Showcasing 'Real' Green Buildings: A Case for Post Occupancy of University Buildings

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Throughout their life cycle; from construction, operation to demolition, buildings contribute to environmental impact. Globally, there has been a shift towards adoption of green building policies, legislation, various programmes and rating tools for all new construction and refurbishment projects. While most of these policies and regulatory developments, including assessments have flowed through into office buildings; universities, particularly as building owner and occupier and operating in mainly urban areas are beginning to recognize the opportunities of following such policies for their own assets.

The University undertook a feasibility study to evaluate the actual versus expected performance of its two new 5 Star Green Star accredited buildings: Building A, housing business related disciplines; and Building B, housing built environment and related disciplines. The case studies were undertaken using a Post Occupancy Evaluation (POE) for monitoring building performance as the green star ratings are design intent only and do not reflect actual building performance.

A survey to understand the connection between the building user's outlook, and building operation and management, was undertaken using a Building User Studies (BUS) occupant survey. These evaluations were carried out in each of the two buildings to measure occupant satisfaction, complemented by internal stakeholder interviews, and energy performance data. This study showed that the buildings did not perform well in all aspects of the BUS survey, but performed well compared to other buildings at the University campus. A major source of dissatisfaction was the lack of engagement with the staff working in these buildings.

This study assists the University to evaluate how the buildings performed and the applicability and value of their existing green building standards. For the wider design community, analysis of the data highlights the importance of measurements to ensure optimization of the built environment, and recommending strategies for efficient management of buildings.

Keywords: Post occupancy evaluation, built environment, university buildings, Green Star, sustainability, building performance, Australia

Karishma completed her Bachelors and Masters degree in Environmental Studies and Resource Management. She has worked in private organisations on projects related to sustainable resource planning and forming corporate-community partnerships in Indian industries. She has also worked on projects related to energy efficiency measures in the commercial and residential building sectors in Australia.

She is currently pursuing a PhD in the field of sustainable buildings and their management. The aim is to enhance the overall energy performance of buildings (academic) by analysing the gap between actual versus expected performance. The research also looks at the impact of stakeholder engagement on project success and recommending strategies to close the feedback loop and establishing appropriate management frameworks in an organisation to achieve energy efficiency.

Usha started working in the field of energy efficiency and conservation since the late Eighties. This has now broadened to encompass sustainability issues in the built environment. She has worked in architectural practices in India, Canada and Australia, bringing practical knowledge of energy efficiency and conservation and triple bottom line sustainability to buildings and the built environment. Usha brings wide industry experience to her teaching and research. Usha is colead of the Sustainable Buildings and Construction Programme, 10 year Framework of Programmes on Sustainable Consumption and Production. She has been invited as key note speaker and invited speaker at National and International Conferences. She has been involved as an expert in panel discussions for Australian government and industry and as sustainability advisor/Board member for various built environment peak bodies in Australia.

Matthew is experienced in leading multi-disciplinary, multi-cultural design and engineering teams and has enjoyed building business opportunities through motivating and empowering inter-disciplinary teams in Australia, China, Hong Kong, Philippines, and the USA. He is one of the twelve active committee member of the Property Council of Australia's Future Trends committee providing advice on the 'new' and 'next' of property innovation trends for Australian property investment businesses. Matthew also sits on the Standards Australia sub-committee for Indoor Air Quality working to develop an Australian standard for air quality within our built environments. He is currently working on measuring occupant productivity and well being in relation to overall building performance.

Introduction

With increasing globalization and population increase worldwide, attention is turning to the significant role buildings play in contributing to harmful emissions to the environment. In addition to reducing building emissions, climate adaptability of new and existing buildings is also critical for mitigating climate change effects on the built environment, particularly in urban areas. As a result, incorporation of renewable and sustainable features in the built environment has become one of the major foci for policy planners and the design community, including building operators.

Tertiary academic institutions generally manage extensive land and building portfolios and have a wide range of schools/departments (built or refurbished) that increasingly need to comply with sustainable design principles. After the implementation of principles of sustainability and climate change, the management of the performance of university buildings throughout their life cycle must be monitored appropriately for ensuring optimal outcomes for all stakeholders. These academic institutions have a high ratio of direct users (staff, students and building managers) involved. They have potential for showcasing themselves as best industry practice models as they nurture future generations of building designers, planners and managers.

This research studies and compares two newly constructed sustainable buildings (Green Star rated buildings) at a University in Australia. The aim is to study the benefits of incorporating green planning, design and construction in these two buildings, and to understand the significance of appropriate building performance and management practices for mainstreaming into the design, construction and operation of university assets.

The University has committed to including sustainability as part of its operations. It has signed up to a greenhouse gas (GHG) emissions reduction target of 25% by 2020 based on 2007 levels. It has also made a commitment to purchase 20% of the University's electricity from certified Green Power. The University has many buildings, both new and refurbished, which may be used to showcase examples of innovation and excellence as well as show commitment to sustainability and climate change on a larger scale. The two buildings included in the study are Building A (housing the schools related to business) and Building B (housing schools of built environment disciplines). The study examines the performance of these buildings with a focus on energy evaluation. Thus the study does not focus only on the intent to achieve sustainable outcomes from a design perspective, but also on the actual performance of the buildings, focusing on energy as a major criterion underpinning sustainability outcomes.

This research, therefore, aims to understand the disconnect between the design and performance of a building which is uncommon in standard practice in the industry. Industry usually focuses on design intent for sustainability, rarely do studies undertake post occupancy to understand whether design intent has been met. The objective of the study was to investigate the significance of evaluating occupant satisfaction and using the respective POE data to facilitate performance management of the buildings involving property and asset management support. Broader outcomes include the development of clear assessment mechanisms for establishing links between performance measurement and performance management at micro and macro levels with an understanding of how occupants view its value and what lessons can be gleaned from this exercise for both the university and the design and build community.

Green Star Education Rating Tool

Green Star has a brand reputation in Australia. It is a certification system, and has a similar foundational basis to similar types of rating schemes worldwide such as LEED (Leadership in Energy and Environmental Design) (USGBC, 2015) and BREEAM (Building Research Establishment Environmental Assessment Method). With more than 428 projects certified, Green Star assesses and rates against a range of categories aiming to encourage leadership in environmentally sustainable design and construction, showcasing innovation in sustainable building practices, and considering occupant health, productivity and operational cost savings.

The Green Building Council of Australia (GBCA) 'Value of Green Star' report of 2013 stated that on average, Green Star certified buildings produce 62% lower GHG emissions, use 66% less electricity than conventional buildings and use 51% less potable water than average Australian buildings. The report also found that Green Star - As Built certified buildings recycled 96% of their construction demolition waste, compared with the average recycling rate for new construction projects of 58% (GBCA, 2013). Green Star may be used for a range of different building types, including educational institutions.

To achieve Green Star certification, buildings are judged on various aspects. Those relevant to understanding how a building operates are management, Indoor Environmental Quality (IEQ), energy criteria including factors such as building commissioning, building tuning, building guides, occupant satisfaction, IEQ parameters, GHG emissions etc. These factors evaluate how buildings are intended to be managed during operation. Hence, as the study focuses on performance management of buildings involving building users, Green Star buildings serve the purpose of understanding the buildings better. Building A scored a total of 13/14 under management criteria, 18/25 under IEQ criteria and 18/29 under energy criteria in the Green Star application originally submitted. Similarly, Building B scored 12/14, 13/25, 14/29 respectively in the three categories.

Post Occupancy Evaluation (POE)

Evidence shows there is a lack of a connection between the building user's outlook, how buildings are operated and managed, and the appropriate techniques for evaluating building performance. 'Evaluating the performance of buildings should be considered as an iterative process which acts as an ongoing process and extends to upgrading and refurbishment of buildings in occupation' (Green and Moss 1998, p. 36). One way to monitor building operations is Post Occupancy Evaluation (POE).

'POE over the years has progressed from a one dimensional feedback process to a multidimensional process that acts as an integrated element that can help drive the building procurement process further' (Hadjri and Crozier 2009, p. 33). The fact that POE is not an established part of the current management guidelines and framework as a mainstream activity reflects the historic obstacles to the building development process. It has been defined in several studies as, '... a process of systematically evaluating the performance of buildings after they have been built and occupied for some time (Preiser 2002, p. 42). It has also been defined as a 'Process of systematic data collection, analysis and comparison with explicitly stated performance criteria pertaining to occupied build environments' (Preiser *et al*., 1988), 'An appraisal of the degree to which a designed setting satisfies and supports explicit and implicitly human needs and value for those for whom building is designed' (Friedman *et al*., 1978, p. 20) and 'More holistic and process oriented evaluation' (Preiser 2002, p. 9).

General Benefits of POE

'By carrying out an evaluation of the building's performance after completion, commissioning and a period of use helps to find whether the buildings actually performed as they were supposed to do' (Derbyshire 2001, p. 81). POE helps to assess occupant's satisfaction and reactions, maintain appropriate management structures, provide inputs to regulatory processes, and helps to achieve operational targets.

POE has the potential to maximise building performance and thereby support social, environmental and economic or triple bottom line (TBL) benefits of sustainability. POE acts as a useful snapshot of users' views and 'assists in better understanding of the use and re-use of buildings over long life-cycles' (Whyte and Gann 2001, p. 460). POE can be explored architecturally, within realms of psychology, sociology and also technology, particularly where technology adoption is an issue. The most optimal time to undertake a POE is when sufficient time is given to the occupants to settle in the building in order to get appropriate results. This is usually a full year after moving into the building so that building services have operated over a whole year through different climate cycles (ASHRAE, 2013).

Involving users, and measuring their level of satisfaction with respect to various factors helps to obtain performance measurement results for a building, which when constructively utilized by facilities or building managers can assist them to affect change in a building. The results can assist facilities managers (FM) to continually test their strategies and meet organizational objectives, because 'whenever there is gap between the current results and FM's strategic objectives, there is an opportunity for improvement' (Amaratunga and Baldry 2002, p. 220).

By carrying out traditional and modified forms of POE, the study evaluates how changes in user behavior results in changes in the overall outcomes for building users and the technologies used in the buildings. By aligning occupants/users' perceptions to the primary design intent, there are opportunities to develop the link between the POE results for the buildings under study and also for the university.

'The overarching benefit from conducting POE is the provision of valuable information to support the goal of continuous improvement' (Zimmerman and Martin 2001, p. 169). Appropriate management or decision-making has a significant impact on implementation of POE and highlights its success within the facilities management framework. Thus in this research, the use of POE methodologies provides the ability for organizations to productively utilize users' feedback to help achieve building performance goals.

Gaps in POE Studies

The literature (for example, Kelly *et al*., 2005) shows particular aspects of thinking and personality that differ between simulation and reality or highlights the difference between the people who build models and those who actually use the space. By creating a bridge between the thoughts of building users and the way authorities manage the buildings is the core of this study. 'The main opportunity here lies in further innovation in the appropriate application of evaluation methodologies already existent' (Baird *et al*., 1996, p. xxi).

Previous research (Preiser *et al*., 2009) has highlighted the absence of scientific exploration of POE as a mainstream activity in the building procurement process. 'The rapid interest in POE quickly evaporated amidst various concerns and it became a subsequent failure to become part of an architect's normal services' (Cooper, 2001, p. 159). 'Distrust about the POE process from within the construction industry especially with concerns about the impact of POE on personal indemnity insurance has made the adoption of POE more challenging' (Cohen *et al*., 2001).

In buildings, distinguishing between an organization's and facilities management related issues has been difficult. The culture of the construction industry does not support ongoing learning and improvements at the same pace as for example, the Information and Communications Technology (ICT) industry. Typically, solutions are sought only when a failure is reported or needs to be investigated. Despite global interest in people's well-being and concerns of the quality indoor spaces and productivity, comparatively little advancements have been made in POE. A major barrier to POE is cost.

The design and structure of educational facilities is intended to shape the ways we think about education for the future (Radcliffe *et al*., 2009). In the 21st century, educational leaders are expected to understand how technologies can contribute to incorporation of sustainability elements in the design. This requires management structures and frameworks to be aligned with the organizational setting in order to support the design intention and overall infrastructural, psychological, social and philosophical objectives. There are many leading examples in literature showing such innovation and Building A explored in this paper is one such example, although this innovation is more prevalent in the commercial building sector than in the academic sector. Other notable recent examples in the non-residential sector in Australia, which have also undergone post-occupancy evaluations, include Council House 2 (Paevere and Brown, 2008), MLC Centre (BUS Methodology, 2015) and ANZ office Docklands (Alessi *et al*., 2014).

It is necessary to pave the way for the adoption of POE in the design and building industry so that buildings may be well managed to the original design intent. More collaboration is needed between architects, building designers and construction professionals as well as those involved in facility management and performance evaluation of buildings. To ensure the study stays within the scope, this research focuses on indoor environment quality of the workplace and the approach required to achieve the energy targets to optimize building performance. The users of the building are therefore the core stakeholders of this research.

Role of stakeholders

Stakeholders in universities are varied and it is worth examining this briefly. Stakeholder management is a critical component to the successful delivery of any project, programme or activity. A stakeholder is any individual, group or organization that can affect, be affected by, or perceives themselves to be affected by a programme (Bourne, 2015). University stakeholders may be quite diverse and a resolution of conflicting demands may be required for effective management.

Effective stakeholder management creates positive relationships with stakeholders through the appropriate management of their expectations and agreed objectives. Stakeholder management is a process and control that must be planned and guided by underlying principles and common goals. Stakeholder management within businesses, organizations, or projects should lead to the development of strategy utilizing information (or intelligence) gathered during common processes. The main criteria to understanding stakeholder management is to identify the stakeholders, prioritize them and understand their needs.

Methodology

The University is committed to improving sustainability across all areas of activities. Despite some of these buildings having received numerous awards, showing appreciation by the design community for their sustainability outcomes from theoretical perspectives, no practical evaluations have been carried out for the buildings.

Detailed evaluations of two recently constructed Green-Star rated buildings were conducted to observe and evaluate performance in reality: Buildings A and B. Both are new buildings completed within two years of each other. The main types of schools housed in the buildings are different, as are their size, number of levels and volume. The key features of the buildings are described in the table below:

Table 1 Key features of the two study buildings

Features	Building A	Building B
Build Type	New Build (completed 2012)	New Build (completed 2010)
Faculty	Business related	Built environment related
Green Star Rating	5 Star Green Star (Design v1)	5 Star Green Star (Design v1)
Building Volume	52,000m^3	22,000m^3
Gross Floor Area	35,000m^2	13,000m^2
Number of Levels	15	7
Number of Occupants/Building Users (Staff)	Academic: 514 Non-academic: 175	Academic: 78 Non-academic: 41

The evaluations were conducted using two main methods: a Post Occupancy Evaluation (POE) using Building Use Studies (BUS) survey and stakeholder interviews.

POE provides a useful snapshot of user/occupant views, and assists in better understanding of the use and re-use of buildings over long life-cycles, in particular to enhance and achieve sustainable outcomes. The types of POE methods used in this study are as follows:

i. Questionnaires - using user satisfaction surveys (hard copy or online versions) to measure occupants' reactions and responses and standard BUS surveys measuring indoor environment quality;

ii. Walk in discussions with building users;

iii. Stakeholder interviews - semi structured interviews and open ended discussions were conducted with various stakeholders (facility managers, property/ asset managers, and academic and professional staff) to understand the design intent, drivers for the sustainable shift, barriers faced throughout the process and lessons learned for future project success. The stakeholder interviews focused more on the process and role of management in the design, construction and operation of the two buildings.

The research activities are explained in detail:

Step 1: Post Occupancy Evaluation: Distribution of BUS surveys

The BUS survey has been applied in numerous research projects across the world for both residential and non-residential buildings (Arup, 2015; Leaman and Bordass, 2001). It is a 3 page survey and takes approximately 10 minutes to complete. The time involvement is critical to note. If surveys take too long, respondents will lose interest in undertaking the survey. A balance between the user's views and time required needs to be considered. The survey measured building user responses and reactions on overall building performance and their indoor environmental comfort.

Survey Format

The BUS standard has 63 questions in total. The survey measures provide a range of quantitative and qualitative responses pertaining to the perceived satisfaction of the occupants based on 12 lines of enquiry:

1. Occupant profile relative to age, sex, time in the building, time at desk, time spent on computer, workgroup size
2. Window seats and other basic information about the sample and the respondents
3. Ratings and feedback for design, needs, image, cleaning, storage, meeting facilities
4. Response times for key variables such as acoustics, travel etc.
5. Perceived productivity
6. Perceived health
7. Thermal comfort
8. Ventilation
9. Lighting, including glare
10. Noise, including interruptions
11. Furniture and space in the building
12. Other workplace performance variables including e.g. perceived control

It is worth noting that this standard survey format, particularly related to thermal comfort and ventilation areas, requires the building occupant to comment on their ability to individually control ventilation and thermal comfort. This level of control is often not provided in commercial facilities, therefore some additional survey interpretation is required.

The POE also analyzed building performance data (electricity, gas, water, temperature and occupancy rates) using data from the respective Building Management System (BMS). Collected data was compared to initial Green Star Educational Design v1 utility performance aspirations as determined by the Green Building Council of Australia (GBCA) in the educational design rating tool, and the wider university Campus building stock to assess building performance compared to other university buildings. Survey data was also cross-checked with the performance analysis and stakeholder interviews to triangulate outcomes.

Survey Response Rate

The survey was distributed as an online version to all academic and non-academic staff of the two buildings. The researcher followed up after a week. A hard copy was also given to occupants who found it easier to complete the survey at the time it was handed out. The overall response rate for the BUS survey for Building A was 20% and for Building B was 79%.

Step 2: Walk in Discussions

Walk in discussions were held with the academic and professional staff and building managers in each building after evaluation of the survey results to support a process of triangulation. This was done to cross check the results obtained from surveys regarding survey efficacy.

The findings from the survey suggested that the teaching and learning spaces are well utilized and liked, and the building image helps to elevate the overall institutional image. What did not work well for users was the lack of project related consultations and not being notified about the design intent and entire project delivery. Further concerns are the open space office planning creating noise pollution (affecting productivity, concentration and privacy) and storage issues. Some of the statements by users are as follows:

[The architects] culture and approach to design is one where they do put sustainability upfront within the design process...From a sustainability engineers perspective, that works in our favor as you know you are going to get that engagement early in the process and buy in. (Stakeholder 2, Building A).

If you don't get the design right the operational impacts are huge, they're massive. (Stakeholder 5, Building A).

Decent facilities (good natural light, security) and a good communal workspace, but flawed all round (Stakeholder 1, Building B).

The utilization stats from last year were 20% more attendance in the classes in the building than the rest of the university. (Building User 9, Building A).

Airflow, glare and noise can impeded concentration. Sometimes I might go elsewhere to work, otherwise the only option is to put up with it or find a workaround (standing fans etc.) (Building User 2, Building B).

As an exhibition venue it is very good, as a venue for office space it is moderately ok, as avenue for teaching it is very difficult (Building User 11, Building B).

The open office planning is terrible. It has affected my productivity greatly. It would have been better if the users were discussed in the design brief and the decision would have not been entirely management driven (Building User 7, Building A).

In many ways it is a beautiful building but the relentlessness of material pattern and harshness of materials used in interiors makes for a strange and ultimately dispiriting place to spend time in (Stakeholder 4, Building B).

A gap from other buildings had been that while the building technically had been delivered very well the actual occupation and transition into the building was something which was sometimes a bit lacking (Building User 2, Building A).

Noise issues alter how we conduct meetings, discussions, etc. Discussions of a private nature are very difficult to have. Security issues heighten levels of vigilance, make it difficult to have and do specific work, some staff + students do not feel safe working in the building (Building User 5, Building B).

I just think that if they just spend a bit more time closing out these things and making sure the monitoring is correct and ensuring the commissioning is done properly and doing sustainability more holistically it will be a brilliant building for the next 20 years (Stakeholder 3, Building A).

Step 3: Stakeholder Interviews

Interviews were conducted with key internal and external stakeholders (17 for Building A and 8 for Building B) involved in the design, construction and/or occupation of both the buildings. Stakeholders included the project manager, builder, architect, Environmentally Sustainable Design (ESD) engineer, building facilities manager, and senior managers, advisors, directors and student representatives from within the University. Interviewees were identified by the University campus and facilities service project manager are key people who had been, or continue to be, involved in the design and development of both buildings.

Interview questions focused on what worked well during the project, what the challenges were, and what they thought the lessons for future projects were. Interviews were audio recorded and transcribed where possible. Care was taken to reduce interviewer bias as much as possible through various techniques such as reframing the questions in different ways to ensure triangulation of responses.

Results and Discussion

This section presents the results and discussion from the evaluation of the two study buildings. The technical performance of the building and BUS survey are presented first. This is followed by outcomes from the interviews with a focus on the role of management in achieving triple bottom line (TBL) sustainability outcomes.

Building Performance

For the environmental element of the triple bottom line (TBL) approach, both buildings achieved a Green Star Education certification rating of 5 stars (v1). As evidenced from the interview analysis, this was a standard driven by senior management of the University and integrated into the development from building conception. To achieve a 5 star rating, a benchmark university building should have 44kWh/m^2 annual energy intensity, and 68kWh/m^2 (in terms of electricity and gas) of usable floor area. Energy intensity in this research was measured in terms of electricity and gas usage per building. Electricity was used for lighting and gas was used for heating and cooling. For Building A, energy intensity equates to a total of 104kWh/m^2/year and 57.8kWh/m^2/year (electricity and gas). For Building B, this equates to a total of 82.6kWh/m^2/year and 49.7kWh/m^2/year (electricity and gas). Building A has a higher energy intensity as it is almost double the volume and floor area of Building B (see Table 1).

Table 2 Green Star Educational Design (v1), 5 Star performance energy criteria for study buildings

	Teaching/ Classroom Spaces	Office/ Administrative Spaces	Common Spaces
Total Electricity kWh/m^2/year	68.6	69.5	39.3
Total Gas kWh/m^2/year	14.3	1.5	0.8

Table 3 5 Star performance energy criteria for study buildings

Energy Criteria	Building A Teaching/ Classroom Spaces	Building A Office/ Administrative Spaces	Building A Common Spaces	Building B Teaching/ Classroom Spaces	Building B Office/ Administrative Spaces	Building B Common Spaces
Total Electricity kWh/m^2/year	88.2	89.1	49.7	71.5	76.3	41.2
Total Gas kWh/m^2/year	23.8	3.2	1.9	17.4	2.1	1.2

Analysis of the utility consumption data found that the energy usage for both buildings was higher, with Building A having a higher value than Building B. Energy use for the administrative spaces in both buildings were higher than the teaching and common spaces, which is logical as they are used mostly throughout the year. On average, the administrative spaces are typically used for 52 weeks of the year and sometimes on weekends for activities such as Open Day etc.

In Building A, energy use in the administrative spaces was 30.2% higher than the common spaces. Again this can be attributed to the fact that common spaces are only used during semesters and in between classes. In Building B, energy use was 5.1% higher. What is significant, however, is that usage is approximately half when compared to University campus buildings (Figure 1). In part, these results are affected by a significantly higher occupancy rate in Building A than in Building B, as well as the fact that Building A is a much bigger building than Building B. In analyzing kWh/m^2/occupant based upon actual occupation, the utility consumption for Building A and Building B were found to be 98% and 92% lower than comparable buildings in the university. From a GHG emissions perspective, Building A is performing at 3.5 times and Building B at 1.8 times higher than the predicted rate. The higher value Building A is again in part due to the higher utilization of this building.

The BUS survey confirmed occupant satisfaction with the building in terms of performance and function. The survey found that the building performed excellently in three categories: overall comfort, design and image to visitors. However, it performed poorly in two categories: perceived health and overall noise level. The survey results placed Building A in terms of satisfaction levels in the 64% top percentile, and Building B in the 57% top percentile, compared to Australian benchmark data. This indicated that achieving improved environmental sustainability performance did not compromise occupant satisfaction.

Figure 1 Comparison of actual and target/predicted energy performance

Table 4 BUS survey results for common variables between both case study buildings

Summary Chart 12 key variables.
Each measured on a 7 point slider scale:
1 = unsatisfactory/uncomfortable/poor/less healthy
7 = satisfactory/comfortable/good/more healthy

Color indicated perceived performance against the benchmark data set. There are 3 ratings:

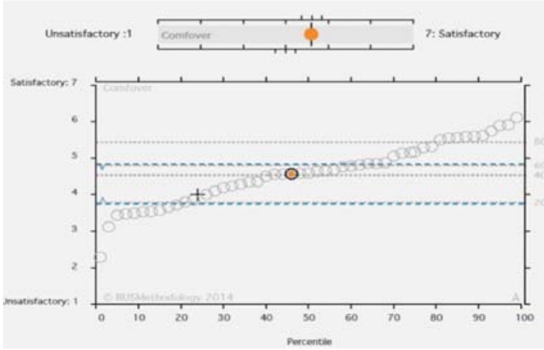
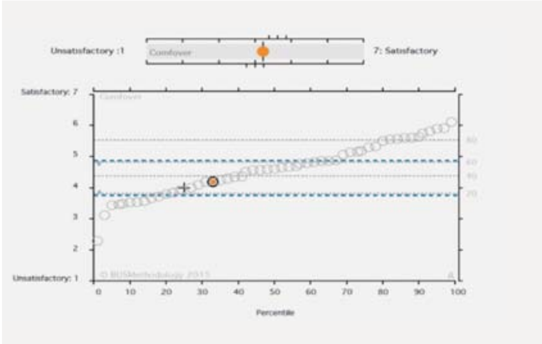
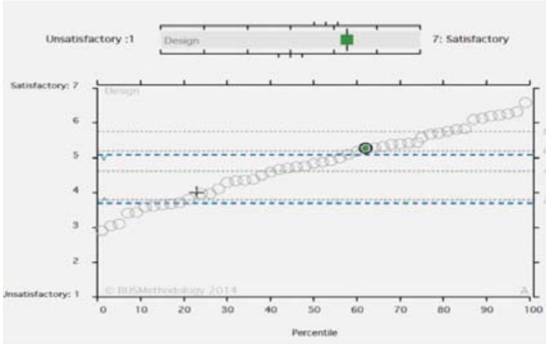
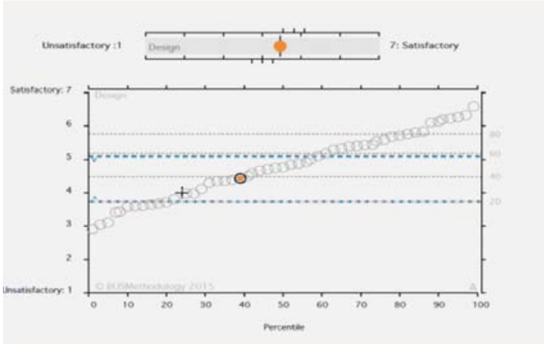
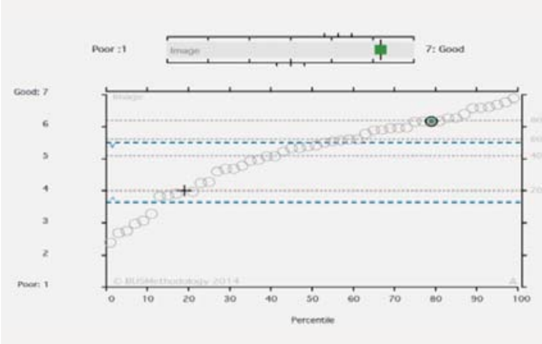
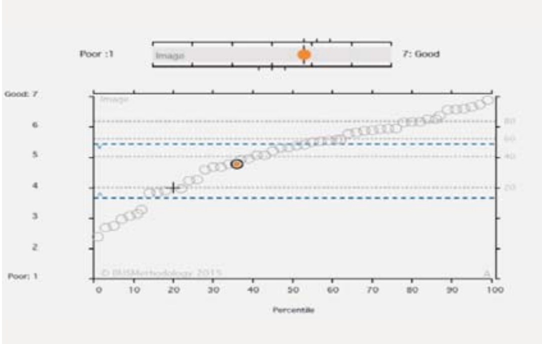
Green	building performing better than data set
Amber	building is average
Red	building under-performing, needs improvement

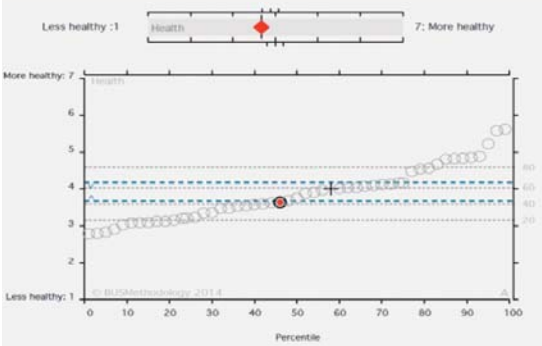
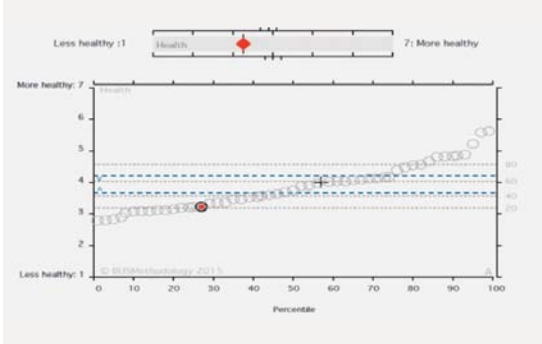
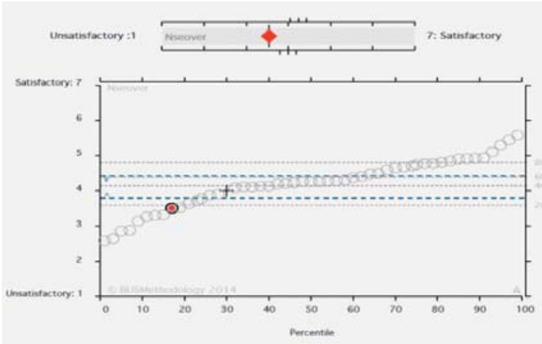
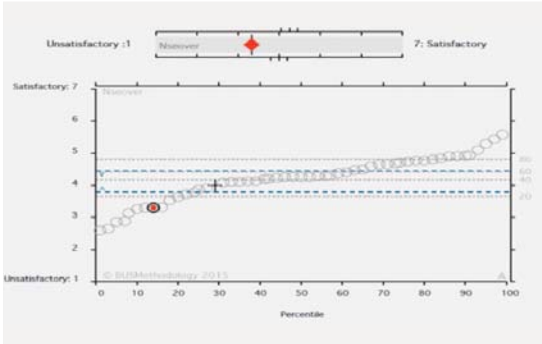
The **graph** shows building performance benchmarked against other Australian buildings. It allows identification of how each variable performs within the building against the benchmark. Dataset available on a percentile chart (0-100), allowing quick identification of 'above' or 'below' average characteristics. It also allows building performance to be rated against the benchmark dataset.

The **circles** (empty fill) are the values of other buildings (commercial only) in the benchmark dataset. **Fill Color** shows test results with the color being green, amber or red (performance against dataset). The two blue **broken lines** represent the upper and lower critical region limits to demonstrate where:

The study building falls, e.g. falls between the critical region limits/falls above the limits.
The **x-axis** represents the percentile score (0-100).
The **y-axis (left)** represents the variable scale (1-7); the **y-axis (right)** quintiles (sample/population is divided into fifths).

+sign represents the scale midpoint: mean of the dataset (in percentile).

Variable	Building A	Building B
	Variables that 'Worked Well'	
Overall Comfort		
Building Design		
Image to Visitors		

Variable	Building A	Building B
	Variables that 'Did Not Work Well'	
Perceived Health		
Overall Noise		

Interviews

The interviews with key stakeholders found a number of challenges, successes and lesson learned. A summary of key outcomes are presented below, with a focus on the role of management in ensuring TBL sustainability outcomes.

By including the requirement for environmental performance targets in the design brief, the architect and other key stakeholders were able to integrate sustainability outcomes as part of the concept design and discussions from the beginning. This meant that environmental considerations were not added on, but informed the philosophy of the design. The use of the Green Star Educational Design v1 framework meant that a broader consideration of all elements of sustainability was required, rather than just whatever were the key strengths of the stakeholders involved. Both buildings had different policy guidelines; Building A was a fixed price guaranteed contract while Building B was a traditional design and build (designed and build by different entities), hence there is no shared ownership of building performance in the latter compared to the former. The University's facilities and campus services have learnt from this experience and are in the process of integrating a number of outcomes regarding different design into the revision of the various types of University Design and Policy Guidelines.

Overall, the development of both the study buildings has been very successful from an environmental sustainability perspective, occupant perspective and financial perspective. However there are lessons which can be drawn upon for future developments to improve outcomes further.

Conclusion

The study presented an analysis of the gap between actual and expected performance in two University Green Star buildings. It demonstrated how POE generated results assisted to achieve this objective. Outcomes included the development of clear assessment mechanisms for establishing the link between building performance measurement and performance management with an understanding of how occupants viewed its value. In addition, the buildings were compared to other University buildings to understand if the energy performance of the building did achieve expectations. Comparisons were carried out on how well the buildings have been managed post construction (in conjunction with annual energy targets), improved (where required) and reported.

From the analysis of POE results of the case study buildings, it clearly indicated that building users (academic and non-academic staff) were dissatisfied in all categories of the BUS survey such as noise and perceived health, and their needs had not been considered in the design brief and throughout the progress of the project. However, after triangulating the outcomes and examining the broader context, both buildings met their key parameters in terms of Green Star certification and energy performance. Most of the factors related to the design, overall performance and study spaces worked well with the exception of a few concerns about temperature fluctuations, noise and storage issues according to the users.

In both buildings, the decision to create Green Star standard buildings was entirely management driven. The buildings were created mainly from a teaching and learning perspective and to achieve high rates of student satisfaction. Focusing on the true building users (academic and non academic staff, as opposed to students who are a transient population) was not one of the key agendas in the framework and design intent, leaving building users dissatisfied. This major gap is found in theory as well as practical emerging examples worldwide where building user interests are not being considered in the design and development of the building. This lack of consultation leads to lower productivity and ineffective performance management of buildings in the long run. Dissatisfied users also prove that respective built environment management frameworks are not well structured, lacking appropriate stakeholder management and understanding of their potential impact on project success. Hence the study indicated that focusing on technical issues alone to achieve building sustainability is not sufficient for a building's success. Being "green" is only one important feature of building success, but other aspects of the building (for example, user needs and comfort) must be considered as well.

POE can provide insights which ultimately can contribute to the continual improvement of a building provided it is well executed. The POE outcomes in this study reflected the value people and processes play in designing, building, using and operating/maintaining buildings. Ultimately, this may be seen as a process to promote and capture valuable data which demonstrates measurable return on investments, creates dialogue between individuals and teams from multidisciplinary service delivery streams, as well as engaging with end users. Based on the results, this paper emphasizes the integration of POE services as a streamlining activity that needs to be incorporated as part of the management framework for new as well as existing building stock.

The research outcomes of the study can be applied to other areas of owner occupied assets such as private property managers as well as government. While this study did not specifically look at productivity in green buildings, this is another area that can be added on to obtain a holistic picture of design, performance and user engagement to optimize outcomes.

Acknowledgement

We would like to express our gratitude to our colleagues Dr. Ian Ridley, Dr. Trivess Moore, and Dr. Jin Woo. We thank them for their assistance in conducting surveys, collecting utility data for Building A and Building B, and providing their insights and expertise that greatly improved the research.

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ISSN 2311740-0