Mainstreaming building performance evaluation for the benefit of users

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The built environment touches the lives of almost every citizen; buildings are where we live, work, learn and play. However, they are also major contributors to energy and resource consumption, pollution and global warming. Beginning with the fuel crisis of the 1970s, but accelerating with the emerging threats of climate change, improved regulations have attempted to address these issues. This has led to changes in building construction and the adoption of new technologies. In most other industries, research and development is inextricably linked to detailed review and analysis. It might therefore seem obvious to any impartial observer that understanding how these buildings perform must be a critical dimension to their design. However, construction has its roots in a custom and practice model and, consequently, the final product is very rarely systematically or robustly evaluated.

This is not due to lack of methodology. Procedures and techniques for the study of buildings in use have been established and developed for more than 40 years, starting from post-occupancy evaluation to more detailed forms of building performance evaluation (BPE) and several previous special editions have reported on these.[1] BPE includes a range of approaches to gather data and insights about the design and in-use performance of a building. It includes information about the way the building was designed and constructed, physical testing of the construction and installed systems, monitoring of energy consumption and environmental conditions in the building over time, and data gathering about occupancy and behaviour. BPE reveals knowledge that can be used to optimize the building being studied, but also reveals key insights that can inform the design and construction of future buildings.

However, BPE studies frequently reveal performance gaps: differences between the intended and actual performance (Cohen & Bordass, 2015; Cohen, Standeven, Bordass, & Leaman, 2001; Gram-Hanssen & Georg, 2018). These are commonly around energy use, but other gaps are emerging around internal environmental conditions and occupant comfort and satisfaction (Chiu, Lowe, Raslan, Altamiro-Medina, & Wingfield, 2014). If these were being identified as part of a research and development agenda, this would be seen as an opportunity to refine and improve. However, as they appear in completed and occupied buildings, these gaps are viewed as failures, which are perceived as threats to an industry in which the avoidance of liability has become a determining factor.

As a consequence, despite a range of initiatives, BPE has not yet become a mainstream or, indeed, a core activity in design and construction. This special issue explores both the impediments and opportunities (Table 1) that BPE faces. The paper by Fionn Stevenson considers the underlying causes of this by examining the roots of BPE and its more recent development both internationally and in the UK. It reviews attempts to develop and embed BPE in construction. It examines the various barriers that exist in the industry, the design professions and their underpinning education systems; and also a lack of government and policy initiative that have undermined its adoption. However, the paper also discusses the advantages and benefits that BPE findings can bring to clients, building users and designers. This is timely for the architectural profession where relevance, credibility and trust are currently being questioned.

The need for the architects and other built environment professions to adopt – and benefit from – BPE pro- cesses is also echoed in the paper on the ethics of BPE by Sharpe, who argues that

adoption of an evidence-led approach is needed to protect the occupants. This must be a core tenet of any profession – at the least to 'do no harm' and aspire to create positive conditions and outcomes. Buildings are, after all, inhabited by people.

Table 1. Authors and titles of articles in this special issue 'Building Performance Evaluation', Building Research & Information (2019), vol. 47(3); guest editor: Tim Sharpe.

This, in turn, raises questions about performance issues that affect building users and inhabitants. Early BPE studies tended to focus on the energy performance of the building, in terms of known metrics such as energy use and environmental conditions. Whilst these data can tell you 'what', other data on how the building are used can tell you 'why' (Palm, Ellegård, & Hellgren, 2018). Whilst the role of occupants in the performance of build-ings has been acknowledged (indeed, they are frequently seen as the cause of performance gaps), much less is known about the underlying causes of why these issues arise. A building is not an energy system: it is a home or workplace and needs to function as such and provide a usable and enjoyable environment for occupants.

One particular area of interest is usability of control systems. The paper by Magdalena Baborska-Narożny and Fionn Stevenson investigates this. As noted above, performance gaps due to occupants are sometimes characterized as 'misuse'. But what if the buildings, in particular the interfaces that people use to control their environment, are not fit for purpose? The need to review and understand the nature of occupant engagement with control systems is therefore a crucial factor. The study examines the nature and theory of usability studies and describes the development of a tool for usability assess- ment and the implementation of this within BPE studies. Whilst the outcomes describe positive opportunities to improve occupant understanding and active feedback for improvement, it also identifies barriers in terms of the communication of findings to key actors, and ability to influence decision-making at design and procurement stages.

Performance gaps are also not just about energy. Issues of comfort, satisfaction and, more recently, health and wellbeing are emerging (Levin, 2006; Lomas & Porritt, 2017; Yu & Crump, 2010). A particular example is the requirement for increased airtightness of buildings to reduced uncontrolled ventilation losses. Successive

regulations have required increased levels of air tight- ness, and this has changed how buildings are con- structed. In a slight irony, the success of these measures has been driven by one of the very few mandatory post-construction compliance requirements: air- tightness testing. However, BPE testing of contemporary homes has indicated that ventilation strategies and the implementation of these may not be delivering adequate ventilation or good indoor air quality with consequent health impacts (Howieson, Sharpe, & Farren, 2014; McGill, Sharpe, Oyedele, Keeffe, & McAllister, 2017).

A critical area of study is, therefore, how the performance of the building affects the users (rather than the converse). Whilst many studies have identified the effects of occupant behaviour on the performance of buildings, fewer studies have attempted to identify what design measures may influence occupant activity and satisfaction.

A particular theme of this edition is therefore examining inhabitants experience of using their buildings. Can- dido et al. assess this through their study of activity- based working (ABW). This is a workplace strategy that gives users some choice over their workplace setting and also discourages sedentary working. Examination of office spaces in Australia indicates that user control over the use of spaces affects satisfaction far more than indoor environments and provides improved satisfaction with indoor environmental quality (IEQ), perceived productivity

and health. These results highlight the benefits of a human-centred approach to design and are clearly of value to future design of office spaces.

One of the major drivers for improvements in energy performance has been improved legislation. However, there are increasing concerns that a 'tick-box' approach to compliance may not result in good environments for inhabitants. This is investigated by Altamonte et al., who examine whether compliance with green building certification results in higher user satisfaction. The focus is particularly on IEQ measures. The analysis of a large sample of Leadership in Energy and Environmental Design (LEED)-certified buildings – in which certification is generally achieved at design stages and signals design intent rather than measured performance – suggests that achievement of IEQ credits does not necessarily result in higher user satisfaction. This is an important finding and illustrates that a lack of any mandatory post-construction evaluation can allow the experiences of users to go unnoticed.

There is evidence that the context for BPE is changing. There is certainly much wider awareness of the presence and, indeed, causes of performance gaps, and the term is now widely understood and referenced. There has been government investment in BPE, for example, the Innovate UK Building Performance Evaluation programme was a four-year, £8 million scheme that supported over 53 domestic and 48 non-domestic BPE studies across the UK. Whilst this has not resulted in direct changes in legislation, a great many groups and organization participated and this has increased the grassroots knowledge base from which a number of communities of practice[2] and networks[3] have emerged. Many clients groups have become aware of the potential risks and liabilities of performance issues. At the Passive and Low Energy Architecture conference held in Edinburgh, UK, in 2017,[4] the BPE forum was one of the largest, with over 150 submitted papers and over 60 presentations. This special issue draws on work presented at that forum, which has subsequently undergone further work and peer review.

Nonetheless, many knowledge gaps remain. On the supply side, there is clearly a need to develop policies and strategies that embed BPE as a core activity. Whilst there are some green shoots, for example, the adoption of Soft Landings by UK government agencies (Bordass & Leaman, 2005; Way & Bordass, 2005), and the National Australian Built Environment Rating System (NABERS) scheme in Australia (Bannister, 2012), it is self-evident that in-use performance compliance mechanisms are needed.

What would this mean for design professionals? The fragmentation of the construction industry and the lack of influence of designers over final outcomes is evidently a contributing factor. Stevenson critiques the loose adoption of BPE in the most recent version of The Royal Institute of British Architects' (RIBA) Plan of Work, but even if this were to be mandated, do the current and practitioners have the necessary skills? What changes to the education, training and continuing education of professionals are needed? Sharpe identifies the need to BPE to be based on a robust and ethical methodology, and whilst there are arguments that direct

feedback loops into design are beneficial, there are uncertainties about the ability to deliver this in a profession that is not predicated on research and development.

Attitudinal shifts are also needed. In the current con- text, performance gaps are seen as failures – but whose? Design professionals remain concerned about their reputation and liability. However, most design decisions are constrained by compliance with regulation and other forms of governance that impact on design (insurance, finance etc.). If these constraints and practices

then result in performance gaps, it is necessary to evidence these issues to inform legislation and standards, as a lack of reporting may result in a profession that is complicit. There is an unfortunate tendency for government to take a retroactive approach to regulation and only introduce or make amendments in the light of significant failres that cause a public outcry.

Demand-side drivers can increase the use of BPE. Building clients and users are the ones that are left to deal with the issues of performance gaps. As the costs and risk of these emerge, there are greater incentives to undertake BPE to mitigate these and also to use findings to inform future client and design strategies. Also, many architectural practices are deeply engaged in the use of BPE. Stevenson cites Architype, which used a knowledge-transfer partnership (KTP) to develop capacity for BPE, and a more recent example is John Gilbert Architects, which also used a KTP to develop the 'Hab-Lab' service for BPE in retrofit (Sharpe, Morgan, & Lantechner, 2018). Not only is this improving the performance of refurbishment projects but also it is significantly enhancing the knowledge base of the practice – it is also generating an income stream. A key facet of this project was a community of client organizations that were sufficiently aware of, and concerned about, performance gaps to collectively part fund the project and to share knowledge emerging from it. What is more, the findings on indoor air quality from this project have led to the inclusion of both ventilation measures and the provision for monitoring the performance of proposed measures in the scope of the forthcoming Energy Efficiency Standard for Social Housing (EESSH 2).[5]

Further research is also needed to refine and improved methodologies for BPE processes. Some aspects have become much more affordable and accessible. Equipment such as thermal imaging cameras, which a few years ago would have cost many thousands of pounds, can now be obtained for hundreds. In recent years there have been significant advances in the technologies available for sensing and monitoring, including wireless sensors and remote collection of data from sites. There is increasing use of smart meters and also consumer awareness and adoption of smart home sensing devices. Pervasive sensing and big data may therefore be able to provide much larger data sets, but there are both practical and ethical challenges associated with this, particularly in domestic environments.

Engagement with building users remains a key dimension and a better understanding of both how and why inhabitants use their buildings in the ways they do is critical to better design. However, the ability of such analyses to produce optimal solutions may be limited. There are few 'one-size-fits-all' approaches, and the reality is that occupant behaviour is, by its very nature, stochastic, and this is emerging as one of the key challenges to performance modelling (Clarke & Hensen, 2015). The consideration of how occupants might use the building and how they might interact with controls, for example, leads to a design approach that necessarily requires a deeper analysis and testing for unintended consequences. This is perhaps an approach that is more fam- iliar in other design and manufacturing approaches in which a detailed analysis searches for all the things that might go wrong, rather than one that assumes that every- thing will work perfectly.

Although the construction industry in general and the design professions in particular do not have a strong research and development tradition, the use of BPE is both an accessible and a valuable way for these groups to engage with research processes. It is an area where academic and research communities share common ground with practitioners. The ability to develop robust methods, understand data and use this to effect useful change is critical if we are to produce high-quality buildings. This special issue moves knowledge forward by identifying some of the common challenges, but perhaps more importantly highlights the advantages to taking a more user-focused approach as a way of improving design and users' enjoyment of the buildings they inhabit.

Notes

1. Special issues on this topic include: 'Post-Occupancy Evaluation' (https://www.tandfonline.com/toc/rbri20/ 29/2); 'Performance-Based Building' (https://www.tandfonline.com/toc/rbri20/33/2); 'Building Perform- ance Evaluation' (https://www.tandfonline.com/toc/ rbri20/33/4); 'Housing Occupancy Feedback: Linking Behaviours and Performance' (https://www.tandfonline. com/toc/rbri20/38/5); and 'Energy Performance Gaps: Promises, People, Practices' (https://www.tandfonline. com/toc/rbri20/46/1).
2. See http://www.bpe-specialists.org.uk, www.hemacnet work.com/.
3. See https://building-performance.network/.
4. See https://plea2017.net/.
5. See https://www.gov.scot/Publications/2018/05/3464/2/.

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