J. Zuo, L. Daniel, V. Soebarto (eds.), *Fifty years later: Revisiting the role of architectural science in design and practice: 50th International Conference of the Architectural Science Association 2016,* pp. 31–40.

Perspectives of sustainability elements in selected South Australian primary schools

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Abstract: In Australia, there has been an expectation that infrastructure associated with sustainability will be used for teaching. In mixed methods post-occupancy evaluations undertaken on selected case study primary schools in metropolitan Adelaide, South Australia, staff and students were surveyed about their perspectives of their built environment. The survey was designed so that participants were given the opportunity to express their general views on school infrastructure, and then they were asked specific questions about the sustainability infrastructure and activities present in their school. All schools were observed to have similar sustainability infrastructure, yet staff and students tended not report this in the general questions. In the questions specific to sustainability, students did report knowledge of this infrastructure, as did staff; however, staff did not indicate that infrastructure was a pedagogical tool despite sustainability being a cross curriculum priority. This lack of inclusion in pedagogy suggests that sustainability teaching requires more than passive infrastructure presence. While important, caution should be exercised when asserting that this infrastructure acts as a teaching tool.

Keywords: School sustainability; post-occupancy evaluation; School buildings.

1. Introduction

Australian Government policy has promoted use of school sustainability infrastructure in curricula. The National Solar Schools Program, which commenced in 2008 proposing environment and education benefits, ended in 2013 with the assertion that the $217 million allotted to 60% of Australian schools '…helped to educate students about renewable energy and energy efficiency, and that everyday actions can prevent the production of millions of tonnes of carbon pollution' (Department of Industry, 2016).

Advice from the Australian Government shortly after this during economic stimulus, identified that school buildings could '…be utilised so that they provide teaching tools or outputs (e.g., energy efficient light fittings, passive solar design)' as a way of 'advancing sustainability' through building design decisions (Australian Government, c2009). This is contemporary with the South Australian Government's ecologically sustainable development protocol requiring infrastructure to have demonstration capability for inclusion in curricula (DECS Asset Services, 2009). These guidelines presume that buildings and sustainability infrastructure are pedagogical tools, suggesting justification beyond a cost-benefit analysis.

In schools, sustainability can cover a range of implementations and resources. First, guidelines provide normative design principles drawn from the Green Building Council of Australia's Green Star ratings categories (DECS Asset Services, 2009). These instructions for designers intend to embed sustainability in the built environment fabric through resource use and waste reduction. This design-oriented guideline positions occupants as passive in their built environment, which provides a silent contribution to sustainability. As a capital investment, this contribution is best reviewed using quantity surveying and life cycle costing techniques, and is beyond the scope of this paper. Second, sustainability is considered integral to the curriculum. While Australian education for sustainability is complex in both curriculum and implementation (de Leo, 2012), at the time of the field work, primary school education included sustainability in the national curriculum as an embedded 'cross curriculum priority' and 'organising idea' (ACARA, 2011). In parallel to this, the 'Australian Sustainable Schools Initiative' (AuSSI) was also in operation, as one component of the South Australian implementation of Education for Sustainability (EfS) (DECS, 2007). Neither of these include school buildings. Third, school infrastructure is seen as a teaching tool. Policy bodies in other countries (DfES, 2006) have promoted school buildings as teaching tools about sustainability for over 10 years. Qualitative studies tend to confirm that this infrastructure can be successful as teaching infrastructure (Higgs and McMillan, 2006; Hes, 2012), but it is noted that these were undertaken in the context of supported sustainability teaching programmes.

Given the continuous political discussions about Australian school funding, it is prudent to review aspects of the effect of installation of this school infrastructure class. This research reports a component of a larger post-occupancy study of selected case study primary schools (Pearce, 2016). The fieldwork was undertaken during the 2012 school year (three years after the economic stimulus) and evaluates qualitative and quantitative evidence for recall about the inclusion of this infrastructure in school curriculum and culture. It was expected logically that, if the evidence-base driving these policy assumptions was reliable, then strong perspectives about this infrastructure would be present.

2. Methods and case studies

The post-occupancy study used a mixed methods approach to compare occupant use and perspectives with observed building fabric and services. This approach, although informed by contemporary building sustainability POE investigation methods (e.g., Bordass *et al.*, 2001; Baird *et al.*, 2012), was grounded in social science mixed methods discussions (Teddlie and Tashakkori, 2009). To maximize learning from case studies (Flyvbjerg, 2006, p. 230), schools were approached if they had been recognised with an architectural award, implying that their building quality was 'extreme', or as 'maximum variation cases' due to age as indicated by heritage listings. Four case studies schools, coded as Yellow, White, Orange and Red, participated on the condition that they were not identified publically (Table 1). All had occupied their buildings for more than five years and represented a mature occupation rather than the initial occupancy phase. Through negotiation, participant classrooms were selected to include older primary school students and enable student surveys. Out of the four schools, twenty teaching spaces (classrooms and library/resource spaces) were observed for use and environment. Across the schools, 147 student participants, aged 10-13, were recruited from eight classrooms. Staff were recruited from all areas of the participating schools (N=44).

The study considered the possibility that, unlike architects, sustainability may not be at the forefront of school users' minds, so any direct questions may inadvertently be leading questions. People draw on 'chronically accessible information' rather than context specific 'temporarily accessible information' (Schwarz *et al.*, 2008, p. 28-29). To mitigate against memory priming, the survey posed general open questions first, followed by sustainability-specific questions. Open response questions were post-coded using thematic analysis, i.e., without an *a priori* code strategy (Liamputtong and Ezzy, 2005, p. 265). Results presented here show summary code categories. These graphs represented collated and normalised thematic detail codes across schools. The five-point scale and multiple-choice questions presented use descriptive and inferential statistics.

Table 1: Summary of case study schools (at 2012)

School / Year opened Approx. floor area	Enrolment Area/student	Building construction description	Award or heritage /AuSSI
Yellow / 1877 1415 m^2	178 7.9 m^2	Buildings include stone buildings over 100 years old, block veneer and permanent lightweight.	Architectural award & heritage
White / 2003 4580 m^2	613 7.5 m^2	Greenfield school < 10 years old. Brick veneer/lightweight construction with passive energy saving devices and centralised HVAC control and BMS. Some lightweight transportables.	Architectural award AuSSI program
Orange / 1998 4300 m^2	597 7.2 m^2	Greenfield site. Construction 60/40 solid mass and lightweight transportables. Permanent buildings include passive energy saving devices (vents).	Architectural award
Red / 1877 3130 m^2	324 9.7 m^2	All buildings except 2 (lightweight & masonry veneer) > 50 years. Old buildings solid stone/brick construction. Significant interior renovations.	State & local heritage

3. Findings

This section commences by summarising the observed sustainable design elements. The contextual perspective of students and staff is then presented, followed by perspectives of school sustainability.

3.1. Observed ESD design features

All schools were audited against the DECS guidelines for ecologically sustainable design (DECS Asset Services, 2009). Selected findings are reported in Table 2 (appendix). All were found to comply with the guidelines for daylight, energy efficiency and use restriction, water conservation and renewable energy in either in their original built form (White School and Orange School), or after retrofits to the original fabric (Red School and Yellow School). All buildings were observed to have the possibility of mixed-mode use, i.e., all had both operable windows and HVAC systems; however, the operable windows were not used. Site biodiversity was increased through either food production or ecosystem in schools. Given this, it was concluded that the schools had incorporated guidelines into built environment design and use.

3.2. Contextual perspectives

3.2.1. School uniqueness

In an open question to provide context, staff and students were asked to state what was special or unique about their school. Nearly 80% of students and 100% of staff responded. Both physical facilities and non-physical school aspects made schools unique to participants (Figure 1). Students responded that buildings, building elements (specific components such as stack ventilation) and grounds made the school unique, but also identified the aspects of school culture, history and teaching / learning made the school special. Staff focussed more on building elements, grounds and visual appearance.

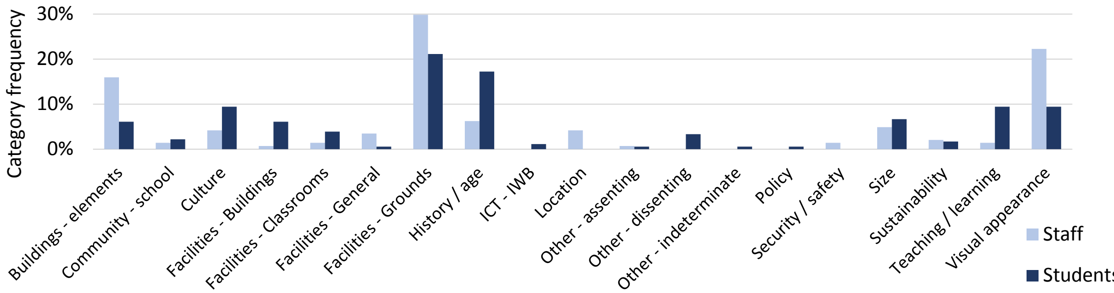

Figure 1: School uniqueness – open question category code frequencies

The detail codes generated through grounded theory coding of the text responses (student responses N=44, staff N=36 separate codes) were not uniformly distributed across case study schools, but were consistent with local conditions. Students and staff reported accurate size perspectives of schools (White and Orange School were large and Red School was small). Orange students noted that there was a variety of buildings (permanent and transportable buildings with visually distinct materiality). Building shape was reported by White School students and staff, which was consistent with the observed skillion roofline and stack ventilation.

Specific responses about sustainability aspects were coded only twice for both students (‘zero carbon’ and ‘focus’), and staff (‘sustainable development’). Other detail codes that could be associated with design for sustainability include building elements. These were coded at a low rate for both students (N=7, materials, ventilation, skylights) and staff (N=7, ventilation, skylights, automatic HVAC/windows).

The response to this open and unstructured question suggested that the uniqueness or specialness of a school was more complex than staff and student perspectives of their facilities alone. Where infrastructure uniqueness was reported, it was consistent with what was observed at the school, thus, suggesting that staff and students actually did notice their built environment, particularly large-scale form. The student participants showed that they hold definite opinions about their school's uniqueness, be it either lacking distinguishing features, or having a wide range of physical and cultural features, which suggested that they had capacity to articulate on their built environment.

3.2.2. Buildings and grounds contribution to teaching and learning

Staff were asked about their views on how buildings and grounds contribute to teaching and learning (Figure 2). Staff responded with an 89% response rate. Participants did not report any sustainability elements as contributing to teaching and learning. Rather, staff tended to report specific architectural design and the holistic learning environment as being the most important aspects of the built environment that contributed to teaching and learning.

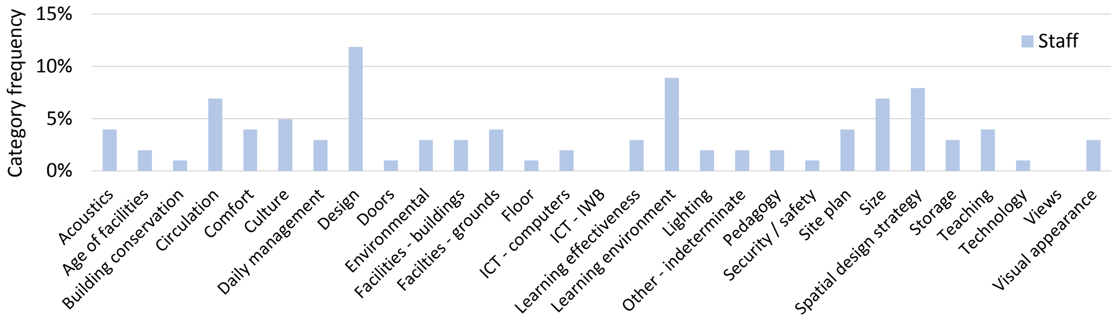

Figure 2: Buildings and grounds contribution to teaching and learning - category code frequencies

3.3. Sustainability perspectives

3.3.1. Sustainability overall and energy and water saving

Participants were given a variety of options to express their expectations and observations of school sustainability. Staff and students were asked to quantitatively rate their school as sustainable on a five point scale (response rate students 91%, staff 80%). Students responded with a perception slightly above neutral (M=3.27), whereas staff had a neutral perception of school sustainability (M=3.06), with no significant difference detected between cohorts (two tail Z-test, α=0.01).

Both groups were tested for differences between schools. Student perspectives differed (one-way ANOVA F(3,130)=3.43, p=0.019) such that students from Yellow School scaled their school as being less sustainable (M=2.84) than the perspectives of Orange School (M=3.49) and Red School (M=3.48) students had about their schools, without any difference to White School students (M=3.16). In contrast, staff responses did not differ across schools (F(3,31)=1.78, p=0.17). Given that Orange (M=3.55) and White (M=2.87) Schools had specific building elements that were intended to indicate sustainability, such as stack ventilation, it was expected that sustainability might have scored higher with these schools. Though not significant, it is noted that the Orange School staff response mean was higher than other schools (Red Staff, M=2.67; Yellow Staff, M=3.00).

Stepwise multiple linear regression on all variables found predictive variables for the perspective of school sustainability. The staff regression could not be mathematically resolved. Student perspectives were predicted moderately (R^2=0.26) by perspectives of buildings being well maintained (β=0.22, p=0.033), perspectives of energy saving (β=0.28, p=0.004), and the perspective that light helps with learning (β=0.23, p=0.022), (F(3,92)=10.96 p<0.0005). This was consistent with the installation of timers or automatic HVAC control, suggesting that these do contribute to sustainability perspectives.

Students and staff were asked to quantitatively rate their buildings for ease of saving energy and saving water. Student responses were just above neutral on a five point scale for both making energy saving easy (M = 3.29) and water saving easy (M=3.30). Staff responded with less than neutral ratings for energy saving (M=2.56) and water saving (M=2.74). For both variables, mean testing resulted in significant differences between student and staff cohorts (two tail Z-test, α=0.01).

One-way ANOVA on student and staff responses found that no schools differed significantly in their perspectives of buildings saving energy for student responses (F(3,114)=1.70, p=0.171) or saving water for both students and staff (students, $F(3,112)=1.87$, $p=0.139$; staff, $F(3,35)=0.547$, $p=0.653$). Staff response of energy saving were found to differ significantly across schools ($F(3,37)=3.74$, $p=0.019$); however, after post hoc adjustment for unequal sample size, no significant differences were found.

To explore nuances, participants were asked about their expectations and observations of school sustainability in open questions. Response rates about expectations were moderate (students 54%, staff 66%), but more attempted the question about observed sustainability (students 66%, staff 90%), suggesting that expectation of sustainability had a low awareness or importance in both cohorts. The category code frequencies for expectations (dashed) and observations (solid) are presented in Figure 3.

Students responded with expectations about building elements, daily management, energy use and reduction (photovoltaics, other energy saving devices), recycling, and described observed sustainability as building elements, energy, buildings, grounds, and recycling. They also described observed student activities as being present far more than expected, and daily management as being present far less than expected. Staff had more expectations about, energy, water and recycling, and observed more sustainability aspects in building elements than expected. Comparing the different cohorts, students expected and observed sustainability aspects in their grounds, whereas staff focussed more on building elements and design, suggesting an influence from different territories of occupation.

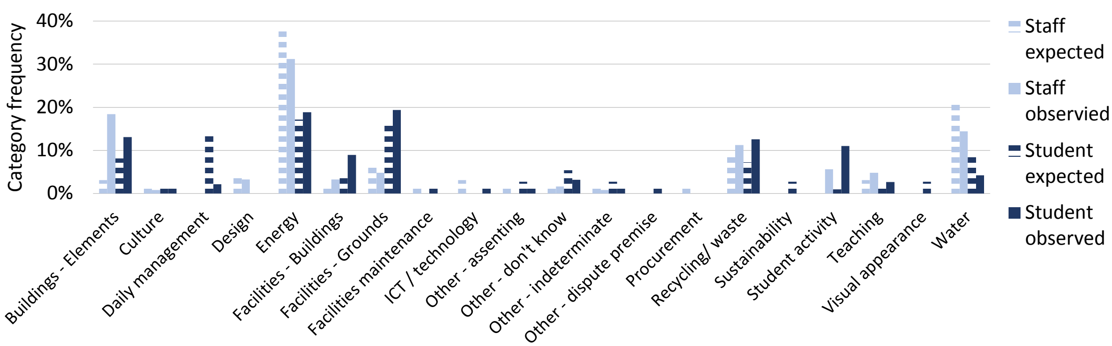

Figure 3: Expected and observed school sustainability – open question category code frequency

3.3.3. Observed use of components by students

Students' observation of staff use of selected components was collected using a multiple-choice question (Figure 4). Responses were consistent with observed case study building elements. For example, students observed heating and cooling used in schools with wall controls (Yellow, Red and Orange). Both Orange and White case study schools have air vents in the walls, but only Orange School students tended to observe them being used, possibly because the White School air vents are centrally controlled and subtly located under storage joinery so are not obviously visible to students. Figure 4 also shows that most 'other' responses came from White School students, who reported seeing that their teachers had no control over the HVAC and opened doors to improve ventilation. This is consistent with observations and the complexity of viewed instructions for the centrally controlled HVAC (observed to be five A4 pages). All of this suggests that students are observing and recalling how teachers are modifying and adapting the room environmentally using ad hoc methods.

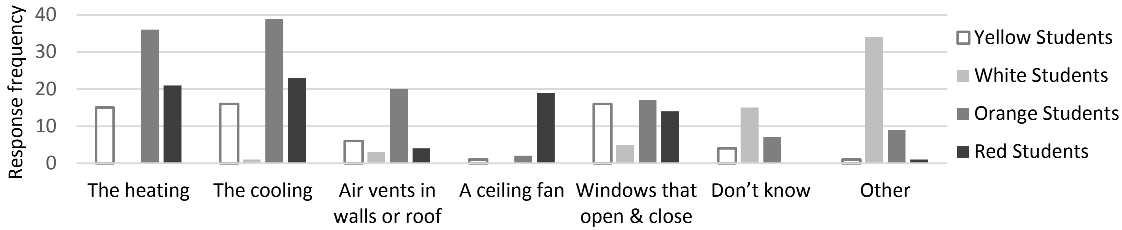

Figure 4: Components used by teachers, as observed by students – multiple-choice frequency

3.3.4. Sustainability discussed in class

A multiple-choice question was posed to capture recall about class discussions (Figure 5) based on items identified with 'ecologically sustainable design' (DECS Asset Services, 2009). Overall, when prompted, students and staff largely agreed with each other about what was discussed. Differences between schools were consistent with school configurations, such as the distinctive solid mass building materials in Orange School. White School staff and students reported air conditioning and windows at a higher proportion than other schools. This is consistent with the poor control of these elements reported elsewhere (Figure 4). The two demonstration components (DECS Asset Services, 2009), rainwater tanks and photovoltaic panels, were reported at low rates (0-5% and 4-8%, respectively).

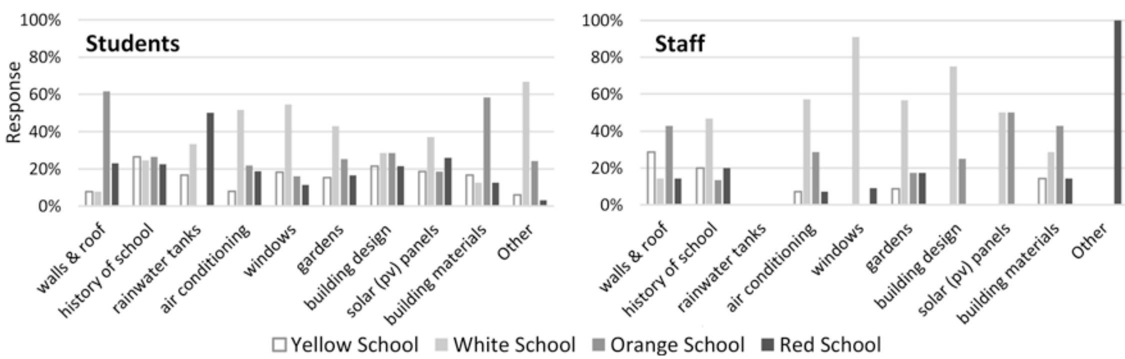

Figure 5: Built environment element discussed in class percentage response

The open section of student responses showed that students identified grounds and garden facilities as being discussed in lessons, which was also consistent with the observation that, regardless of school size, all schools had some form of garden. This suggests that when compared to, say, photovoltaic panels, the act of participating in gardening may increase student awareness and may offer more value to learning than items not maintained by students.

4. Discussion

In questions where participants were not specifically asked about aspects of sustainability, few volunteered this as, say, something that makes their school unique or special (2-3%, Figure 1), or what is considered to help with teaching and learning (Figure 2). Thus, the presence of sustainability elements is not at the forefront of recall about the school or the role of buildings in teaching and learning. This lack of sustainability building components in the school narrative, as compared to gardens, can be explained in three ways. First, the inclusion of these components as part of the curriculum may be so integrated that they become ubiquitous and are a completely normative part of the environment, rather like desks.

The second explanation offered is that additional specialist teaching resources are required to integrate these technical elements into teaching and learning, yet there was little evidence collected that this staff resource was available. In South Australia, it was recommended that a ‘key staff member’ be available for the on-going operation of ESD and reporting (DECS Asset Services, 2009), which has also been reported as necessary in other programs such as AuSSI (Lewis et al., 2009). Thus, lack of integrative resourcing may reduce awareness. Third, this inquiry did find that students tended to report activities such as gardening rather than the existence of infrastructure. This is consistent with other reported preferences for biodiversity over other sustainability themes (Lewis *et al.*, 2009).

Turning to the sustainability questions, since all schools had built environment design, fabric, and systems, that were intended to contribute to sustainability and sustainability teaching, when asked directly, it was expected that users would rank their schools highly in perspectives of sustainability. This did not occur. Given the selection of extreme case studies, this alone implies falsification of the premise and the case studies are more likely classed as critical (Flyvbjerg, 2006, p. 230).

Expectations of sustainability and reporting of sustainability elements present differed between cohorts. Staff were aware of the more (possibly intellectually) complex concepts of energy use, water, and building elements. These were consistent with the component-driven approach as proposed by the facilities standards (DECS Asset Services, 2009) but did not include the 'organising ideas' of social and environmental sustainability as proposed by the Australian Curriculum (ACARA, 2011). In contrast, student responses tended more towards participatory action rather than fabric-integrated solutions, suggesting sustainability means different things to different groups.

It has been proposed that school buildings act as teaching tools (Newton *et al.*, 2009), but also that behaviour modelling is more effective in teaching sustainability (Higgs and McMillan, 2006). The quality of interaction with the fabric also suggests a complex socio-technical interaction. There was no evidence that White School’s BMS was used as a teaching tool. Rather, staff were observed to have problems adjusting the BMS to achieve comfort using mixed-mode system. Given this, the system could be categorised as ‘risky, with performance penalties’ (Bordass *et al.*, 2001, p. 148). Where control is automated, such as in White School, modelling knowledge is lost, or replace with ad hoc ventilation solutions such as opening a door, which results in a negative modelling behaviour. On the positive side, gardens and biodiversity seem to be far more interesting to students, suggesting capital expenditure in this area is supported. Given that sustainability elements were only recalled when participants were directly asked, future evaluations should not assume that recall to specific questions about buildings is equivalent to prominence in attitude. Without establishing the relative importance of building elements to a participant in the context of their built environment, there risks claims based on false positives.

5. Conclusion

Sustainability elements in the built environment have high social expectations placed on them. In the late 2000s, as part of capital expenditure programs in Australia, education infrastructure policy expected sustainability infrastructure to contribute to teaching and learning. As part of a wider post-occupancy study, the mixed methods research presented demonstrated that staff and students have some perspectives about these components of their learning environment, but it is not prominent in their overall recall of their school suggesting a lower priority than that of design professionals. Some sustainability elements were reported as being used by teachers, thus initiating learning by modelling behaviour. While, this modelling was demonstrated to be both correct and ad hoc operation, and might comply with the notion of a demonstration appliance, it did not contribute to the narrative of school identity or teaching and learning, and ad hoc operation may detract from sustainability objectives. This is not necessarily a failure of policy, since the intention of this expenditure was also to future proof for climate change. Rather, the evidence presented here suggests that the justification of the expenditure for teaching and learning is not strongly supported; however, funding school buildings to be quietly robust in the context of climate change and sustainability has merit and is likely to be stronger evidence-based policy.

Acknowledgements

This work was completed during a PhD candidature at The University of Adelaide, South Australia. The author wishes to thank her supervisors, A.Prof. Dr Veronica Soebarto and A.Prof. Dr Terry Williamson, and the South Australian Department of Education and Child Development and participant schools.

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Appendix: Observed built environment summary of case study schools

Table 2: Observed available sustainable components (DECS Asset Services, 2009) in case study schools.

Components	**School infrastructure > 30 years old**		**School infrastructure < 30 years old**	
	Red	**Yellow**	**Orange**	**White**
Natural vent	Op. windows (unused)	Op. windows (unused)	Op. wins, wall vents, stack	Op. wins, wall vents, stack
Glazing ht	> 1200	> 1200	> 1000 high; Skylights	> 1000 high
Sill height	1200	1200	800, 1100	0, 1000, 1200
Daylight control	No shade devices Retrofitted interior blinds	No shade devices Retrofitted interior blinds	Shade devices: Retrofitted film-perm Blinds-Transportables	Shade devices: Blinds (west) Veranda extension
Insulation - roof	Likely[a]	Classrooms – unikely[a] Library - No	Permanent blds - Yes Transportables- no	Likely[a]
Insul. - ceiling	Unknown	Library	Yes	Likely[a]
Insulation - walls	No, except one classroom	No, except library	No - permanent blds Yes - transportables	Likely[a]
Mass-walls/floor	Yes / Yes	Yes / Yes	Yes / Yes	No / Yes
Reduce const. resources	Possible - use of local mass wall material	Possible - use of local mass wall material	Possible - use of local mass wall material	Unknown
Energy eff. components	T5 lamps Heat exchanger[a]	T5 lamps	T5 lamps	T5 lamps, BMS Heat exchanger[a]
Energy limiting	Timers HVAC, lights	Timers HVAC, lights	Timers HVAC, lights	AutoHVAC, Timers lights
Renew. energy	Photovoltaics	Photovoltaics	Photovoltaics	Photovoltaics
Water, saving, harvest, reuse	Rainwater tanks - toilet flush	Nil	Rainwater tank (disconnected)	Suburb recycling system water saving taps
Site biodiversity	Food production garden	Food production garden	Eco-system, Food	Food production garden

a. No roof access due to WHS issues. Judgement based on reading local conditions using professional architect knowledge.