How Do Occupants Perceive the Building Performance of Award-winning Schools in the UK

YANTI CHEN, BRIAN FORD[2]

[1, 2] Department of Architecture and Built Environment, Faculty of Engineering, University of Nottingham, Nottingham, United Kingdom

ABSTRACT: School design can contribute to reducing carbon emissions and raising environmental awareness among the next generation. A good school environment can have positive effects on occupant behaviour, mood and working productivity, etc. This paper selected three RIBA award-winning schools as research examples in order to investigate how the occupants perceive the actual building performance of their school, and its impact on their use of the building. Post-occupancy evaluation (POE) based on occupant surveys and interview was linked to internal environmental performance and energy use. Generally, the feedback was satisfactory. However, some aspects of the buildings' environmental performance, such as air quality, lighting environment and thermal comfort, were considered unsatisfactory by school staff at certain times. This study indicated that there are gaps between design intent and actual building performance, and also highlighted the importance of the relationship between school design and school users. Design suggestions to achieve a better school environment are identified in the conclusion.
Keywords: sustainable school, building performance, occupant perception, post-occupancy evaluation

INTRODUCTION

• Background

The built environment, the largest source of energy consumption and carbon emissions, accounts for 40-50 percent of greenhouse gas. To address this issue, the previous UK Government announced an ambitious target for both new homes and non-domestic buildings (new schools, both public sector and private sector) to be 'zero carbon' from 2016 and 2019, respectively.

Schools are important in achieving wider low-carbon ambitions, not least because of the impact on students in terms of increasing their environmental awareness. And it is not only about influencing students, but also their families and the surrounding communities [1].

• School programmes in the UK

A series of school programmes which aimed at improving school quality and providing comfortable environment were set up by the Government and education department, and the programme projects have been reviewed by professional panels in terms of their design quality and environmental impacts. Building Schools for the Future programme (BSF) was the largest single capital investment programme in schools in England in 50 years, and it was aimed at rebuilding and renewing all of England's 3,500 state secondary schools to achieve better school environments and design quality. However, it was scrapped in 2011 by the new Government because of the UK public financial deficit [2]. A project review showed that the design quality of BSF schools were "not yet good enough" [3]. The latest school programme in the UK is the Priority School Building programme (PSBP) launched since July 2011 and centrally-procured by the Education Funding Agency (EFA) on behalf of the Department of Education. It is set up to address the condition requirements of the schools most in need of repair.

• The importance of the school environment

"*Sustainable schools are better environments for learning* [4]." The value of sustainability in design, construction and operation can bring either economic or environmental benefits to schools, such as lower operating costs, higher student test scores, increased building life and lower environmental impact, etc. Hence it is essential for architects to understand how to design successful schools having good environmental performance. 10 criteria were provided for successful school design by the Commission for Architecture and the Built Environment (CABE) [5]. In these criteria, the importance of the relationship between schools and environment is emphasised, as well as the links between the quality of the internal environment, occupant well-being and performance.

• Research objectives

In this research, it was assumed that award-winning buildings represent 'design excellence' to a certain extent, and three of the UK's award-winning schools were selected as case studies. The three schools have been awarded high appraisals from professional panels in the aspect of their 'sustainable design'. The objective of this investigation was to explore how the school occupants feel about the building's internal environment in use, and how the schools impact on users. And it attempted to draw some useful 'design messages' for future school design.

POST-OCCUPANCY EVALUATION METHODS

Many buildings do not perform as intended. Sometimes building design negatively affects running costs, users' satisfaction, productivity, health and comfort, etc. Post-occupancy evaluation (POE) is the process of acquiring feedback from users on building performance in use. It is useful to identify existing problems of building design, indicate the weak links between management and operations and also provide recommendations and benchmarks to improve design and procurement on future projects [6].

• BUS Methodology Occupant Survey

Building Use Studies (BUS) Occupant Survey Method [7], which has comprehensively considered various factors in order to maximise the evidence reliability, has been utilised in this research for POE. It covered aspects of the building's mechanical design, environmental performance, and operational strengths and weaknesses.

The respondents are asked to score these aspects of the building on a 7-point scale: typically from 'unsatisfactory' to 'satisfactory' or 'uncomfortable' to 'comfortable', where a '7' would be the best score. In presenting the results, the green square denotes a variable with an average score better than both the scale mid-point and the corresponding benchmark. The amber circle indicates an average score which is typically better than the mid-point of the scale, but not significantly different from the benchmark for that variable (Fig.1), and the red diamond shows an average score that is lower than both the mid-point of the scale and the corresponding benchmark [7].

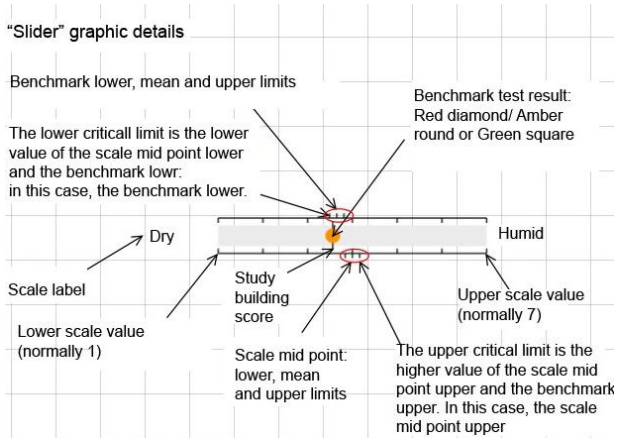


Figure 1: The details of an example of the BUS survey results analysis. (Source: Building Use Studies)

In this research, staff of the selected schools were treated as participants of the POE survey, including teachers, headteachers and service staff. The three-page questionnaire was distributed to each member of staff, and above 50 percent of staff responded to it, hence the POE results are able to generally reflect occupant perception regarding those schools in use. Additionally, short interviews were also involved to provide valuable comments and feedback from occupants.

DESIGN INTENT VS. POE FEEDBACK

Three primary schools in the UK which received RIBA awards were selected as field study projects, and the criteria for the award related to design quality, including sustainable design issues. This section describes the design strategies of each school separately. The following POE feedback reflected users' overall perception regarding the buildings in use, and identified the existing issues negatively affecting user comfort, well-being and productivity.

• School A- design description

School A is a newly-built community school, located on a semi-rural residential area in Hampshire. It was built in 2008 and serves 210 pupils age 6 to 11. The awards it received highlighted its spatial design quality as well as its potential in environmental performance.

Designed in two principle linear forms, the main teaching block is to the southwest, and the northwest block is where all the communal spaces are located, making it easy to manage after-hours community use (refer to Fig.2). The central courtyard is an external relaxing area for both students and staff. The main structural frame of the building is steel. Bricks and cedar panels were used as cladding materials for external walls.

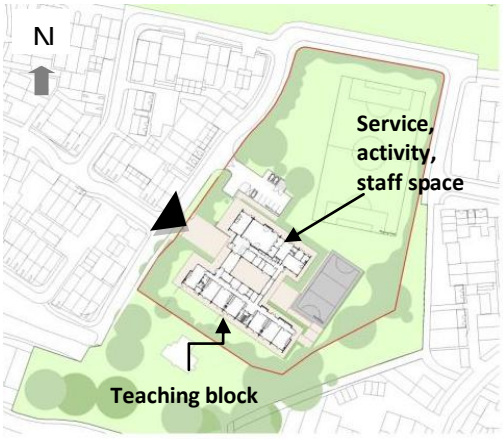


Figure 2: The site plan of school A with function explanations. (Source: HCC Property Services)

In terms of the environmental design, daylighting was implemented by large glazed areas on school elevations and rooflights in classrooms, the hall space

and circulation space. The building is naturally ventilated, and classrooms are provided with specially-designed ventilation panels (with acoustic attenuation), while windows and doors are normally closed during classes or cold seasons (Fig. 3). There are no radiators in the school, and the under-floor heating system is controlled by the Building Management System (BMS). Hot water for heating is primarily provided by ground source heat pumps underneath the hard play area, and photovoltaic panels were installed to off-set electricity for ground source heat pumps.

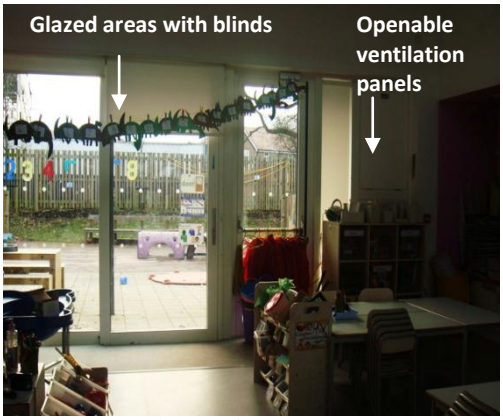


Figure 3: The internal view of a classroom in school A.

• School A- POE feedback

The POE survey achieved a 76% response from staff in school A. The overall feedback was generally good (Fig. 4), and most of the staff felt satisfied about the school design and said that "it is a great environment to work".

However, although the overall variables indicated generally satisfactory feedback, some factors are not that successful. Figure 5 shows the indicators which were either lower than the benchmark or the middle of the scale. Issues of slightly dry air in summer and less air movement in winter were emphasised by some users, and the glare risk in classrooms as well as too much natural light was also pointed out. In terms of adapting to the school environment, some staff commented that *"it is difficult to adjust the interior temperature except opening doors"* and the *"ventilation panels were hard to open (normally not open)"*. Besides that, the headteacher complained about the inconvenience to manage the building by using BMS and the high electricity bill due to the use of ground source heat pumps.

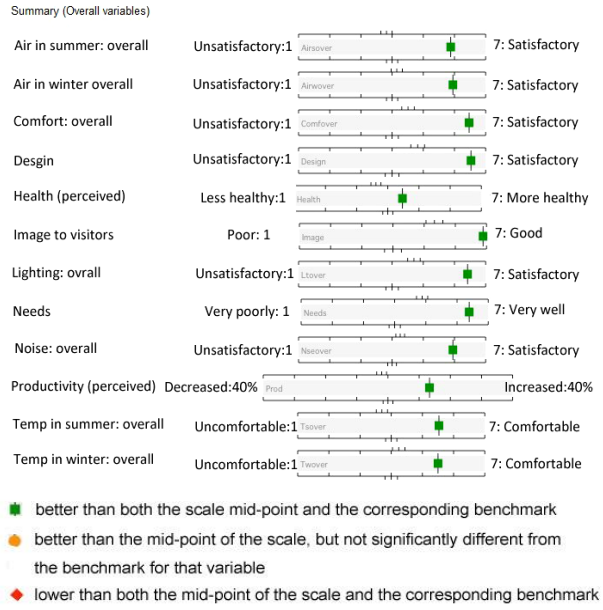


Figure 4: The POE summary of overall variables in school A. (Source: Building Use Studies)

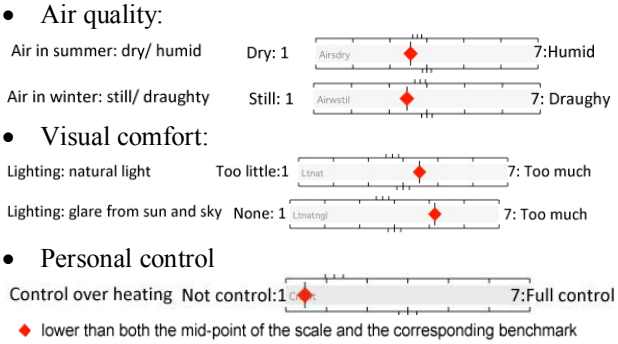


Figure 5: Detailed factors indicated by occupants that are not successful in school A. (Source: Building Use Studies)

• School B- design description

School B completed in 2010 is a replacement of a Victorian primary school in Wakefield, located on a semi-rural site surrounded by a vibrant multi-culture community. The RIBA panel appraisal stated: *"the school deserves high praise for its design quality, functionality, sustainability and aesthetics, but most of all for the joy it brings to all its users…* [8]"

The school consists of three parallel, single-storey wings: the northern block contains classrooms and teaching spaces, the middle block is the foundation unit and the hall, and the southern block provides staff rooms, offices, the kitchen and the community room (Fig. 6). The primary structure of the school consists of the cross-laminated timber roofs and the load-bearing masonry cross walls which provide thermal mass, and various

materials were used as cladding materials in the school to add texture and interests to the building.

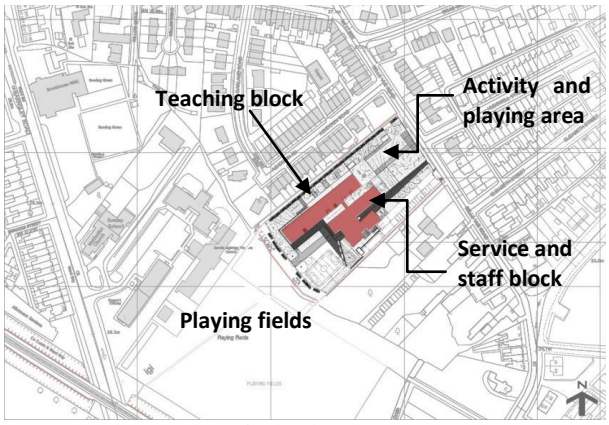


Figure 6: The site plan of school B. (Source: SWA)

Figure 7: Exposed masonry wall, lighting and air intakes underneath windows in a classroom, School B.

The architects decided to use the school as a demonstration and teaching tool to support school's sustainability curriculum, so the environmental strategies and construction are exposed to users in order to help them understand how the building works. Natural light was promoted through windows and rooflights. Natural ventilation throughout the school was implemented by stack effect through windows and 'chimneys' in classrooms, as well as single sided ventilation. Photovoltaic panels and ground source heat pumps were also employed in school B. The under-floor heating system used in majority of the school is controlled by sensors and the BMS, and radiators were only installed in the circulation spaces where the under floor heating has not covered.

• School B- POE feedback

The majority of the staff responded to the survey. The overall feedback was reasonably satisfactory, and almost all staff noticed the improvements in behaviour since they moved into the building. They thought that the design of the school was "eco-friendly" and unusual compared with other schools, and they were generally happy about the teaching environment and classroom design.

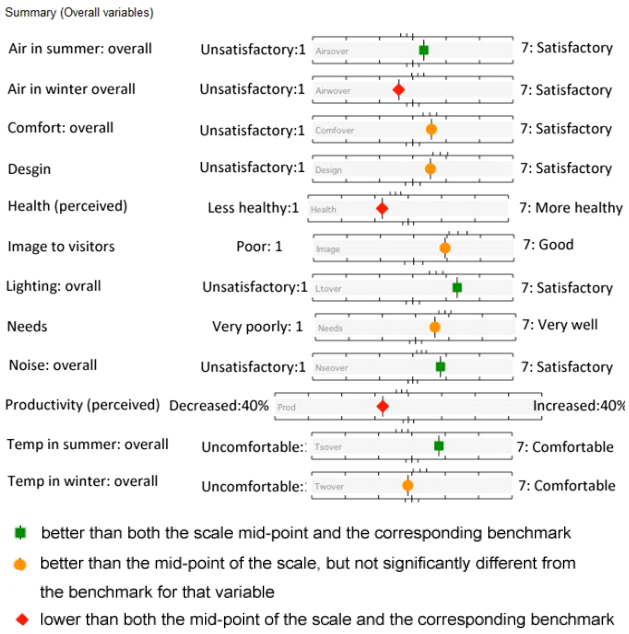


Figure 8: The POE summary of overall variables in school B. (Source: Building Use Studies)

However, most of them pointed out the existing issues of overheating in the south-facing offices and staff rooms, less natural light, and down draught problems in classrooms. Easier adjustment of the heating was desired, (perhaps a reaction to the slow response of underfloor heating). The lack of storage space was also identified as an issue (Fig. 8). Difficulty in managing the building properly by BMS was highlighted by the site manager, and also the issue of high electricity consumption due to the use of ground source heat pumps raises a question over whether this is an appropriate heating solution for this school.

• School C- design description

School C is a newly-built primary school located in a residential development in Wolverhampton, and serves the surrounding communities. It is the first school in the UK which achieved the 'Excellent' standard in the BREEAM rating [9], and received the RIBA awards because of its *"excellent environmental performance"*.

It is a two-story building, divided into two parts shown as Figure 9, and each part consists of one central hub and surrounding classrooms. The central hub acts as a multi-activity space for flexible usage, and at the same

time it acts as a buffer space for the surrounding classrooms (Fig. 10).

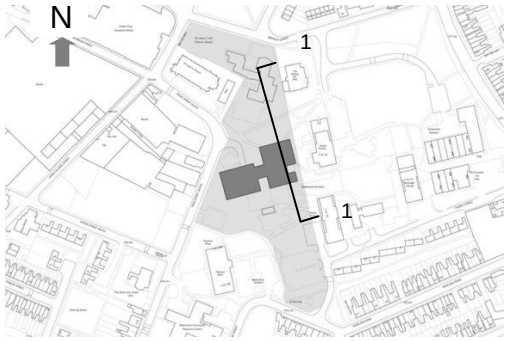


Figure 9: The site plan of school C. (Source: [9])

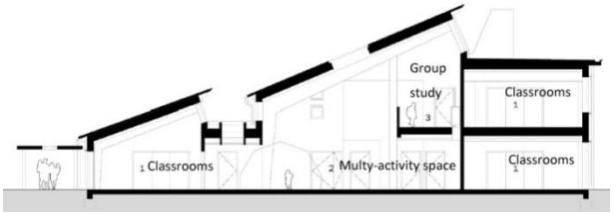


Figure 10: Section (1-1) of the school C. (Source: Architype)

Large glazed windows with openings were adopted in classrooms to maximise natural light, as well as the rooflights and high-level clerestories in hub spaces and classrooms (Fig. 10). The whole school is naturally ventilated, and most of the windows can be manually controlled. Under-floor heating is provided and controlled by the BMS, and the whole building is mostly supplied with a woodchip biomass boiler to provide heating. In order to reduce the embodied energy, timber was used for the primary structure and construction material.

• School C- POE feedback

Over 50% of staff in school C participated in the POE survey. The average feedback score of school C was the best of the three schools studied. Most staff felt very satisfied with the school design quality and school environment (Fig. 12), and they commented that "*the environmental considerations throughout the school, such as the environmental knowledge notes pasted on walls, really promote either students or adults environmental awareness when using the building every day"* (Fig. 11).

Figure 11: The note of "Environmental Principles" pasted on the wall of a classroom in school C.

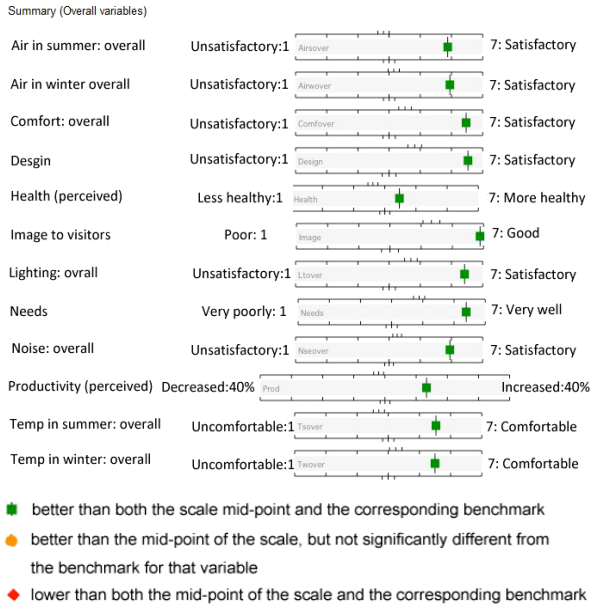
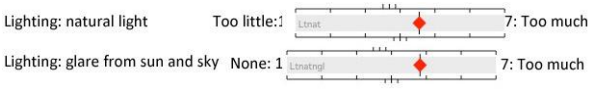


Figure 12: The POE summary of overall variables in school C. (Source: Building Use Studies)

Although the general feedback was fairly positive, some specific issues related to comfort were identified through the POE process. Too much natural light and glare risk from sunlight was the biggest issue in classrooms due to lack of blinds, and the problem of uneven temperature was also highlighted by some staff. Noise and distraction from other people inside the school happened frequently in the central hubs whilst different activities proceed together. In winter, improved control over heating was also seen as desirable (Fig. 13).

- Visual comfort:



- Noise:

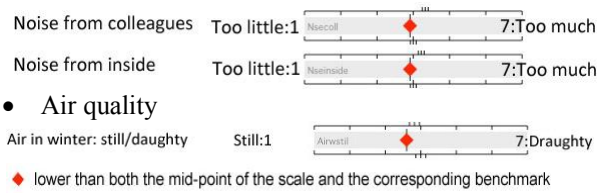


Figure 13: Detailed factors indicated by occupants that are not successful in school C. (Source: Building Use Studies)

CONCLUSION

• Design intent and actual building performance.

Environmental strategies, such as natural ventilation, generous glazing and Building Management System, etc., were generally employed in these award-winning schools in an attempt to improve environmental performance and reduce energy consumption. However, the above POE results demonstrated that there are gaps existing between design intent and actual building performance, which is a similar conclusion to other post-occupancy studies of new schools in the UK.

The design of the schools studied provided extensive glazing, (and rooflights), in classrooms to allow "*sufficient*" daylighting according to lighting standards for educational activities, such as the "*minimum daylight factor*" in overcast conditions. But the issue of glare and too much natural light was found in two of the three schools. This highlights a very important design issue that various interrelated factors must be balanced in order to achieve a comfortable lighting environment under different sky conditions. Also the control of light in classrooms involves the occupants' active response. These issues deserve greater attention from designers.

Natural ventilation in the three schools is by openable windows and openable rooflights, but the related strategies such as the ventilation panels in school A do not work effectively. Robust solutions for natural ventilation require careful consideration by the design team to be successful under varying conditions.

In terms of the thermal aspect, the three schools are generally heated through under-floor heating system controlled by BMS, which are slow to respond to changing conditions. Moreover, ground source heat pumps employed in two of the three schools were originally considered as beneficial technologies to reduce carbon emissions. However, they can cause high electricity bills in practice as evidenced in the schools' annual energy consumption.

• Relationship between school design and occupants

According to the staff comments, behaviour change has been noticed after they moved into the new schools. Comments such as *"bright and airy schools do bring a good mood to work"*. Additionally, some design strategies were highlighted as successful in improving environmental knowledge and awareness of school users, both staff and students. The 'environmental notes' used in school C are an illustration of this perceived benefit.

• The issue of integrated design

The issue of integration in design has been emphasised for a long time, but it is difficult to achieve in practice. The gaps between design intent and actual building performance indicated the value of POE studies in providing feedback to the profession. Architects will need to have better professional knowledge of environmental design issues to collaborate with engineer teams in order to avoid using inefficient or misconceived design strategies.

ACKNOWLEDGEMENTS

The authors would like to thank all members of the schools and their architects, and Adrian Leaman for his supportive help in analysing POE feedback.

REFERENCES

1. Road to zero carbon: Final report of the zero carbon task force - Digital Education Resource Archive (DERA). [Online] Available: http://dera.ioe.ac.uk/672/ [Accessed April 29, 2013].
2. School building programme scrapped in latest round of cuts, The Guardian. [Online] Available at: http://www.guardian.co.uk/education/2010/jul/05/school-building-programme-budget-cuts [Accessed October 9, 2012].
3. CABE, (2008). Most BSF designs 'not good enough', CABE, London
4. Gelfand, L., (2010). Sustainable School Architecture: Design for Elementary and Secondary Schools, John Wiley & Sons.
5. 10 criteria for successful school design: CABE. [Online] Available at: http://webarchive.nationalarchives.gov.uk/20110118095356/http://www.cabe.org.uk/design-review/schools/criteria [Accessed June 14, 2011].
6. BRE Group: Post-Occupancy Evaluation (POE). [Online] Available at: http://www.bre.co.uk/page.jsp?id=1793 [Accessed May 2, 2013].
7. Leaman, A. & Bordass, B., (2001). Assessing building performance in use 4: the Probe occupant surveys and their implications. Building Research & Information, 29(2), pp.129–143.
8. RIBA Award Winners 2011 – School | Building study | Architects Journal. [Online] Available at: http://www.architectsjournal.co.uk/2011-stirling-prize/riba-award-winners-2011-school/8616145.article [Accessed May 12, 2013].
9. St. Luke's C of E Primary School, [Online] Available at: https://www.educate-sustainability.eu [Accessed September 4, 2012]