 - enhance teaching and learning and accommodate the needs of all learners;
 - serve as a center of the community;
 - result from a planning and design process that involves all community interests;
 - provide for health, safety, and security;
 - make effective use of available resources;
 - be flexible and adaptable.

