The comfort dimension when evaluating the discrepancy between predicted and actual energy performance in new school buildings

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Abstract

This paper presents results of work carried out with three case study UK secondary schools in the East and West Midlands and South Yorkshire respectively using post-occupancy assessment (POE) methods. These results form part of a project in Loughborough University Department of Civil and Building Engineering (PostOPE) investigating the extent and causes of discrepancies between computer-based predicted performance of buildings during design and their actual in-use performance, using a number of case study buildings. A post-occupancy evaluation and performance assessment approach was used for the case studies in the form of measurement-based performance monitoring, innovative user surveys and a review of the historical records of information from the design and construction phases of the projects. Alongside consumption monitoring studies, research also developed and tested an action-research based post-occupancy assessment (POE) approach for working with whole school communities in new school buildings.

Keywords

Sustainability, comfort, performance-gap, schools, post-occupancy

Introduction

PostOPE a research project in Loughborough University Department of Civil and Building Engineering was focused on post-occupancy evaluations to investigate why modern buildings, designed for energy efficiency, using modern simulation prediction tools, frequently fail to perform as intended. The project aimed to inform design practice of relevance to architects, engineering consultants, builders, contractors, and operators/owners of buildings at the same time as helping simulation tool developers to improve and extend the scope of their tools. Early on in the research it was recognized that achieving this aim meant ensuring the perspectives of all users of buildings were involved, and where case studies were school buildings, this included children. It was understood that the standard post occupancy

evaluation (POE) methods would not elicit sufficient information and needed to be adapted for use with children's participation.

Within the POE research context there is a tendency to use standard methods of assessment in order to allow, for research purposes, a comparison of data across building types. This aim of the PostOPE project was, however, to explore how different users contributed to the energy use in the buildings and how this contribution might influence energy prediction, and this required participation of all the building users in order to identify contributing behaviours and their causes. Whilst schools were the primary context of research it was deemed necessary to explore how to best engage children in the post-occupancy processes and standard methods did not allow sufficient scope to adequately engage with children.

Hence, the PostOPE project combined different assessment methods including measurement-based monitoring of the building performance, user surveys, and the review of historical records of information from the design and construction phases of the buildings. In addition, through a critical review of participatory social science research methods, few of which have influenced POE, the project examined ways of engaging school communities, and in particular children, in the POE process. Reviews of existing literature suggested that the school culture was a significant factor influencing pupil behaviours. However, developing an adapted research approach, and being able to integrate it with more traditional quantitative data collection methods, meant negotiating some complex issues surrounding the relationship to the quantitative data about actual energy use also being collected.

Whilst the Building Schools for the Future programme has now been discontinued, and it seems unlikely that new schools will be built on anything like the scale intended by the previous Government, there is still a significant requirement to be able to assess existing newly-built schools for energy performance and improve new and retro-fitted school buildings to actually reduce energy consumption. If anything, POE methods are becoming more important. Moreover, the broadly art-based participatory research methods developed provided means to examine the problem of building sustainable schools from more integrated perspectives: behavioural, and educational. In Participatory Action Research (PAR) methods, for example, key exponents of the methods have argued that participants are co-producers of knowledge. PAR methods have at their core the need for critical reflection on the relationship between researcher and the research participants (Askins and Pain, 2011).

The Method

Our method was used to facilitate a deeply context based interaction with building users. Watson and Thomson described a participatory "walk-through" POE method, which they opted for in the context of school buildings (Watson and Thomson, 2005). We adopted this approach alongside more open discussions and allowed children to use a video camera to show to researchers the places within the school they liked and disliked and describe how well or poorly they functioned. We attached particular importance to stories told by the children about their new school environment throughout the sessions, as we saw this as a first

crucial step in providing ways to productively engage with the issues and concerns of sustainability, and to be able to determine why there was an excessive use of energy in the case study schools. We also employed visual research methods asking children to draw or list positive and negative aspects of the school day and the building and as a group we asked them to devise solutions to improve the school. Children's illustrative stories, which peppered some dialogues, were often also used as a way of explaining to others energy behaviours. Conversations during all activities, whether 'walk-throughs' or during the drawing/design task, were recorded, and selected dialogues transcribed. Analysis took the form of a simple content analysis but the use of broadly action based research methods meant that the transformative aspect of the research project and recording the impact of the research activities on school communities also played an important part.

We worked with schools over a three week period and with every year group in the school. We gave no instruction to the teachers and asked for mixed groups of students, boys and girls, not all from the School Council or highest achievers. In our first meetings with the children, we ensured that all were happy to take part in the project and in every session we made sure they would not prefer to be in their classes. We spent an hour with each year group each week. Activities for the first week consisted purely of open discussion; this served to allow the group to establish a relationship with us as researchers (and often also with each other), for them to identify some of their first and most immediate concerns and for them to tell us all their stories about the school and what had happened in it.

In the first school case study this was about how a group of students were stuck in the lift of the newly opened school for over an hour (the pupils were now prohibited from using the lifts): "*When the first new school was opened they had the elevators and they got silly and they crowed into them and they crammed all in and it got stuck. So you can't use them anymore. You can't go in them. Only teachers are allowed in. [...] My sister says that there were about eighteen all cramped in. And it could only hold only five or ten. Researcher: How long were they stuck in there? About half an hour my brother said because my brother was one of them. I was called out of school 'cause they had to call fire engines to get them out.*"

Whilst the open discussions allowed researchers to begin a dialogue with the pupils, the stories also inspired engagement and other students to tell us about related experiences of new building. For example, asking about whether it was a good idea to have lifts in schools, one of the children from the same session responded: "*I think that they have got it in case you break your leg and you can't go up the stairs. The stairs are really wide but you get cramped in them you can only go up one set of stairs, you can go up one and down the other one. But when you go up to class they are all trying to cramp in and because there is only one set of stairs [...] It's hard especially at home time when you are on the top floor and you have to get down all the stairs, especially the main stairs. Yeah, because everyone pushes you out of the way [...] and it takes you about 10 minutes to get out and you have to try to hold onto the handrails to pull yourself forward [..]I go down with my brother and he makes a little circle and I walk...*"

These sorts of user experiences of the building emerged throughout the sessions and with all of the case studies. The rush of children all eager to leave the school building at the end of the day, even with wide staircases rising up two storeys from the ground floor – designed by the architects to ease circulation problems at lesson change over and the end of the day – was a cause of some considerable anxiety.

In the second case study school visited the stories, told by the pupils, were of the earwigs and beetles in the kitchen and dining room, the smelly drains and of the "school riot". According to the Year 8 pupils: "*In the dining room there is an infestation of earwigs and beetles. They come in from outside [...] The drains are really bad as well, they always stink. This is how they've told us it is: you know when you get straws that bend with a corrugated bit, yeah well, instead of buying decent pipes, they've built with ones that you bend and is someone has a dump at school, it all gets stuck in it and then they have to flush it out, and they flush it out in lessons and it reeks. We had to be evacuated from Tech because it smelt that much.*"

The smell was later explained as being caused by grease from the kitchen blocking the drains, but there was a lack of understanding about what was causing it, from teachers and students alike. The initial responses to the school were not, by any means, all critical. The sixth formers told us that the new school was nicer, warmer and did not let the rain in, but at the same time that there was a "riot": "*We had a riot and chairs got thrown around, and bins and such like*".

In the third case study, the most dramatic story that emerged from dialogues was about the road crossing in the incorrect place outside the school, described as "an accident waiting to happen". According to sixth formers the first approach to improving the design of the school had to be solving traffic management issues outside the school gate. As one of the sixth formers put it: "*I nearly get run over every day. I need to watch where I'm walking and if a kid in year 7 doesn't watch where he's walking he'll run out with his mates, like, and he's going to get run over. I reckon a lollypop lady would work [...] Someone's waiting to be run over, it's madness in the morning [...] And what about the one [bus stop] on the corner, we need something there, because that's where that accident happened with the little boy, he was trying to get across the road to the corner*".

Introducing the school through the students' stories presents a dramatic picture, (perhaps a little over dramatic when taken out of the context of the three weeks of workshops). However, encouraging the telling of stories had a purpose: it allowed dialogue to develop and encouraged children to enter into explaining both failures and successes of the school from their own perspectives. Table One demonstrates these conversations and hence the depth of information that can be gained using these methods.

Table One

	Case Study One	**Case Study Two**	**Case Study Three**
Windows and ventilation systems	"We also have this automatic window thing for when it gets too stuffy. When you produce too much CO2 the windows open, it's automatic [...] If you talk too much in classroom they open (laughs)".	"In the whole school there are automatic windows that you have to open and close with a key and there are only about four keys in the whole school. So that kind of means that you can't open the windows in some departments because you haven't got a key."	"Sometimes they [the classrooms] are really warm and the windows don't open. None of the windows open. Only the lower ones. In the summer it's really hot" (Year 7 pupil.) Researcher 1: "Are there things you think the architect could have done better?" "Just the windows."
ICT and computers	"All the computers are always on, they are never switched off by the power. They are always on standby. [...] it's just that the monitor is off. You just logoff and you don't shut it down".	"In there [computer room] as well is the study centre [full of computers] and it gets very hot and even if the air con is on only slight areas get it and it gets very hot."	"On hot days the IT suites are the best because of the air conditioning."
Attitudes to energy efficiency and sustainability	"I think we should but we have gotten used to everything and don't want to go back to basics"	""I don't even think we are trying. It feels like they don't even think they care. But they are always banging on about it. They are always telling us to save energy but why not them".	"...if no one moves in the classroom then the lights go out and so it's like when people go out of the room the lights go off and so the bills are lower. So do you think the bills are lower in this new school? You're paying less for your electricity and gas or not? Possibly not, because it's bigger."
Natural and artificial light	"It happens [automatic lights switch on] when you go in, but when you go out everyone turns them off anyway. In PE that's what happens as they will go off in the changing rooms and in PE you just have to jump about a bit. In the store rooms it is straight on. You walk in and it just turns on. Cleaners' cupboards and stuff".	"In the art and music corridor there are full size windows, they go down the full length of the building, the problem is that you have to, if you have projectors on in an art department you can't actually see because they don't have blinds so you can't actually lower the blinds so the projector can see so then you can't really see anything."	"I think we should stop lighting the school in the day as the sun lights it up alot and we're wasting electricity" (Final 'design' session, Year 8 pupil).

Themes emerging from workshops

Our nascent approach to post-occupancy assessment research provided essential clues to the factors contributing to the difference between the actual and predicted performance of new buildings. However, the methods developing also offer the potential for much more than this as they are opportunities: to explore children's relationship to their environment and to transform this relationship; and to provide the foundation for an integrated approach to building a sustainable school. Feedback methods are, by their very nature, ways to continuously learn about the energy performance of buildings and to understand people's behaviours in relationship to those buildings. Adapted feedback methods also hold the potential to change those behaviours. With the new wave of school building and with an ongoing need to retrofit old buildings children will grow up within architectural environments that pay significant attention to the idea of reducing energy consumption. Just by virtue of their new environments different ideas towards energy efficiency will emerge and it is important that schools can act to reinforce emerging lifestyles.

Themes, however, emerged that raised criticism and suggested that whilst an increased motivation to care for a building and its environment could only be seen as a positive contribution, where this was driven by rules and by penalties imposed on school finances by the PFI partner; and even perceived as prohibiting the proper use of the building by children; such an inefficient use of space and of the buildings utilities impacted negatively on pupil's experience. These prohibitions did nothing towards children establishing their own "authentic" relationship to the environment and a deep or lasting critical perspective on the problems of sustainable development.

The PFI arrangement was a constant source of complaint from teachers, school managers and has even been communicated to children. One pupil described the school's policy that prohibited drawings to be attached to the walls, as like a rented house where you were not allowed to decorate. Prohibitions extended to toilets being closed and only one girls and one boys' toilet open in a school with 1300 pupils to avoid the potential for vandalism which would be charged as an additional repair cost to the school by the company. Moreover, corridors and play areas were commonly closed to students during break times to avoid littering. Many of the themes emerging related to this uncomfortable relationship between the PFI company, the local authority and the school leadership team.

Factors contributing to the difference between predicted and actual energy performance in new school buildings

The dialogue of children and other users of the building provided clues to the factors contributing to the difference between the actual and predicted performance of new buildings. Whilst more and more buildings are achieving higher energy efficiency ratings, efficiency improvements are expected to be offset by lifestyle factors. Improving new energy efficient technology is important to the future of building design, but if buildings are actually going to reduce their energy consumption the human factors in energy consumption have to be considered. Building a sense of agency in relation to the natural, social and built environments presents a profound challenge for both architects and other construction

professionals, teachers, leadership teams and facilities management. The school rules and regulations (especially where determined by the PFI company) were a common and constant source of complaint for pupils and teachers but in many instances justified when proper use of the building was being prevented.

The project took the opportunity to set about making a real impact on the school communities of cases study buildings we examined and to motivate action to improve the energy performance amongst pupils and teachers. The adapted POE methods provided opportunities for children (and for some children these were the only opportunities they had had) to examine the social and cultural factors impeding the reduction of energy demand and to devise plans for action. Results found that the approaches adopted provided more holistic understanding of energy use in buildings than could have been achieved either from observational or more traditional questionnaire-based methods. Very little is known about children's everyday experience of the built environment of schools (especially the more energy efficient new schools) or of the diversity and range of young people's experiences of their own comfort. These issues are rarely taken seriously but this project aimed to do just this what emerged were pupil communities competent and willing to take energy efficiency seriously but with their agency compromised by the PFI arrangement.

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