

Sustainability vs. pedagogy: synergies and tensions to be resolved in the design of learning environments

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Abstract: Learning environments in schools are purpose-built spaces. They are designed to be places of learning and are inclusive of the building structure, the furniture, fixtures, incorporated technology and learning resources. In the 21st century, it has become common practice for the design of new learning environments to be driven by issues of contemporary pedagogy and environmental sustainability. However the question that remains unanswered is what are the synergies and tensions between achieving environmental sustainability and contemporary pedagogy within the same learning environment? The purpose of this paper is to stimulate conversation around this topic. The findings relate to three researcher's observation over a seven year period of learning environments research, undertaken at The University of Melbourne as part of the Learning Environments Applied Research Network (LEaRN) and two Australian Research Council Linkage Projects *Smart Green Schools* and *Future Proofing Schools*. Discussion of these observations highlights some of the issues and/or opportunities, which include more targeted research on how to deliver learning environments that are 3D textbooks; holistically integrated biophilic design, and greater occupant control of indoor environment quality.

Keywords: Sustainability; architecture; contemporary pedagogy.

1. Introduction

Over the past decade, there has been substantial growth within Australian schools regarding levels of awareness and action for environmental sustainability. The majority of this growth was triggered by the United Nation's proclaiming 2005 to 2014 as the 'Decade of Education for Sustainable Development' (DESD). Governments across the world were invited by the United Nations to strengthen their contribution to issues of environmental sustainability through initiatives aimed at specifically learning and education (UNESCO, 2005). In Australia, the Federal Government's DESD strategy was communicated through the 'Caring for Our Future' report (Australian Government, 2006). It broadly outlined specific initiatives aimed at embedding issues of sustainability into schooling through the National Environmental Education Statement for Australian Schools; the Australian Sustainable Schools

Initiative; the National Goals for Schooling; and the National Statements of Learning (Australian Government, 2006).

Of specific interest to this paper is the Australian Sustainable Schools Initiative (AuSSI) – a national program “providing practical support to schools and their communities to live and work more sustainably” (Australian Government, 2015). In 2010 there were approximately 3000 public, private and Catholic schools participating in AuSSI – a number equal to 30% of schools nationally (DEWHA, 2010). An evaluation into the operational effectiveness of AuSSI revealed that collectively these schools were “achieving immediate and measurable improvements in their use of resources, grounds and facilities” with reductions of 80% in waste collection; 60% in water consumption and 20% in greenhouse gas emissions (Australian Government, 2015; DEWHA, 2010). However, as learning environments are made more sustainable through the revised use of resources, grounds and facilities, what impact is this having on desired pedagogy?

The purpose of this paper is to stimulate conversation around this topic by identify some of the synergies and tensions that exist between achieving sustainability goals and desired pedagogy within the same learning environment. The findings do not relate to an exhaustive research methodology, but instead relate to observations made during a seven year period of learning environments research at the University of Melbourne, in Australian primary and secondary schools.

2. Literature review

This paper begins with a literature review of the current and historical paradigms of environmental sustainability; contemporary pedagogy; and learning environments. As well as provide important background information this review highlights that growing interest in schools regarding issues of in environmental sustainability, occurred alongside an emergent shift amongst educators towards contemporary pedagogies, thus providing opportunity for solutions to be holistic (Dovey & Fisher, 2014).

2.1. Environmental Sustainability & Schools

The Australian Sustainable Schools Initiative (AuSSI) was launched nationally in 2004. It is a program overseen by the Australian Government, aimed at assisting schools in the public, private and Catholic sector to invest in whole-school approaches to sustainability (DEWHA, 2009). The AuSSI program’s definition of sustainability is modelled on the Brundtland Commission Report (1987), which calls for sustainable development that “meets the needs of the people today without compromising the ability of future generations to meet their needs” (DEWHA, 2010, piii). By ‘whole-school’, AuSSI advocates for the entire school community to be actively involved in activities and learning that promotes sustainability. AuSSI’s is invested in opportunities that enhance education, environment, social and economic outcomes for the environment (DEWHA, 2010). Broadly categorised, AuSSI is concerned with curriculum development and investment/management of school infrastructure and grounds.

Regarding curriculum development, Education for Sustainability (EFS) is the preferred term amongst Australian educators for educational initiatives in schools directed at environmental issues. EFS is not a concept that is exclusive to AuSSI. In Australian schools, EFS has been an evolving concept since the first education conference hosted by the Australasian Science Education Research Association Ltd (ASERA) at Monash University in 1970 (DEWHA, 2009; ASERA website, 2015). The significance of AuSSI is that it provided EFS with a framework that has

“assisted schools and teachers to develop the skills and knowledge to make effective sustainability decisions and for schools to implement sustainability as part of their everyday operations...across the curriculum within a whole-school plan” (DEWHA, 2009, p.5).

With the introduction of AuSSI, there has been a shift in how Efs is taught in schools. For example, rather than focus on giving students only knowledge of the threats posed to natural ecosystems by overuse and depletion of resources, Efs focuses on also empowering students to make informed and sustainable decisions. This is done through a diverse curriculum that includes components such as: Envisioning a better future; Critical thinking and reflection; Participation; Partnerships for change; and Systemic thinking (DEWHA, 2009). It is intended that Efs components be integrated into the day-to-day life of the school through promoting and implementing initiatives such as recycling and compost, kitchen gardens, rubbish free lunches, energy and water audits, permaculture, biodiversity walks and environmental hero class awards (DEWHA, 2009). AuSSI support schools implementing Efs by providing links to a range of educational resources on their website. However there remain barriers to Efs, including the time required to develop lesson plans; the level of general knowledge about Efs amongst educators; the lack of professional development for educators about Efs; the availability of appropriate resources; and the C2C curriculum, which focuses on literacy and numeracy (Evans, *et al.*, 2012; Simoncini, *et al.*, 2012; Stevenson, *et al.*, 2012).

Outside of the classroom, AuSSI schools are required to show their commitment to sustainability by outlining their action plan to reduce waste, water and energy through improved management of school infrastructure and grounds (DEWHA, 2010). To aid in this process, AuSSI connects schools with environmental initiatives and programs offered by all levels of government. At a state and territory level the programs promoting sustainability in schools are Energy Smart Schools, WasteWise, WaterWise and Landcare (DEWHA, 2010). At a national level, one notable initiative was the Commonwealth Government funded ‘National Solar Schools Program’. It resulted in over 5000 schools receiving grants of \$50K to install solar panels and other energy efficient technologies aimed at offsetting energy expenditures (GBCA, 2014). A 2010 evaluation into the operational effectiveness of AuSSI revealed that through the sustainability commitment made by 3000 schools, there had been reductions of 80% in waste; 60% in water consumption and 20% in greenhouse gas emissions (DEWHA, 2010).

While AuSSI is a government-led program, there are important contributions to sustainability being made by the private sector. One such organisation is the Green Building Council of Australia (GBCA), who is also an advocate for improved sustainability in schools. In the decade directly following the creation of GBCA (2002-2012), it certified over 500 GreenStar buildings, of which 10% were in the education sector (GBCA, 2012; GBCA, 2014). The GreenStar Education tool, released in 2008, promotes the use of environmentally sustainable design features (ESD) in schools, such as controlled daylighting through correct building orientation, fenestration design and window coverings; minimised heat gain and loss through sun-shading, double glazing and insulation with high R-values; enhanced thermal comfort through thermal mass and energy efficient heating and cooling systems; good air quality through natural ventilation, reused and recycled materials and/or materials with low volatile organic compounds (Taylor, 2009)..

2.2. Contemporary pedagogy and space

The term ‘pedagogy’ refers to the instructional style or strategy employed by teachers to educate learners. The pedagogies that teachers employ involve not just the types of tasks that they set for

students, but complex sets of relations, practices and behaviours. Pedagogy also includes the social and intellectual climate that teachers create to promote learning, such as through different forms of questioning and methods of responding to students' interests and ideas.

Historically, instructivist or didactic (teacher-centred) teaching strategies were most common in Australian schools; however, in recent years there has been growing promotion and acceptance of constructivist, or student-centred, approaches to teaching and learning (Carrington, 2006; Pendergast & Bahr, 2005). Constructivism challenges the validity and effectiveness of education based on the transmission of knowledge via the traditional teacher-student relationship. Strommen and Lincoln (1992) described how learners actively construct knowledge and invent ideas through the integration of new information with simple, pre-existing notions. They suggested that through a constructivist process learners "develop critical insight into how they think and what they know about the world" (p. 468).

The design and construction of a range of 'innovative' learning spaces has followed the shift towards the adoption of constructivist pedagogies in schools (both in Australian and other parts of the world). This shift follows the belief that the physical spaces in schools effect the ways students learn (Weinstein, 1981; Upitis, 2004) and that non-traditional learning environments can aid the development of student-centred approaches to education (OECD, 2009).

Based on findings from environmental psychology studies into person-environment relations, Weinstein (1981) suggested that the physical spaces in schools can facilitate or inhibit learning through both 'direct effects', such as noise or crowding, and through 'symbolic effects', such as when poor conditions communicate to students a lack of respect for them on the part of the school they attend.

The built environment may also affect how students learn and teachers teach is through communicating pedagogical intent (Upitis, 2004). To this end, Upitis (2004) identified traditional classrooms as learning environments that embody a transmission model of teaching and learning. She concluded that traditional classrooms, born out of the Industrial Revolution, have perpetuated a transmission style of education based on core subjects such as English, mathematics and science, usually at the expense of interdisciplinary studies.

Over the past decade considerable money has been spent by the state, Catholic and private education sectors in Australia on more open and interconnected learning spaces (see below). These spaces are intended to support contemporary approaches to teaching and learning based on constructivist pedagogies. While the designs of such spaces in the early 2000s were somewhat rudimentary, more recent designs have incorporated some of the anecdotal and research-based lessons learned to create stimulating and engaging environments for learning and teaching.

2.3. Learning Environments & the Building the Education Revolution

The term 'learning environment' is used liberally in educational discourse. It describes a place that

"supports multiple and diverse teaching and learning programs and pedagogies, including current technologies; demonstrates optimal, cost-effective building performance and operation over time; respects and is in harmony with the environment; and encourages social participation, providing a healthy, comfortable, safe, secure and stimulating setting for its occupants" (OECD, 2011, p.1, citing OECD, 2006).

This definition elicits different images about the physical space requirements of learning environments. In recent decades, researchers have undertaken studies aimed at translating into a set of

guidelines the “intrinsically vague and fuzzy” ideas that exist in response to the question ‘what is a learning environment’ (Mononen-Aaltonen, 1998, p.164).

Research undertaken by Dovey and Fisher (2014) proposes that the physical layout of a learning environment can be explained using a spectrum of typologies that range from “traditional classroom through various degrees of convertibility to permanently open plans” (p.1). The notion that such a spectrum of learning environments exists, is a point of view shared by the OECD (2011, p.2) who describe physical learning environments “in the narrowest sense” as being conventional classrooms and “in its widest sense as a combination of formal and informal educational systems, where learning takes place both inside and outside of schools”.

Through an analysis of 59 plans of middle schools, Dovey and Fisher (2014) identified a continuum of five learning environment typologies, which they labelled Types A, B, C, D and E. Type A is cluster of traditional classrooms connected by a central corridor. Type B is identical to Type A, except that the corridor between is widened to create a breakout space, identified as ‘street space’. In Type C, the walls between two or more adjoining classrooms are made flexible, enabling these classrooms to be opened-up, creating a new space identified in as ‘commons’. In Type D, the walls between adjoining classrooms and the street space are flexible, allowing for the entire learning environment to become one larger space, whilst also retaining the ability to close it down into single cell classrooms. In Type E learning environments, the space is open plan where “the bridges to traditional pedagogy are burnt and doorways are largely abandoned” (Dovey & Fisher, 2014, p.12).

A study of learning environment typologies is relevant to this paper as both the defined areas of space, and the physical boundaries that define the space, are factors that can influence pedagogy opportunities and environmental sustainability. Contemporary pedagogy and environmental sustainability were amongst the issues addressed by the architects leading the Victorian Government’s first round of school projects (known as the ‘template designs’) during the 2008 Federal Government’s Building the Education Revolution (BER) (OECD, 2011). The BER was part of an Australian economic stimulus package. It was the Rudd Labour Government’s response to concerns about threats posed by the Global Financial Crisis to the Australian economy. Nationally, the BER program was worth \$16.2 billion. In Victoria, \$2.5 billion was invested into 2904 government school projects across three programs: Primary Schools for the 21st Century; National School Pride; and Science and Language Centres for 21st Century Secondary Schools (Victorian Department of Education and Training website, 2015). For the BER program, Victorian Architects Hayball and Gray Puksand developed 34 template designs for classrooms and libraries, multipurpose centres, gymnasiums, science centres and other facilities (OECD, 2011). A report on the BER by the Victorian Auditor-General (2013, p.vii) found that the opportunity to evaluate the success of the program and the new learning environments still existed, after the Victorian Government (specifically the Department of Education and Early Childhood Development (DEECD)) had “not evaluated these programs in a comprehensive and timely manner and it may have missed an opportunity to apply the lessons learned from these programs to improve its asset management practices”.

3. Methodology

The purpose of this paper is to set the agenda for future research by identify some of the synergies and tensions that exist between achieving sustainability goals and desired pedagogy within the same learning environment. The findings do not relate to an exhaustive research methodology, but instead relate to general observations made during a seven year period of learning environments research, by

three researchers working at the University of Melbourne as part of the following research teams and Australian Research Council linkage projects:

- *Smart Green Schools* (2007-2010), investigating the links between pedagogy, space and sustainability using methods such as environmental monitoring, ethnographic observation, interviews, spatial mapping and participatory action.
- *Future Proofing Schools* (2010-2012), investigating new opportunities to improve the quality of Australian prefabricated classrooms, using an international ideas competition, environmental monitoring, interviews, questionnaires, participatory action and ethnographic observation
- The *Learning Environments Applied Research Network* (LEaRN), established in 2009 to provide a multidisciplinary forum, a portal and an international network for academia and industry to research, imagine and discuss physical learning environments in schools, vocation, university, medical and corporate contexts (LEaRN, 2015). Learning environments research undertaken by LEaRN utilises a mixed methodology with methods such as interviews, questionnaires, environmental monitoring, participatory action and ethnographic observation.

The qualitative data discussed was collected using observation, which Marshall and Rossman (1989, p.79) define as "the systematic description of events, behaviors, and artifacts in the social setting chosen for study". At the time of the observation, the researchers were collecting data about a different set of research questions, but became sensitized to a broader set of issues.

4. Discussion

4.1 Synergies: Sustainability & Pedagogy

The first synergy relates to opportunities for overcoming the challenges identified in the literature, for schools trying to embed EfS into the curriculum. In *Linking Architecture and Education*, Taylor (2009) outlines the rich opportunities that exist to use the physical learning environment as a resource in teaching and learning. It requires what Taylor (2009, p.32) calls the 'knowing eye':

"a visual literacy that opens eyes and minds to the ideas and principles that are embedded in and govern the physical world, and that constitute the order of the universe".

During the *Smart Green Schools* ARC, Hes and Soccio (2012) used Taylor's ideas as a framework for research that explored how sustainable school buildings could be used as a 3D textbook. To assist educators develop relevant EfS lesson plans, Hes and Soccio (2012) created a series of adaptable 'off the shelf modules' that highlighted how the learning environment could be used to develop in students an 'ecological knowing eye'. The benefits of the 'ecological knowing eye' related to raising the general knowledge of EfS amongst educators and enabling the physical school building to become a resource for teaching EfS. Hes and Soccio (2012) explored their ideas inside four case study buildings located in three Victorian Schools. In this paper there is only the scope to discuss the research from one school.

Hes and Soccio (2012) worked with students inside Type A and Type E learning environments. The Type A learning environment was the science facility, opened in 2002. It was single storey building with a long rectilinear plan, constructed with steel and concrete, containing single cell classrooms accessible from an external covered walkway. The Type E learning environment was the agriculture/horticulture (Ag-Hort) facility, opened in 2006. It was a smaller single storey building constructed with straw-bale walls, reclaimed ironbark posts and timber cladding. ESD considerations had been part of both

architectural briefs and design responses of the two architects to ESD were dramatically different. In the Type A classroom, the main ESD consideration was for good access to daylight. The external covered walkway was a deep eave that provided summer-time shading to floor to ceiling glass walls, which faced north. There were strip skylights allowing daylight to penetrate into the back of the classrooms. Concrete would provide thermal mass and time-lag to for thermal comfort benefits on warmer summer days. In the Type E learning environment the building employed traditional passive design principles, with an exposed concrete slab and north-facing windows for thermal mass, double glazing, daylight access and sun shading, photovoltaic array, radial-sawn timber cladding and straw-bale walls.

The different design responses to ESD on display in the two buildings provided rich educational opportunities that Hes and Soccio (2012) leveraged from with the aid of environmental monitoring equipment. Inside the two buildings, students used light, acoustic, temperature (ambient and radiant), humidity, ventilation and energy-use meters to investigate how the design of two buildings responded to the surrounding environment, asking questions such as: 'How efficient it is? Does it do its job well? Is it comfortable and does it support a good learning and teaching space?' The equipment was not prohibitively expensive, with each meter ranging in cost from \$40-\$60; the exception being the infrared camera used to measuring and communicate the performance of radiant temperature. For the activities this item is not critical and can be substituted with an infra-red scanner (\$80-\$100).

Hes and Soccio (2012) observed how engaged the students were during the activities. The environmental monitoring equipment gave them a unique lens in which they could develop their ecological knowing eye. The students took ownership of their learning, often choosing to explore options that were not part the prescribed activity. The learning later informed the work that students did towards the redesign of their homestead buildings, and a much-needed composting toilet building for the Ag-Hort facility.

A second synergy relates to indoor environment quality (IEQ), which is the combined impact of acoustics, thermal comfort, lighting and air quality inside a space (Soccio, 2014). IEQ performance inside a space will be influenced by how a building has been designed, constructed, operated and maintained (Vittori, 2002). IEQ is one of the sustainability markers assessed by the GreenStar Education tool. The other sustainability markers are energy, water, emissions, land use and ecology, management and innovation (GBCA website, 2015). Inside learning environments, IEQ performance is an important issue that can have a positive and negative impact on how well students learn (Coalition for Healthy Schools, 2013). There is a relationship between poor IEQ and the energy performance of school buildings, however there is not the scope in this paper to explore this issue (Newton, 2012). Instead, the focus is on describing how IEQ can enhance pedagogy, using observations from Soccio's PhD fieldwork (2014), undertaken as part of the *Future Proofing Schools* ARC.

The research by Soccio (2014) centred on the development of a methodology for evaluating IEQ performance inside learning environments. Over 2011-2012, Soccio collected data about the performance of 16 IEQ components, which through a literature review were identified as having the potential to impact of effective teaching and learning. Eight of Soccio's case studies were prefabricated learning environments. Five of these case studies were single cell classrooms, which resembled Type A learning environments. Two of these case studies were Type B learning environment, with multiple single cell classrooms that connected to a commons. One of the case studies was a Type C learning environments; though the shared wall between two classrooms was not used over the data-collection period. Working inside her case studies over four seasons, Soccio (2014) observed cases of where careful design of IEQ systems, complemented the desired pedagogy. One of the most important related

to the level of control given to educators and students over lighting and thermal comfort. This allows for the classroom conditions to be matched to specific activities and programs. For example, in one of the Type A classrooms, the teacher had the ability to override the heating and cooling system and open large windows located on two sides of the classroom. At the time, the students were engaged in an art project and were instructed to draw inspiration from the sound of the Eucalypt trees moving in the wind and the birds nesting. In this case, the synergy between sustainability and pedagogy goes beyond IEQ, to highlight the place-based opportunities to integrate Biophilia into the curriculum. Biophilia is the term used to explain human's affiliation with nature (Kellert, 2005). In the literature there exist arguments that biophilia can strengthen student's affinity with nature and preparedness for act with environmental stewardship (Hensley, 2015).

4.2. Tensions: Sustainability & Pedagogy

Under Version 1 of the GreenStar Education tool, the IEQ category accounts for approximately one fifth of the available points (GBCA, 2015). This highlights the important standing of IEQ performance inside learning environments, due to the potential for IEQ to impact on effective teaching and learning. As outlined above, giving users control of IEQ systems can be complementary to pedagogy. In the same vein, removing user control of IEQ systems, to enhanced sustainability, can prove detrimental to pedagogy. This was observed to be the case in research undertaken by LEARN, which involved piloting the School Spaces Evaluation Instrument (SSEI). The case study was a newly constructed Type E learning environment – built using funding from the BER. Through the provision of a mezzanine level with clerestory windows, operable sliding doors and full height glazing around the perimeter of the space, the open plan learning environment had an abundance of daylight. However without any window treatment, the uncontrolled access to daylight created challenges with glare and reflection for educators and students when they wanted/needed to use audio-visual (AV) equipment to support a specific learning and teaching activity. Lux measurements undertaken by Cleveland and Soccio (2014) revealed that switching off the artificial lights inside the learning environment only accounted for a 29% reduction in the illumination levels on the smart board. The educators and students did not have a satisfactory way to resolve the issue and often had to resort to relocating into a dedicated space for using AV equipment, or “swivelling the board away from a specific glare spot” (Cleveland & Soccio, 2013, p.33).

There were other instances where automatic systems aimed at improving sustainability performance, created a tension with pedagogy. A Type A learning environment under evaluation by Soccio (2014), as part of the *Future Proofing Schools* ARC, was fitted with motion detectors for controlling the artificial lights. The teacher commented to Soccio that one of his frustrations was with the sensitivity of the motion sensor, which turned the lights off during period of low movement. This was most prevalent during tests, when students where working independently at their desks.

However, the researchers also observed instances where educators were given full control over manual systems for IEQ, but received inadequate training and information about how to optimally use them. This was the case inside the newly constructed Type E learning environment, discussed above, which was one of the learning environments evaluated by LEARN with the SSEI tool. The open-plan learning environment with operable sliding doors, mezzanine level and clerestory windows was designed to be natural ventilated. The only provision for cooling in summer was ceiling fans and in winter, semi-commercial space heaters. Cleveland and Soccio (2014) noted that the educators may “overlook” opportunities to optimize the building' environmental performance “due to a lack of specific knowledge about the preferred operations of the space in different weather conditions” For example, to

encourage air ventilation, the learning environment occupants must open the clerestory windows using a motorised system activated with a button. Once open, the clerestory windows would start the convection cycle, where fresh air would be pulled through the space while less fresh, hot air rose and was expelled.

The issue was not educating the teachers about *how* to press the button, but instead about *when* to press it. Data collected about carbon dioxide levels inside the learning environment, revealed major problems with ventilation. On average, carbon dioxide levels inside the learning environment during winter exceeded the levels set out by Australian Standards 1668.2-1992 for 1000ppm, 88% of the time. For 50% of the time, the carbon dioxide levels were 1.5times AS1668.2 recommended levels; for 20% of the time, carbon dioxide levels 2 times AS1668.2 recommended levels (Cleveland & Soccio, 2013). Through observation, the researchers noted that carbon dioxide levels peaked after activities that involved students being quite active. On such occasions, it would be recommended that the educators take action be taken to increase the volumes of fresh air circulating through the space, even if this means counterintuitive behaviour, such as opening a window in winter. High concentrations of carbon dioxide in the air can reduce the effectiveness of good pedagogy, as students can experience headaches, fatigue and/or respiratory tract irritation (USEPA, 2014). Newton, et al. (2012) exposed similar problems with high concentration of carbon dioxide inside learning environments, evaluation of three BER learning environments (Type J Templates). They concluded that “the environmental systems installed needed further adjustment to ensure both temperature and carbon dioxide levels were within acceptable limits” (Newton, et al., 2012, p.200).

4.2. Agenda for Future research

The set of synergies and tensions discussed in this paper relate to observations made by the researchers during an extended period of learning environments research. The period of observation sensitized the researchers to a set of issues that were broader than those which they originally set out to understand. By providing background information and a summary of the issues, the aim of this paper is to highlight the potential more targeted research to be undertaken into realizing how tensions may be resolved and synergies leverage from, particularly in pursuit of better understanding cross disciplinary issues.

5. Conclusion

During the first decade of the 21st century there has been unprecedented change in Australian schools. Alongside a shift by educators towards the use of contemporary pedagogy, there has also been the provision of new learning environments through the BER and increased pressure on schools to integrate environmental sustainability into their infrastructure and curriculum. The intersection of these elements has created synergies and tensions between achieving desired pedagogy and sustainability goals. The synergies discussed in this paper related to the opportunities to (1) use the learning environments as 3D textbooks, which teach students about environmental sustainability through showcasing the application and use of environmentally sustainable design (ESD) features; and (2) integrate biophilic design features that strengthen the relationship between students and the natural environment, complimenting lesson plans and learning objectives. The tensions discussed in this paper related to the amount of control that users have over ESD design features, particularly those which can impact on indoor environment quality (IEQ). Two case studies highlighted how giving educators’ little-to-no control over can cause IEQ issues that prevent optimal use the space. However, a third case study highlighted that full control over the systems coupled with inadequate training can also cause IEQ issues that prevent optimal use the space.

This paper does not propose what the answers are, instead the authors have reflected on observations made during an extended period of learning environments research to advocate for more targeted, interdisciplinary research into the issues.

References

- Australasian Science Education Research Association [ASERA] (2015) <http://asera.org.au>. Accessed 20/06/2015.
- Australian Government (2015) 'What is Aussi?'. Department of the Environment website. <http://www.environment.gov.au/sustainability/education/aussi/what-is-aussi>. Accessed 20/06/2015.
- Australian Government (2006) *Caring for Our Future: The Australian Government Strategy for United Nations Decade of Education for Sustainable Development 2005 – 2014*. Commonwealth Government.
- Carrington, V. (2006) *Rethinking middle years: Early adolescents, schooling and digital culture*. Crows Nest, NSW: Allen & Unwin.
- Cleveland, B., & Soccio, P. (2013) Research report. Development and pilot testing of the School Spaces Evaluation Instrument (SSEI): Module 2 – Technical Performance Evaluation/Indoor Environment Quality (IEQ) & Module 3 – Alignment of Pedagogy and Learning Environments(CEOM). Melbourne: The University of Melbourne.
- Department of the Environment, Water, Heritage and the Arts [DEWHA] (2010) Evaluation of the operational effectiveness of the Australian Sustainable Schools Initiative. Commonwealth of Australia.
- Department of the Environment, Water, Heritage and the Arts [DEWHA] (2009) Education for Sustainability: the role of education in engaging and equipping people for change, Commonwealth of Australia.
- Dovey, K., Fisher, K., (2014) Designing for adaption: the school as socio-spatial assemblage. *The Journal of Architecture*. 19(1), 43-63.
- Evans, N., Whitehouse, H., Hickey, R., (2012) Pre-service Teachers' Conceptions of Education for Sustainability. *Australian Journal of Teacher Education*, Vol 7.
- Green Building Council of Australia [GBCA] (2012) A Decade of Green Buildings 2002-2012.
- Green Building Council of Australia [GBCA] (2014) The future of Australian education – Sustainable places for learning. https://www.gbca.org.au/uploads/167/34983/Green_Schools_report_2013_Final_for_web.pdf, Accessed 21/06/2015.
- Hensley, N. (2015) Cultivating Biophilia: Utilizing Direct Experience to Promote Environmental Sustainability. *The Journal of Sustainability Education* 9.
- Hes. D., Soccio, P. (2012) Developing the "knowing eye" in students – a visual literacy of architecture and sustainable building using school infrastructure, proceedings at the Australian Association for Educational Education National Conference, Melbourne Convention Centre, Melbourne, 30 September - 3 October 2012.
- Mononen-Aaltonen, M. (1998) A Learning Environment – A Euphemism for Instruction or a Potential for Dialogue? *Media Education Publication* 8, 163-212.
- Newton, C., Wilks, S., Hes, D., Aibinu, A., Crawford, R.H., Goodwin, K., Jensen, C., Chambers, D., Chan, T.-K. and Aye, L. (2012) More than a survey: an interdisciplinary post-occupancy tracking of BER schools, *Architectural Science Review*, 55(3), 196-205.
- OECD (2009) OECD (2009) Innovative learning environments. International seminar and meeting of participating systems. The ILE 'universe' - cases to date. Utdanningsdirektoratet, Norway: Organisation for Economic Co-operation and Development. Centre for Educational Research and Innovation (CERI). <http://ks.event123.no/ile2009/documentation.cfm>. Accessed 15/3/10.
- Pendergast, D., & Bahr, N. (2005) *Teaching middle years: rethinking curriculum, pedagogy and assessment*. Crows Nest, NSW: Allen & Unwin.
- Soccio, P. (2014) Communicating succinct and targeted information to design professionals about the indoor environment quality inside Australian primary and middle school classrooms, Unpublished PhD, The University of Melbourne, Melbourne.
- Stommen, E. & Lincoln, B. (1992) Constructivism, technology and the future of classroom learning. *Education and Urban Society* 24(4), 466-476.
- Taylor, A. (2009) *Linking Architecture & Education*. Albuquerque, University of New Mexico Press.

- Uptis, R. (2004) School architecture and complexity. *Complicity: An International Journal of Complexity and Education*, 1(1), 19-38.
- UNESCO (2005) International Implementation Scheme (IIS) for the DESD. Paris: UNESCO.
- United States Environmental Protection Agency website (2014) <http://www.epa.gov>. Accessed 11/05/2014.
- Victorian Auditor-General (2013) Implementation of School Infrastructure Programs. Melbourne: Victorian Government Printer, <http://www.audit.vic.gov.au/publications/20130220-School-Infrastructure/20130220-School-Infrastructure.pdf>. Accessed 21/6/2015.
- Weinstein, C.S. (1981) Classroom design as an external condition for learning. *Educational Technology*, 21, 12-19. In K. A. Graetz, & M.J. Goliber (2002) Designing collaborative learning places: Psychological foundations and new frontiers. *New Directions for Teaching & Learning* (92), 13.