SUSTAINABILITY FOR LEARNING ENVIRONMENTS

EDITOR'S PREAMBLE: Every brief and every client anticipates that building designs will be informed by sound environmental decision making. Quantitative research, particularly from the USA, has confirmed our commonsense notion that learning improves with good lighting, ventilation and water proofing as well as thermal comfort and acoustic control. In this paper, Dominique Hes provides an introduction to and critique of the relatively new Green Star rating tool for education buildings. One of the aims of the rating tool is to provide a road map for designers and clients to help them make good environmental decisions.

Dominique concludes with a critique of the current rating tool for education and a suggestion for how to move forward even if the tool is not yet ideal.

INTRODUCTION

Schools have a significant impact on the environment through their embodied and operational use of resources and through their ability to shape young minds.

Further, school design has a significant impact on the ability of the teacher to teach and the learner to learn. Currently, there is a large investment being made in the renewal of existing schools and the design of new ones along Ecological Sustainable Design (ESD) or ‘green’ principles. But in the push to produce greener schools, it is important not to forget that these spaces need to work well pedagogically as well as ecologically; the design of schools should provide effective healthy learning spaces that use energy, water and resources efficiently. This paper briefly introduces Green Star—Education v1 and how it is used, but its main focus is on those aspects of the rating tool that relate to the provision of effective learning environments. This will lead to a suggested definition of what it might mean to create effective, ‘green’ learning environments.

Effective Learning Environments (ELEs) support teaching and learning by providing the appropriate facilities and environments to carry out learning activities. That is supporting student centred, problem based learning through the ability to use multi communication methods, engagement with knowledge in active, flexible ways and the ability to work at different scales with different sized learning groups.


Tools

To support the design and construction of effective ‘green’ learning spaces, building rating tools, guidelines and checklists have been developed in many countries. However, caution needs to be applied in their use, for the tools may not cover: ‘the social aspects of sustainability such as inclusion, participation and fair shares for all. Nor ... take account of what makes a good learning environment (for example... integration of external and internal space, flexibility of spaces for different uses, adaptability of building structure etc.).’ That is, they are only useful in as far as they facilitate the design of effective learning environments. If a ‘green’ school does not facilitate learning then the author would argue that it is not sustainable and the invested energy and resources have been wasted as the designed space is not fulfilling its function.

Yet rating tools can provide a road map that together with educator input can lead to buildings that are sustainable. The recently released Green Star—Education v1 rating tool is one such tool. It has been based on the Green Building Council of Australia’s (GBCA) experience with office building tools which were developed using the UK’s Building Research Establishment Environmental Assessment Method (BREEAM) system, and the North American Leadership in Energy and Environmental Design (LEED) system.

According to the GBCA, the Green Star rating system was created to:

- define green building by establishing a common language and standard of measurement;
- promote integrated, whole-building design;
- identify building life-cycle impacts;
- raise awareness of green building benefits;
- recognise and reward environmental leadership; and
- transform the built environment to reduce the environmental impact of development.

Green Star—Education v1 is a tool designed specifically for educational buildings because of their unique requirements and user profiles. Also, unlike the office tools, the Green Star—Education v1 tool incorporates a tailored energy calculator that assesses the designs based on their potential and predicted greenhouse gas emission in operation. It is designed as a voluntary tool and aimed at the industry-leading project. The pop-out box over outlines the tool and describes the process of using the tool.

“Rating tools can provide a road map”

Dr Dominique Hes

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GREEN STAR—EDUCATION V1—ELIGIBILITY, ASPECTS COVERED AND PROCEDURE

Specifically, the Green Star—Education v1 tool ‘evaluates the environmental initiatives and/or the potential environmental impact of new education facilities, and additions to and major refurbishments of existing education facilities’.  

Eligibility criteria for Green Star—Education v1

Buildings primarily used for educational purposes (e.g. primary or secondary schools and university buildings, including libraries) are eligible for Green Star—Education provided that they:

1. Have the following mix of GFA (measured to exclude internal car parks):
   - A minimum of 80% of BCA Class 9b, 8 and 5 space;
   - A minimum of 50% of BCA Class 9b space; and

2. Are not any of the following:
   - Buildings with over 20% of GFA dedicated to retail food service and/or indoor swimming pool(s);
   - Libraries that are not on education campuses; or
   - Facilities primarily dedicated to childcare.

As with other Green Star tools, a spreadsheet which is freely available online, guides the user through the assessment. It is only if a project wants to publicise its use of the tool and its assessment that an official assessment is required. Though, if it is the intention of the project to make the use of Green Star publicly it is advisable to begin the assessment process from day one. Many of the assessment credits align with that of the other Green Star tools those that are specific to educational buildings are:

- Efficient External Lighting;
- Centralised Energy Systems;
- Transport Design and Planning;
- Potable Water Use in Laboratories;
- Recycled Content & Reused Products and Materials;
- Flooring;
- Joinery; and
- Loose Furniture.

To meet the conditional requirement: The project’s predicted greenhouse gas emissions must meet the greenhouse gas emission benchmark. The Green Star—Education v1 Energy Calculator determines the benchmark for each project based on the composition of space types within each project. The conditional requirements are:

<table>
<thead>
<tr>
<th>Primary and High Schools Conditional Requirements (kgCO2-e/m²/annum)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Classrooms</td>
<td>61</td>
</tr>
<tr>
<td>Computer and physics labs</td>
<td>127</td>
</tr>
<tr>
<td>Office and staff rooms</td>
<td>85</td>
</tr>
<tr>
<td>Library</td>
<td>73</td>
</tr>
<tr>
<td>Common space</td>
<td>53</td>
</tr>
<tr>
<td>Canteen</td>
<td>65</td>
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<tr>
<td>Workshops</td>
<td>77</td>
</tr>
<tr>
<td>Gymnasiums</td>
<td>58</td>
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<tr>
<td>Car parks</td>
<td>58</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Universities Conditional Requirements (kgCO2-e/m²/annum)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching/classroom spaces</td>
<td>82</td>
</tr>
<tr>
<td>Dry labs/specialty learning spaces and libraries</td>
<td>88</td>
</tr>
<tr>
<td>Office/administrative spaces</td>
<td>79</td>
</tr>
<tr>
<td>Common spaces</td>
<td>57</td>
</tr>
<tr>
<td>Wet labs (varies based on density of fume cupboards)</td>
<td></td>
</tr>
<tr>
<td>Gymnasiums</td>
<td>143</td>
</tr>
<tr>
<td>Car parks</td>
<td>52</td>
</tr>
</tbody>
</table>

The process for attaining a Green Star rating is, firstly to register with the GBCA. This incurs a cost depending on the size of the building. Next it is a matter of working through the spreadsheet to determine which criteria the project will aim for. Having a Green Star professional as part of the team will not only provide one credit, but will also ensure that the design team has someone to help them understand the level of commitment each credit will require. The documentation required is extensive and this needs to be both well understood and allowed for in the process from the beginning. Figure 1, shows the process of application. Once all the documentation has been collected it is submitted and sent to a third party panel of accredited assessors commissioned by the GCBA. It is usual for most projects to only get a fraction of the credit in the first round, thus there is a second round where they can address any feedback. Usually the reasons for this is a lack of documentation for the credits applied for, for example credits claimed for installing a large rainwater tank but it not being shown in the plans. Projects generally achieve most of the credits they have aimed for in the second round.

<table>
<thead>
<tr>
<th>APPLICANT</th>
<th>GBCA</th>
</tr>
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<tbody>
<tr>
<td>Round 1</td>
<td></td>
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<tr>
<td>Project eligibility</td>
<td>Project registration</td>
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<tr>
<td>Requires round 2</td>
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<td>Round 2</td>
<td></td>
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<tr>
<td>Round 2 submission</td>
<td>Round 2 assessment</td>
</tr>
<tr>
<td>Rating not achieved</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Application procedure for a Green Star certification

Finally, a Green Star rating is only given for those buildings that achieve 4 or more stars, in line with the other Green Star tools:

- 4 Star Green Star Certified Rating receives a weighted score of 45–59, this signifies ‘Best Practice’
- 5 Star Green Star Certified Rating receives a weighted score of 60–74, this signifies ‘Australian Excellence’
- 6 Star Green Star Certified Rating receives a weighted score of 75–100, this signifies ‘World Leadership’

Credits are divided over 9 categories of:

- Management—14 credits aiming to ensure a good foundation is set for the project, looks at issues of commissioning, the design and development process, documentation and future guidance;
- indoor environment quality—26 credits aiming to ensure that the indoor environment of the schools are performing optimally in relation to the air quality, lighting and pollutant;
- energy—29 points aimed at ensuring the building's design uses the minimum amount of energy while maintaining amenity and thus generates a minimum amount of greenhouse gases;
- transport—13 credits related to how people get to the school, specifically bicycle facilities, car parks, access to public transport etc.;
- water—16 credits related to design for water efficiency and recycling;
- materials—27 credits aiming to ensure that those materials chosen for the school are low in impact;
- land use and ecology—8 credits which aims are ensuring a minimal impacts is had on land use and the environment;
- emissions—14 credits aiming to deal with issues of Legionella prevention; refrigerant choice in relation to ozone depletion, greenhouse gas emissions and leaks; water course pollution and discharge to sewer and light pollution; and,
- innovation—5 credits aimed at supporting innovation through use of new technologies, ability to go beyond the Green Star bench marks and scope.

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EFFECTIVENESS OF GREEN STAR TOOLS IN TRANSFORMING SPACES

There is only sporadic evidence of the capacity of the other Green Star tools to inform the design of better performing ESD buildings. This is due in part to the fact that there is no requirement for Green Star rated buildings to report on their performance publically. One of the main sources of information about Green Star rated buildings is the GBCA’s own reports aimed at helping to argue the business case for adopting Green Star to achieve sustainable building outcomes\(^\text{11}\). While this report shows the resource and financial savings of Green Star rated buildings, it does not discuss the effectiveness of the spaces designed. Results from individual case studies, however, do highlight the impact Green Star has had on the design of effective spaces.

Council House 2, housing the City of Melbourne staff, includes natural ventilation, thermal mass and indoor air quality design strategies that have resulted in a low noise, open-plan environment filled with greenery and gentle diffuse light. Aside from reducing energy and water usage by over 70 percent, CSIRO research has also found productivity and occupant health improvements of almost 11 per cent over previous council accommodation\(^\text{12}\). 40 Albert Road, a building refurbishment, resulted in energy efficient spaces saving even more energy and water than CH2 while providing occupants with high air quality, using natural ventilation and daylighting where possible.

In reviewing these examples, what is evident is that the design of buildings using ESD rating tools is better considered. By employing the Green Star tool the design outcomes were occupant-sensitive resource-efficient buildings effectively integrating aspects of the local environment such natural ventilation, light, solar collection, etc.

However, using a tool such as Green Star does not guarantee a more sustainable building. Research done in Australia and internationally points to the operation of the facility and the behaviour of the occupants as central to determining the effectiveness of the design\(^\text{13}\).

For schools this means how well the school is operated and maintained and the systems in place for training staff and students is as crucial as is the design of the space itself.

"HOWEVER, USING A TOOL SUCH AS GREEN STAR DOES NOT GUARANTEE A MORE SUSTAINABLE BUILDING"

Dr Dominique Hes

ASPECTS OF GREEN STAR THAT SUPPORT DESIGN OF EFFECTIVE LEARNING SPACES

Many of the aspects covered by Green Star—Education v1 are related to potential building performance and not to the creation of effective learning spaces. From the

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research discussed below lighting, ventilation and water proofing have the highest impact on learning effectiveness, followed by providing adequate thermal comfort and minimising acoustic problems. The remainder of this paper outlines these aspects of learning spaces design, citing why they are important outlining the relevant Green Star credits associated with them.

**LIGHTING**

The Heschong Mahone Group\(^{14}\) showed that the effects from the introduction of controlled natural daylight to classrooms, along with allowing views to the outdoors, resulted in an increase in student achievement of 26 per cent. In addition, Shum Miller\(^{15}\) showed that daylight in classrooms can have an impact on reducing illness, absenteeism and an improvement in student behaviour. Daylighting strategies are most effective when the user can control heat gain and the amount of light and glare. If possible design should make use of indirect light either by allowing light in from the south (for the southern hemisphere, north for the northern hemisphere) or bouncing it in through light shelves. Light shelves will increase the distance natural light will travel into, and may illuminate a space by an extra 25 per cent.

In recognition of this Green Star—Education v1 provides six credits related to windows and daylight. ‘IEQ 4—Daylight’ provides the bulk of the credits and is related to providing a two per cent daylight factor over as much of the floor plate as possible, ‘IEQ 11—Daylight Glare Control’ provides one credit where it is demonstrated that glare has been adequately dealt with while ‘IEQ 14—External Views’ which provides one credit if 60 per cent of a nominated area has direct line of sight to views.

Significant savings on operational lighting costs can be achieved through effective natural and artificial lighting. For example, it is not necessary to have uniform lighting across an entire classroom, varying the lighting allows for the highlighting of spaces and the differentiation of activities and will lead to energy saving\(^{16}\). Long-term savings can be achieved through the future proofing of function through design for retrofitting by using different luminaries, diffusers or adaptive switching strategies. Green Star ‘IEQ-12—High Frequency Ballasts’ and ‘IEQ-13—Electric Lighting Levels’ provide one credit each in relation to artificial light levels and IEQ, under Energy ‘Ene-4—Lighting Zoning’ provides a further credit.

**AIR QUALITY AND VENTILATION**

The link between respiratory illnesses such as asthma and mould has been thoroughly demonstrated in medical research.\(^{17}\) Mould commonly occurs in poorly water proofed and ventilated buildings. A significant percentage of absenteeism in schools is due to asthma-related illnesses. Cox-Ganser et al.\(^{18}\) found that in the US between 1994 and 1996 asthma led to 14 million days of school loss—an average of 3.4 school days per child. Thus effective green learning spaces must be designed to ensure that areas where mould typically occurs are eliminated. According to Edwards:

... it appears evident that those green schools which give priority to daylight and natural ventilation generally outperform other schools.\(^ {19} \)

Within Green Star—Education v1 air quality and ventilation is covered by three credits which includes appropriate ventilation rates (IEQ-1) and Air Change Effectiveness (IEQ-2) and specifically through ensuring relative humidity is controlled in mechanically ventilated buildings (60 per cent relative humidity in space and 80 per cent relative humidity in ductwork) or by specifying naturally ventilated buildings (IEQ-10—Mould Prevention). Limiting the ability for moisture to build up has the added benefit limiting that aspect in the degradation of buildings, leading to longer lasting facilities and therefore a better return on financial and environmental investments.

Moisture ranks as a leading cause of structural damage, and excess moisture in a building has been associated with a variety of health problems in children and adults.\(^ {20} \)

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Thermal comfort

Richard de Dear concluded that there are productivity benefits (through the perception of comfort by building users) if the indoor temperature reflects the outdoor temperature more closely, particularly if they have control over their environment. From an operational energy perspective this means that the temperature bands do not need to be as narrow, for example 21.5+/–1°C, saving conditioning energy as well as reducing the size of plant and equipment needed. Green Star—Education v1 ‘IEQ-5—Thermal Comfort’ provides the potential for three credits to improve thermal comfort: one credit is awarded if there is adequate user control for workstation areas (note not classrooms) and a further two credits are allotted if defined standards are met of either ASHRAE or ISO7730.

Acoustics

Many schools aiming to integrate ESD and a more flexible approach to the use of space have large open areas to allow multiple activities and though this offers good opportunities for daylighting and cross-ventilation it often results in poor acoustic performance. Careful analysis of the potential internal and external noise levels when considering space design is crucial. Often, within the design process, the acoustic analysis is carried out too late requiring either a change in the design or expensive retrofitting. Bringing in the acoustic engineers earlier will help minimise this extra effort ensuring an integrated design minimising the chance that acoustic treatments are removed as a cost-cutting exercise. Green Star—Education v1 covers acoustics through ‘IEQ-7—Internal Noise Levels’ providing two credits.

“OFTEN, WITHIN THE DESIGN PROCESS, THE ACOUSTIC ANALYSIS IS CARRIED OUT TOO LATE”

Dr Dominique Hes

occupants of when to open windows, close blinds and turn off lights, in order to maximise its ESD performance—green building perform best if they have green occupants. Green Star—Education v1 approaches this through ‘Man-5—Building Guides’ which provides two credits for the development of building guides while ‘Man-10—Learning Resources’ provides one credit for fostering an understanding of the building by making it a learning resource. This mean that the resources invested into the efficient design of the building will be used by the occupants (students and teachers) for lived, tacit, learning, fulfilling one of the criteria of an ELE. Wilkinson agrees arguing that an educational space:

... should show the interconnections between natural systems and human needs where possible, making the building itself a positive factor and tool in learning about sustainability rather than just a neutral backdrop.

GREEN STAR—EDUCATION V1 AND EFFECTIVE LEARNING ENVIRONMENTS

The Green Star—Education v1 rating tool supports the design of ‘green’ schools by providing guidance on what is considered best practice for adequately lit, ventilated, comfortable, acoustically effective and resource efficient ESD buildings. However, as Green Star is primarily an ESD tool it only provides limited guidance on the design of Effective Learning Environments. Further research on how to achieve both educational and green objectives and create Effective Green Learning Environments (EGLEs) is necessary. A tentative definition of an Effective Green Learning Environment is:

... an environment that supports teaching and learning through the provision of adequately lit, ventilated, thermally comfortable and acoustically effective spaces that are resource efficient in construction and operation. Further, EGLEs provide opportunities for tacit learning through interaction, understanding and engagement with the building, systems and space.

The design of EGLEs requires the use of established strategies for the ‘green’ design of schools but also the inclusion of expertise on current pedagogical requirements from project inception. A current Australian Research Council project called ‘Smart Green Schools’ has brought together a multidisciplinary team of educators, architects and ESD experts to explore these issues.

CONCLUSION

The aim of this paper was not to provide an overview of the whole Green Star—Education v1 rating tool, but to reflect on those credits that support both more environmentally friendly building and effective learning outcomes. It is interesting to note that those credits related to more effective learning outcomes, as discussed here, only make up a small percentage of the total credits available. This raises the question: should a tool such as Green Star just focus on environmental performance and ignore the less quantitative issues of comfort and student performance, or is a more complex tool that includes learning effectiveness, pedagogical and curriculum aspects required? For now, ensuring the educators and students have a voice in the design alongside the use of Green Star seems to be the best way forward.

ACKNOWLEDGEMENTS

The author would like to thank Kate McMahon and Kendra Wasiluk for their assistance and Sean McArdle from SBE for his input. The Smart Green Schools’ research has been funded by the Australian Government through the Australian Research Council Linkage Grant Scheme. The Chief Investigators of the grant entitled, Smart Green Schools, are Clare Newton, Dr Dominique Hes, Dr Kenn Fisher and Professor Kim Dovey with Dr Sue Wilks as Senior Research Associate. The industry Partners are the Victorian Department of Education and Early Childhood Development, the Victorian Government Architect’s Office, Rubida Research, Mary Featherston Design, Hayball, H2o Architects, McGauran Giannini Soon Architects, McBride Charles Ryan Architects and SBE Melbourne.

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Title:
Sustainability for learning environments

Date:
2009

Citation:

Persistent Link:
http://hdl.handle.net/11343/192438

File Description:
Published version