Post-occupancy Evaluation

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"Feedback in design is a hackneyed yet useful concept ...".

(Building Performance Research Unit, 1972)

Introduction

Post-occupancy evaluation of buildings (POE) tries to answer two broad questions: "How is a building working?" and "Is this intended?". POE was coined in the 1970s in the USA [References 1,2] to describe the process of assessing buildings in use, initially from the occupants' point of view. Landmark studies in POE are in Box 1.

A more informative phrase is "building performance appraisal" introduced by the Building Performance Research Unit (BPRU) in the UK in the early 1970s [Reference 3]. This tells us more of what POE is about, including early decisions, the design and production processes and the building in use.

Baird and colleagues [Reference 4] say that the performance approach is ...

"... the practice of thinking and working in terms of ends rather than means ... concerned with what the building (or building product) is required to do, rather than prescribing how it is to be constructed."

This is the essence: POE is more about real-world outcomes and their consequences ("ends") than design prescriptions ("means"). It aids learning from experience to improve the next generation of buildings, a kind of quality control writ large.

BPRU [Reference 5] also pioneered the systems approach to buildings [Reference 6] which gave opportunities to:

- see buildings as a working whole within their wider environmental and social contexts, and over time;
- break buildings down conceptually into non-denominational sub-categories (like "objectives', "activities". "environment", 'hardware" and "resources") - with implied freedom from any dominant disciplinary or professional viewpoint;
- look in more detail at design as an activity in its own right (treating design as a separate 'sub-system' within the whole);
- examine other areas such as cost.

The systems approach has turned out to be less promising than first thought. It is now more accepted as an analysis framework and a source of value-free terminology.

Feedback from completed building projects

There are three types of feedback:POE is normally understood to fall in the third of these, although it can sometimes be included in any or all three:

1. Review of project performance. This covers the brief, design, project management, programming and co-ordination, cost control, build quality, etc..
2. Feedback during the year or so after completion. This can help to fine-tune, inform the client,design and building team,and ease transition into full and effective operation.
3. Assessing the complete product and its performance in use. This is what is usually understood as a POE.

Feedback has recently come to prominence. For instance:

"Those of us who study buildings in use regard … feedback as essential. Not only can a recently-completed building be better understood and improved in operation, but all those involved in procuring and making it can learn from their experience and do better next time. Forty years ago the Royal Institute of British Architects put a feedback stage into their Plan of Work for Design Team Operation. In spite of this, such feedback is by no means routine. Indeed, after briefly blossoming in the late 1960s, POE in the UK has struggled to maintain its existence, at least until recently." [Reference 7]

Complex systems

Because we live in buildings and use them everyday, they seem to be simpler than they actually are. In fact, buildings have many physical sub-systems (e.g. site, fabric, shape, services, fit-out etc.), relationships with the external environment (e.g. lighting and ventilation) and many of their governing processes are intangible (e.g. the normally invisible time dimension is just as important as visible spatial form but gets less attention). Buildings are also a mixture of physical ('hard') and behavioural ('soft') systems. It is often difficult to resolve this complexity.

Context

If this were not enough, the most problematic complicating factor is often a building's context (which includes not just its physical location but also e.g. procurement, design, operation, management and use patterns). Contextual factors often explain a lot (e.g. why one building's performance may differ substantially from another although they seem to be superficially similar). Management factors often turn out to be more important than designers envisage.

Real-world research

Given that buildings in use are "multivariate" and "context-dependent" in the senses just described, it often is better to approach them with a real-world research framework [Reference 8, Box 2] looking less for causes and effects and more for risk factors and consequences. This involves examining things that are likely to happen in a given real situation, rather than at cause and effect, which may require contrived situations like laboratory experiments. .

A real-world approach also helps:

- to create improvement strategies which involve occupants and management rather than just solely being technically or physically based;
- to deal with system-wide complexity (taking in not just the building and its occupants but other related factors like company culture and journeys to work); and
- with the practicalities of an occupied building (managers may not allow you to do all the improvements you want or they may not have enough time or money).

POE techniques

Capturing how an occupied building really works can be a mesmerising task. For example, CPBR's Checklist of Techniques [Reference 9] has over 150 possible POE analysis methods. A list recently prepared for a UK project "Feedback" [Reference10] has 50 potential POE methods.

With this embarrassment of riches some of the dangers are that you:

- choose the wrong method/s;
- waste time reinventing an approach that has already been tried elsewhere;
- generate far more data than you can manage to analyse;
- subsequently discover that you have focused on the wrong area;
- use a technique for which no robust benchmarks are available, making it difficult to interpret your findings. For example, your building may score 2 out of 5 on your study but is the average building 1.5 or 3?

POE has taken thirty or more years to get off the ground partly because it has not been obvious which techniques are best. Weakly developed inter-disciplinary research, lack of support by the professions and lack of funding continuity are also to blame.

POEs that no-one knows about

There have been thousands of studies which can potentially be called POEs but most of them:

- are hard to get hold of, or not published at all;
- cannot be effectively compared with each other (they often do not use performance benchmarks, and are effectively “one-off”' projects);
- have too many different points of reference (e.g. some are mainly about lighting, others noise, others indoor air quality, so, again, comparing like with like is impossible);
- do not report their analysis procedures clearly enough, so it is often difficult to assess findings to find out whether they are believable (this especially so with research studies carried out by design firms for their own purposes, the results of which may be used in their publicity);
- are hard to follow because they include jargon and do not report conclusions in formats which designers, managers or building owners can easily follow and from which they can easily learn;
- seldom take sufficient account of context.

Which are best?

Researchers embarking on POE are usually not clear which techniques:

- work well and can be applied quickly and efficiently;
- are reliable (i.e. they give roughly the same results when used by different people in similar circumstances);
- do not intrude too much on occupants’ and managers’ time and patience;
- are most relevant in a given situation;
- give results which are easiest to compare with other studies;
- give good value in terms of the quality, content and range of information derived;
- rely too much on measured data from e.g. physical monitoring equipment, which can be time-consuming to set up and collect, and sometimes still be incomplete and thus hard to interpret;
- do not suffer from incomprehensible "normalisation" (that is, results have been adjusted, but the assumptions for the adjustments are not made clear).

One of the reasons why the Probe project has been relatively successful is that it [Reference 11] used just three existing methods, which were known already to be practical and robust:

1. The Energy Assessment and Reporting Methodology (EARM) [Reference 12] ; which comprehensively covers building energy performance from both a supply and demand perspective, which helps in a thorough understanding of technical performance, is helpful with diagnostics. For example, it tells you not just how well the building is doing overall compared with benchmarks, but precisely where it succeeds and fails.
2. Building Use Studies’ occupant questionnaire [Reference 13], which covers occupant issues like comfort, health and productivity in a format which gives useful information across a range of disciplines (e.g. architecture, building services, facilities management) and is also helpful to non-specialists. Altogether, 65 variables are covered to give a comprehensive coverage, but not too much or too little.
3. An air pressure test to CIBSE TM2314 specifications, which examines the air-tightness of the fabric.

Benchmarks

Vitally, the three assessment methods incorporate benchmarks based on performance evaluations of the building in use (not models, simulations or design prescriptions, all of which tend to introduce untestable, and often unrealistic, assumptions):

1. EARM uses “Typical” and “Best Practice” energy benchmarks for various building types [Box 3], and may be adapted for uncommon situations which are hard to categorise (e.g. warehouse with office attached).
2. The BUS occupant survey method [Box 4] has benchmarks for 65 occupant ratings for the UK, and is now used world-wide in comparable formats. Like EARM, this is also applicable across different building types, and may be used for various user permutations (e.g. permanent staff, library users, etc..)
3. The pressure test [Box 5] has a database and benchmarks for comparison. [Reference 15]

As well as these three, Probe also has:

- a Pre-Visit Questionnaire (PVQ) [Reference 16] to collect basic data data about hours of use, technical systems, plans and other background information in advance of the actual survey. This provides valuable consistency and is a useful test of the seriousness of the client. If they cannot give you the information , it will usually be best not to attempt the POE. ;
- a water consumption method, but this is not yet fully benchmarked;
- a supplementary questionnaire to the occupant survey for journey to work and transport mode.

Why not more?

Probe has been relatively successful because it relies on methods perceived to be robust. It does not attempt to include too much, which ensures that the work does not become mired methodologically. This also enables individual studies to be carried out relatively quickly.

Probe restricts itself to:

- Energy (with a technical and management emphasis; water assessments were introduced in the third phase [Reference17]);
- Occupants (using perceived ratings and attitudinal observations from questionnaires followed up by interviews and discussions if necessary);
- Air tightness (with measured data, introduced in the second phase of the project).

This was a practical decision based on what was achievable within onerous time and cost constraints. Probe also was to publish the results which added an extra dimension. [Reference 18]. This approach gave an energy and services perspective, with an emphasis on sustainability through assessing the robustness of the building, the satisfaction of the occupants and management, and the avoidance of waste.

As Probe was published in Building Services Journal it has been perceived as having a services bias. In fact, services is just one of the windows through which the material may be viewed. The Probe data can also be looked at with an architectural or facilities management perspective, for example. Probe also yields “strategic” conclusions at one level up from the individual building studies.

In order to meet the delivery criteria as described above, Probe deliberately did not attempt to cover directly any of the following:

- first costs;
- costs in use;
- aesthetics;
- space efficiency, density or utilisation;
- design and procurement history.

However, in course of their work, the Probe team developed insights on each of these aspects. All may find their legitimate place in POEs. However some, like costs, are notoriously difficult to pin down:

- organisations rarely hold cost information on a building-by-building basis,
- they can be extremely reluctant to release it;

- it is often inconsistent anyway;
- the resulting conclusions may be vetoed, making it harder to publish the rest of the study.

Of other topics which are of interest in POEs:

- aesthetics has specialist methodologies which cannot be readily applied and compared in all situations;
- space use is relatively easy to carry out, and can be included as an option, but is rarely asked for;
- design and procurement history is often quite hard and expensive to study, especially as the design team will usually have dispersed, and can rake up old disputes which may be best left undisturbed.

Choice of content and approach often depends on:

- What you actually want to find out (for example, a relatively modest exercise based on walkthroughs and interviews may be all that is necessary).
- Whether it is important that conclusions stand up to peer-group scrutiny (many building assessments do not report their assumptions, sampling procedures and methods clearly enough) but can nevertheless be useful for those involved.
- Whether the results are likely to be published (probably less than 10 per cent of POEs ever are).
- Whether or not the work is to be carried out by investigators who are independent of the building project itself (which ultimately will carry more weight).
- The resources and time available.

In practice, Probe found that most of the salient points about performance can be arrived at either directly or indirectly without needing to cover everything in painstaking detail. As well as this, the results had enough credibility to be taken as an authoritative record. Probe shows that it is possible to get perhaps 80 per cent of the performance story by collecting less than (say) 20 per cent of available data.

Successful POEs

Experience has shown that successful POEs have most of the following: [Reference 19] :

- A sponsoring organisation with the initiative to collect the POE information, time to make sense of it, and the will to share it.
- Management support and long-term commitment to signal the importance of the exercise at senior levels.
- Broader opportunities and incentives for participation and reflection, especially with respect to the goals of the organisation and its business strategy.
- Opportunities to identify critical stages where lessons from feedback can be built in.
- Some kind of involvement in the POE in contracts and pre qualification for suppliers.
- Information which is understandable for different audiences: e.g. policy and planning documents for senior management.
- Backed by simple databases [Reference 20], both for individual buildings studies (to extend the number of questions that may be asked of the data) and for the management of benchmarks over many buildings (to keep this process manageable).
- Ideally include design hypothesis, photos, data summaries, some cost, size and technical data, lessons learned, connections to other studies and recommendations.
- Cover projects where there are complaints or controversy (not just on buildings which are perceived to perform well).
- Cover innovative buildings to decide whether to continue with the innovations but give the designers due credit for innovations if outcomes do not work properly (otherwise the POEs may be criticised for nipping innovation in the bud).

- Start modestly to demonstrate potential and usefulness, then build up the cases into a bigger benchmarkable sample. [Reference 21]

Where do you start?

As one of the main purposes of POE is feedback, it is sensible to begin by organising the material so that it may be used first in a strategic brief, then later on in the POE itself. In this way, the targets set in the brief may be followed through and eventually evaluated. This also provides a way of keeping the brief on track, and managing it throughout the course of the project. However, this also depends on access to a project with the foresight to do this! Unfortunately, most projects are not like this: the POE team only rarely has input at the briefing stage, so opportunities for management of the feedback loop are less.

If the opportunity arises the following approach may be useful.

1. Organise the strategic brief using the main headings shown below.
2. Develop the detailed brief or briefs within the framework of the headings.
3. Use the headings for the main categories of assessment in the POE.
4. Then examine overall feedback in a more generic way, again within the overall discipline of the topics in the headings.

The headings may also be used as a means of managing the brief as it evolves, so that assumptions of various participants can be addressed, and the needs and expectations of the client and potential users set out. There is potential for POE to be extended into a fully-fledged briefing and evaluation tool by management of the design brief to embrace it. This process can be as simple or detailed as you wish to make it: from a simple diagram to a detailed spreadsheet.

The main areas to consider fall into three major headings:

1. Context.
2. Qualities.
3. Implications.

Each has subheadings as developed below.

1. Context

Context covers:

- The Business Case. Why was the building needed and for what main purposes?
- Locational, site and planning considerations - the main “physical” constraints.
- Investment potential, including value.
- Adaptability options for future changes of user or use.
- User requirements and human impacts for first and subsequent occupiers.
- Environmental considerations and impacts, especially energy, water, waste and demolition strategies.
- Transportation impacts created by users’ journeys to work.
- Likely technological, social and economic impacts that may affect the project in the short and medium terms. Here, the project should be “future-proofed” against premature obsolescence.
- Organisation culture [Reference 22] and changing lifestyle considerations.

Any POE needs to be underpinned with a well-developed understanding of such whys and wherefores.

Usually, contextual factors turn out to be the most important in the final performance analysis. For example, the Centre for Mathematical Sciences at the University of Cambridge [Reference 23] was subject to planning constraints on building height which infuenced the visibility of artificial lighting after dark in order to satisfy local residents’ concerns. This added constraint then affected factors such as ventilation strategy, which in turn had unexpected knock-on effects on performance.

Investment and planning criteria often dominate, with user and environmental requirements being left on one side. Investor caution is often the reason why environmental strategies are left out. Investors are notoriously risk-averse and tend to avoid anything which does fit not the market's perception of the norm. One role of POE is to provide factual information to help overcome scepticism, especially with newer ideas. For example, property investors have yet to appreciate the advantages of mixed-mode ventilation strategies, which can give good results in POEs on both energy performance and human comfort and can have flexibility / adaptability benefits [Reference 24].

Human performance is also under-represented. After all, the purpose of a building is to help create added wealth through better human performance. Because human factors are not costed or given due value in the project itself, they often get much less attention than they deserve. This applies especially to fundamentals like thermal comfort, personal control, usability and responsiveness, which have been shown in many POE studies to be associated with health, satisfaction and productivity. [Reference 25].

A POE should thus capture the context within which a building has been procured and developed. This provides a rounded understanding of the main constraints and realistic choices.

The interpretation of the POE results will to some extent depend on taking regard of ruling circumstances and making due allowance for them, especially when constraints are more onerous and the level of difficulty of the project is higher. However, it will usually be impossible to quantify these factors, so judgement will be needed.

2. Qualities: essential and desirable features summing up the building as a whole.

The central task of the POE is to assess the main performance attributes of a building given the context. These attributes (called "qualities" here, but they could equally be called "values" - there seems to be no English word which works properly) depend on what the client who is paying for the POE actually wants to find out. In many POEs only two or three qualities will be emphasised, with the others given less or no consideration.

Six qualities are described below:

1. space;
2. operations;
3. environment;
4. users;
5. image;
6. cost.

The list is in no particular order. Almost every POE will use a slightly different list and give different weights to the attributes. Note that cost is treated here as a quality in the sense of perceived qualities like "expensive", "typical" and "good value". As with other performance attributes, perceptions of cost attributes are usually context sensitive.

Space

The physical attributes of the enclosed spaces, plus their ability to meet performance requirements, is an obvious area for POE analysis. Probe does not treat space as a primary object of enquiry (it could easily do so if funds were not restricted). For example, it is possible to measure occupant density, room utilisation and space efficiency if required. In Probe, information about spatial performance is derived mainly from observation, interviews and the occupant questionnaire. Information about space can cover:

- Size and capacity, and the ability to cope with use bottlenecks.
- Adaptability and flexibility strategies, especially with respect to the management of change and churn.
- Density of occupation, especially in open-plan workspaces.
- Basic layout, workgroup and floor plate use.
- Disposition of circulation and support space uses.
- Evacuation strategies.

Operations

Operations covers most of the areas relevant to facilities management including maintenance. It reflects how well the building in use responds to needs over time, a neglected area of study in buildings. It is becoming clearer that a buildings' performance over time, especially user response times, is a vital element in good performance. The time dimension is given much less emphasis than space because it is harder to "see" and because time-series monitoring data are usually ignored (e.g. Building Management System (BMS) demand monitoring data) or non-existent. Operations performance in Probe is derived from the pre-visit questionnaire, interviews with key facility management staff, observations of systems in use and inference from occupant questionnaire data. Areas to cover include:

- Operations, especially effectiveness out of core hours.
- Security.
- Maintenance.
- Usability, especially for personal controls for users in use of heating, cooling, ventilation, lighting etc., and usability of main building management system control interfaces for facilities managers.
- Manageability, which is obviously connected to usability, but also including, for instance, how well the building's operations manuals are understood and key areas implemented. This also includes help desk response times and the management of occupant complaints.
- Flexibility in response to everyday needs, and adaptability in the longer term to medium and long-term requirements. This may include, for example, performance bottlenecks not just in the use of physical space (e.g. excess demand for meeting rooms, lengthy dwell time of lifts, car parking bottlenecks) but also other performance problems (e.g. excessive IT network log-in times, slow speed of network access problems to remote network).
- Cleaning, a vital area for human health but rarely given the importance it deserves.
- Health and safety requirements and their implementation.

Environment

Environment as a sub-heading covers both indoor environment requirements and environmental impacts. The Probe studies examine environmental performance as one of its primary areas, although Probe does not have a full coverage (e.g. embodied energy and demolition are excluded). Transport modes was included in Probe #20 for the first time because however well a particular building may performance for energy consumption, this always begs the question of how people travel to the building. [Reference 26]. From a user point of view thermal comfort is one of the main correlates with human performance variables like perceived productivity. Also covered are other vital areas like lighting, noise and ventilation. Possible sub-headings here are:

- Indoor environmental performance
- Energy efficiency and provision for effective waste management and avoidance.
- Embodied energy.
- Demolition strategies (for efficient disposal both for the base building and fit-out changes).
- Transport modes and journey times (especially with respect to excessive car use).

Users

As Gary Raw said, : "People are the most valid measuring instruments: they are just harder to calibrate." With careful sampling even seemingly contradictory responses from wide ranges of people can yield useful information. Probe found that a short occupant questionnaire covering the main topics is by far the most effective means of eliciting useful data from a building in use. [Reference 27]

Many still think that 'measured' data (for e.g. temperature or lighting levels) are somehow more valid than the ratings of occupants, but as one occupant in a Probe questionnaire so succinctly put it: "The building management system may know about the temperature, but it does not sit in the draught it causes."

As well as questionnaires, structured interviews, walk-though surveys and focus groups are also valid means of gathering useful user data, but they may be less able to stand up to scrutiny for objectivity.

User surveys can successfully include:

- Comfort, health and satisfaction.
- Demographic characteristics: age, sex,

time in building, time at VDU etc.

- User needs.
- Users' responses to the building design.
- Usability and fitness for purpose.
- Perceived productivity.
- Facility management services including response times.
- Personal control.
- Further observations about job tasks, life style and related management and cultural factors, although discourage excessive use of these in a POE should be discouraged because they give managers an extra excuse to veto the project.

Image

The image of a building is one of its most potent characteristics. Corporate companies often place great emphasis on image; others, like military establishments, may deliberately want their buildings to look inconspicuous or not be austenacious: either way, image is a factor.

During the emergence of environmental psychology in the 1970s many techniques were developed to examine how people perceived buildings. Most of these do not now find their way into POEs because they are often costly to set up and ultimately do not yield sufficiently interesting results. Possible topics include:

- Aesthetics, styling, branding.
- Wayfinding and signage.
- Mental mapping.
- Townscape imagery

Cost

Cost is the biggest begged question in POEs. Probe specifically excludes it, for example, because it proved expensive and unwieldy to get believable cost data, and can be a hostage to fortune. Surprisingly, most organisations do not collect useful information about costs-in-use on a building-by-building basis. They can be reluctant to give researchers access to what they perceive as confidential information. This is one of the reasons why building economists tend to use cost models of theoretical buildings based on tender price indices for analysis of first costs, rather than continuously monitoring real examples.

This approach to cost, realistic as it is in the circumstances, beggars the whole point of POEs, which try to piece together an empirical snapshot of a building in use, not just a hypothetical model of it. One of the most important aspects of this area is not just first cost or cost-in-use but "perceived value for money". We have found cases of buildings which perform reasonably or very well on many of our POE criteria, but are still perceived as "poor value for money" even though their outturn costs per metre squared are still close to industry norms!

If costs are to be included they should cover:

- First costs
- Costs-in-use
- Value for money.

3. Implications (for different types of user)

In laying out the ground rules for a POE we have so far introduced the context of a project and its qualities. Quality improvement is the main aim, but the relevant qualities of a building depend on what is rated as important by the different parties involved. It is useful to think of four broad classes:

1. corporate;
2. normal users,;
3. facilities managers;
4. the design team.

Each has its own interpretation of good performance and a different set of objectives.

Corporate

This covers executives and leading decision-makers in organisations of all types. They are often pre-occupied with the organisation's image (and thus the way the building reinforces or changes the image, sometimes trying to use a new building as an opportunity for culture change). They examine industry-wide benchmarks on, for instance, productivity and financial performance, and will usually want to see their organisation amongst the highest-rated. They often want evidence of "value for money" in their buildings, and will pay more attention to cost norms than to other performance features like user comfort or energy efficiency. Some POEs include interviews with corporate decision-makers, but this is not always found.

Everyday users

This includes the many sub-types of building occupants: individual users (e.g. visitors to libraries or museums, permanent staff, contract staff), users in their workgroups or departmental groups, tenants as users, owner occupiers and also "user" organisations and interest groups like trade unions. Users' objectives are usually focused on the task in hand, either at an individual or group level. They want conditions in the building that help them carry out their tasks as well and as easily as possible. They are far more concerned with everyday practicalities than the way the building looks, and will usually be satisfied if things work reasonably well. They often tolerate faults and will be prepared to give designers and managers the benefit of any doubt that arises, but only if they like the building and/or the management well enough. Most POEs include detailed examination of users' attitudes and preferences.

Facilities managers

Although primarily about support services for users, facilities managers have different priorities to ordinary users. In the best-performing buildings, they try to be as responsive and helpful in providing what users need, and making sure that the building is comfortable, healthy and safe. They may also be a source of performance data (e.g. energy data, maintenance logbooks or complaints registers). Ideally, occupants should be able to have enough control over their indoor environment so that there is no need for constant intervention by facilities managers. However, many modern buildings have reduced user control and replaced it with a facility management service, often operated via a help desk. This makes the FM service more critical in certain larger buildings. If this is under-resourced, then there will be performance penalties. Usually, a POE will involve detailed interviews with facilities managers as a first step in the analysis.

Design team

The design team (perhaps also including other suppliers of services in the construction team) tend to see the building from yet another perspective. Often (and for good reason), the time/cost/quality aspects of the project pre-occupy them, sometimes to the expense of the attention to detail required by users and facilities managers. They may caricature users' requirements, or fail to appreciate some of the goals in the brief. If the design team stresses corporate priorities (e.g. image) at the expense of user and/or FM requirements this may be a formula for disaster. Here the architect may be perceived as arrogant, obsessed with imagery and out-of-touch with reality. Best-performing buildings have been given due and equal emphasis to corporate, user and FM requirements, and have recognised that there may be conflicts between them that need to be resolved either at design stage or in the building management if they cannot be reconciled in the physical building.

Assumptions of different types of user

Not only do user types have different goals, each of them may also have conflicting assumptions about behaviour, requirements and provision. For example, a corporate client may assume that the design team will provide an energy-efficient building, although it has not been explicitly mentioned in the brief. The design team, on the other hand, may work closely to the written brief and may not pay enough attention to energy efficiency if is has not been explicitly itemised. Ordinary building users almost always assume that usability and comfort will be a "given" in the project, and can become disenchanted if it they do not find them in the finished product. If corporate managers have raised occupant expectations too much, and the finished building does not live up to the hype, then this can also be a recipe for disaster. The management of assumptions and expectations is a vital part of this process, especially so in buildings that have cost a lot of money or have been designed by a well-known architect. Users often give designers the benefit of the doubt in cases where they have been genuinely consulted, but will be much less forgiving if they have been treated peremptorily.

Context / quality virtuous circle

Good performance qualities in buildings depend on how well context have been defined in the design brief and, in turn, the design response to the requirements. By "well-defined context" we mean a realistic picture of the ruling constraints, including lists of realistic choices with a profound knowledge of their likely consequences and risks attached.

As the POE tries to understand the ensuing qualities in action (space, cost, operations, etc.) then this helps to get a better idea of how to deal with contexts in the future. Foremost is a more realistic picture of risk factors and their consequences. Probe. for example, found that air tightness (a construction quality issue) had a major effect on poor indoor environment performance, although it was hardly ever perceived as such (air tightness tended to be ignored).

The best buildings operate as "virtuous" systems with a well-defined context helping to foster pre-conditions for good qualities to emerge from both the eventual design and serendipitous outcomes from the building in use.

Once established in the building, the qualities themselves (e.g. airtight fabric, the character of the spaces, ease of maintenance, thermal comfort) will normally make the building easier to look after, which again helps with their performance in use. This is why POEs often find clusters of variables, with good features occurring together (e.g. comfortable, energy-efficient buildings which are relatively easy to manage and a pleasure to work in). This inter-dependence between performance qualities and context is vital. Usually, POEs give too much emphasis to the performance aspects and not enough to the contextual.

The converse applies as well, in fact, it is more common. Where the context has not been properly described [Reference 28] (for instance, an important constraint may have been absent from the design brief or the designers may have failed to act on it) the consequence will emerge later in the form of an acute or chronic problem [Reference 29] with which the building users will eventually have to cope.

Acute failures (like structural collapse) are relatively rare because building and health regulations guard against them, but chronic (i.e. more frequent but less life-threatening) defects like poor energy efficiency or poor thermal comfort conditions are endemic. Once established they become difficult to eradicate because of the self-fulfilling nature of the vicious circles of which they form a part. An example of this is "sick-building syndrome" [Reference 30] where a combination of chronic failures with e.g. cleanliness, discomfort , inadequate ventilation and poor air quality create a potentially unmanageable self-reinforcing cycle of deterioration (with "sick" buildings, correcting the management deficiencies are often more challenging than physical problems with the design).

Why isn't feedback better used?

Despite growing awareness and presence of POEs and its advocates, the take-up in the UK is still poor, and funding especially difficult. There are many reasons, some of them embedded historically in how knowledge about buildings is organised and applied.

- A sustained programme of POE is harder to carry out than most realise at the outset. The most difficult and under-estimated aspect is data management, that is, the maintenance of the benchmarks and methods over a series of buildings. Organisations rarely have the foresight to see this.
- The industry is not organised to collect POE and feedback information and deal with it. It also sees it as a threat despite the tendency for most POEs to accentuate the positive in reporting their findings.
- Clients do not see why they should be doing something they hope to take for granted. Nor does government - in spite of the major public interest aspects. Nobody wants to own POE as their own area.
- Academic disciplines do not regard building performance as an area of legitimate interest. It seems both too trivial - even anecdotal - and at the same time too difficult.
- POE is interdisciplinary, so it does not fit well into career paths and funding stereotypes. As POE has a real-world bias, it also is not very fashionable because it does not theorise overly or draw on trendy computer models and simulations.

- Professions tend to be territorial, defending their perceived areas of expertise, and are often ill-equipped to include the client's and user's perspectives. Partly this goes with the job - they know too much about buildings to step back far enough.

- Most designers and builders go straight on to the next job without learning from the one they have just done; this is also related to time/cost pressures.

- The tendency of those concerned with running buildings (e.g. facilities managers and surveyors) not to talk to those who provide them.

- Learning curves are quite steep and ill-defined. You need to know a lot in order to do POE. It is basically a real-world, not a laboratory problem; and systemic, not single-issue. Only a handful of schools of architecture (e.g. the Victoria University of Wellington, New Zealand) have courses on building performance.

- The lack of a quality-control tradition at the level of the building itself (although products and components within the building do have this tradition). Integration between systems is often the sticking point.

- The "not invented here" tendency, endemic in the UK, for research organisations not to recognise the work of competitors.

Eight cases of POEs from the UK

Case 1: One for the future?: BT Brentwood

[Reference 31]

British Telecom (BT) Brentwood [Reference 32] is a particularly good example to begin with because the building has many of the features which earlier POEs have shown to be beneficial to users such as stable thermal performance and higher provision of occupant controls than are usually found in open-plan workspaces.

First results from occupant surveys show that the approach has probably been vindicated. For example, independently audited perceived productivity gains of 8 per cent are reported. At the time of writing, energy efficiency measures and physical monitoring of the indoor environment were ongoing.

Noteworthy features at BT Brentwood include:

- Mixed mode ventilation (with ventilation provided either naturally through openable sash windows or via air supplied mechanically through floor plenums and outlets). The ventilation strategy is both seasonal and zonal (with deep-plan space treated differently from peripheral areas). A red-green system of lights on interior columns tells occupants which operating mode is current. Red means "Don't open the windows." The system seems robust enough for occupants to ignore this if they like, although this is frowned on by facilities management.

- Relatively generous floor-to-ceiling heights (3.1m - 2.7m is the norm in speculative offices) which allows cross ventilation across a greater depth than normal (18m. in this case; 15-16m is normal). Better daylighting and views out are also achieved.

- Double-skin facade with single outer glazing which creates a thermal flue and provides protection from high winds. The inner wall has double-glazed sash windows and manually-controlled solar blinds.

- Programmable individual lighting, controlled by users from their desks via telephone handsets (which seemingly works well and fits the BT telecoms culture, although it may transfer less well elsewhere).

Case 2: Historic building under transformation: National Trust for Scotland headquarters building

26-31 Charlotte Street, Edinburgh (with the 2-6 Hope Street Lane extension at the rear) [Reference 33] accommodate the headquarters of the National Trust for Scotland. NTS (and other bodies) wanted the restoration to be an exemplar of sensitive restoration with conversion to modern uses. In keeping with the Trust's aims and philosophy, the terrace of (originally) large houses (with a Robert Adam facade) has been refurbished to accommodate the current functions of the Trust, while retaining as many of the original features as possible.

The strategy for conversion was to meet NTS's requirements while retaining and restoring the original domestic qualities. For example, vertical divisions between the six houses have been kept and sometimes reinstated, and all six front doors have been brought back into use. A main circulation spine in the basement connects all six houses and a new basement link connects with the extension in Hope Street Lane.

An internal POE using Probe methods was commissioned to examine how well the aims of the project had been met, and to make recommendation for the future. As might be expected with an 18th century terrace, the severe constraints of conservation had meant that many compromises had to be made to accommodate the modern activities. Nevertheless, the predominately cellular nature of the layout plus its city centre location and natural ventilation meant that staff, although critical of layout and the resulting effects on communication between departments, for example, found the building comfortable to work in. Energy consumption fell between good practice and typical benchmarks.

Case 3: Exception that proves the rule #1. The Elizabeth Fry Building, University of East Anglia (UEA)

[Reference 34]

The Probe POE made the Elizabeth Fry building famous beyond its modest attributes. The comfort ratings given by the occupants of its offices to the Elizabeth Fry building are the second highest ever recorded by Building Use Studies Ltd in the UK. At the time of the survey it was the highest. On occupant satisfaction, the building has one important physical property on its side - the cellular office. The next task is to achieve the similar excellence in energy and comfort in the open-plan offices that many organisations now require. As Case 1 (BT Brentwood) shows, this may now be possible.

These results didn't just happen by chance, or by the selection of a particular technical system such as ventilated hollow core slabs. It came from committed people and attention to detail which is rare in an industry which puts too much emphasis on time and particularly cost, often to the detriment of quality. Elizabeth Fry's energy performance - although excellent - still leaves room for engineering systems improvement. Services engineers Fulcrum think that with refinements - and specific attention to specific fan power - they might halve the fan energy consumption in a future building. Lighting efficiency and control could also be better.

Factors for success included:

- A good client. For the past decade at least, the UEA has been seriously trying to obtain better buildings.
- A good brief. UEA takes care in brief preparation, and since the late 1980s has been particularly interested in obtaining buildings with ground-breakingly low energy and maintenance costs.
- A good team. You seldom get the best out of a team on its first job: people are still getting to know each other! But clients often wish to shuffle the pack every time, in the hope that the organisation you don't know will be better, or cheaper. On Elizabeth Fry, UEA used a team which had worked with them and with each other before.
- A good design. The response to the brief led the design team to seek to avoid air-conditioning in the lecture rooms; and they found that Termodeck (with modifications) was appropriate. Initially the offices were to be naturally-ventilated, but Termodeck proved affordable here provided that the fabric insulation and airtightness performance was good enough to eliminate the costs of perimeter heating. Less is more!
- An appropriate specification. The team took advice on aspects of the design with which they were unfamiliar, in particular the Termodeck system and on obtaining the well-insulated and airtight shell which was so important to achieving their objectives.
- A good contractor. For an innovative solution, a traditional JCT contract worked well, with a main contractor who entered into the spirit of the

design; together with that seemingly vanishing species - the client's Clerk of Works.

- Well built, with attention to detail. Often the things which cause the most technical difficulties occur at the interfaces: an issue which subcontract packages, co-ordinated by management, too often ignore. At Elizabeth Fry, designer, contractor and client all paid particular attention to the unusual insulation, airtightness and Termodeck details

- Well controlled. Here there was a false start. The client wanted "fit and forget" stand-alone controls. Although the building is a stable thermal flywheel, its slow response makes it like the proverbial supertanker: difficult to "steer" until you become familiar with its handling characteristics - and this needs good control and feedback! Fortunately, UEA was able to retrofit a Bems, and to use it effectively - improving comfort and performance and halving gas consumption.

- Post-handover monitoring and support. Probe advocated a "sea trials" period during the first year of occupation (Termodeck UK Ltd now suggest two years). At Elizabeth Fry - as in most other buildings - this did not happen initially. However, following initial problems with controls, and feedback from monitoring, the attention devoted to understanding and fine-tuning has allowed the building to deliver such high levels of comfort and energy performance.

- Management vigilance. Universities tend to have limited resources for looking after their buildings. Recognising this, and having some maintenance nightmares from the past, UEA has clear requirements for simplicity and manageability. Having contained the problem, they then endeavour to keep on top of things, and have recently reorganised themselves to respond locally, effectively and rapidly. However, now EF is running sweetly, UEA will be turning its attention to other buildings.

Case 4: Exception that proves the rule #2. One Bridewell Street, Bristol

[Reference 35]

If it is possible to call a building enigmatic then this is the one. Surveyed first in 1990, then subsequently in 1994 and 1996, but never the subject of a formal POE, One Bridewell Street has turned out, like the Elizabeth Fry Building, to be another exception that proves the rule. For an air-conditioned, open-plan office, its energy and occupant performance has been exceptional, especially during the period in the 1990s when the building was operated under a diligent facilities management department.

Case 5: Modest project assessment: National Centre for Early Music

[Reference 36]

In 1975, the York Civic Trust assumed responsibility for five redundant churches. One of these - St Margaret's, Walmgate - was offered by the Civic Trust as a possible base for the activities of the York Early Music Foundation. Although the Foundation had not been looking for premises, the offer opened up new possibilities. The Trustees subsequently sought a National Lottery Arts Council grant of just over £1 million. with a further £360,000 from matching funding, for a national centre for early music. The Arts Council asked Jane Priestman to assess the application. She thought that a grant greater than that applied for would be more appropriate to develop the full potential of the idea.

This post-project appraisal is a model example of a warts-and-all assessment of the lessons learned. It includes:

- The original business plan
- Initial organisation and project development.
- Strategic brief and appointment of professional team.
- Validation and briefing.
- Submissions and final plan
- Detailed design.
- Negotiations with the Arts Council.

- Construction.
- Revisiting Business plan during construction and restatement of need.
- Evaluation of project process.
- Budget out-turns.
- Building evaluation, including acoustics etc.
- Evaluation of performance
- Lessons for the future.

In essence, the performance space for musical recitals and events uses the restored church, and the ancillary and support services, including offices, reception and toilets, are accommodated in a new single-storey building immediately adjacent .

This project's scale is not really appropriate for a fully-fledged POE. However, this review gives valuable insight into the processes involved - especially into the Lottery funding process - with particularly valuable information about the briefing stages.

Case 6: Small-scale "green" building: Woodhouse Medical Centre

[Reference 37]

Woodhouse Medical Centre (WMC, 640 m2 gross) is the smallest building studied in Probe. The single-storey medical centre on the outskirts of Sheffield is domestic in scale and construction. It is divided into three individual units occupied by two separate general practice surgeries and a dental practice. Opened in 1989, it was built to very high standards of insulation (Wall U-value 0.2 W/m 2 K, Roof U-value 0.1 W/m 2 K) and includes several other low energy features such as mechanical ventilation and heat recovery (MVHR), gas condensing boilers and low energy lighting. It was also completed within the strict financial and spatial constraints of the local Health Commission, with no additional funding for the low energy features.

WMC has the lowest CO_2 emissions per square metre of any of the Probe buildings. It is well liked by occupants despite several gaps in their understanding of the design intent - which appeared to stem from little contact between the designers and the building's end users during and after handover. For example, the heat recovery room ventilation units were generally assumed by users to provide a form of year round air-conditioning, and hence to provide improve summer comfort. In fact, they had no bypass, so would actually tend to increase air temperatures. These units were largely unused at the time of the Probe survey. Similarly, the natural ventilation strategy was to use casement windows (sometimes now with their movement restricted by added external security bars) and if necessary to cross-ventilate with outlets through openable roof windows near the ridge in corridors and public areas. However, the roof windows were not used because they are high up and impossible to reach. Although operating poles or motors could quite easily have been added, they were not, and consequently summertime temperatures could be high. In addition, the intended cross-ventilation of doctor's surgeries via high-level windows to the corridors proved impossible owing to the need for acoustic privacy. One practice decided to retrofit split DX air-conditioning room units in a number of spaces: since these are only used in times of need, their contribution to annual energy consumption is low.

Case 7: Well-known "green" building Queen's Building, De Montfort University

[Reference 38]

The Queen's Building has academic facilities for about 100 staff and 1,500 students in the School of Engineering and Manufacture at de Montfort University, Leicester. Occupied in 1993, it is of particular interest for its daylighting strategy and its innovative use of natural ventilation, with its distinctive ventilation stacks. The 9,850 m^2 (gross) building has three distinct areas: the central building, the mechanical laboratories and the electrical laboratories. A full-height concourse in the central building acts as lightwell and thermal buffer zone for adjoining spaces, including ground floor main auditoria and classrooms ventilated by the stacks. The mechanical laboratories are mainly a naturally ventilated machine hall, flanked by small specialised mechanically-ventilated labs which also form an acoustic buffer. The electrical laboratories are housed in two shallow plan, four storey wings either side of a narrow courtyard which facilitates simple cross ventilation and well-distributed daylighting; though with somewhat unusually placed windows.

The design team's concept was a highly insulated (e.g. wall U-value is 0.3 W/m 2 K), thermally massive envelope with generous ceiling heights (3 to 3.3 m) to facilitate natural ventilation and daylighting; and greater heights in main circulation and the mechanical laboratories.

Control of internal conditions relies extensively upon a BMS to control roof vents and motorised dampers. It is also a good example of a building whose "green" credentials have been over-hyped, notwithstanding its innovative features. Probe found it to be not particularly energy efficient for its type, and rather uncomfortable for the occupants.

Case 8: Transport counts too: Centre for Mathematical Sciences, University of Cambridge

[Reference 39]

The project came about from Cambridge University's need to rehouse the increasingly congested Faculty of Mathematics, together with a generous endowment. The resulting Centre for Mathematical Sciences pulls together several departments on a greenfield site less than one mile from the centre of Cambridge. With the site surrounded by houses, there were understandable restrictions on the development's height and its visibility at night. The complete development includes a gatehouse, a library, and central building (Pavilion A), surrounded by six pavilions (C to H) and a further double pavilion (B) at the west end. The design process incorporated a strong low energy agenda, informed by the first series of Probe reports with which the design team were familiar. The client was also averse to sealed, air conditioned work spaces, preferring instead den-like spaces with openable windows for their cerebral occupants.

Key design lessons included:

- The advanced natural ventilation strategy with solar shading, exposed thermal mass, single-sided buoyancy assisted natural ventilation with secure night-time automatic ventilation works reasonably well.
- Occupants' rating for summertime comfort are good for a building of this type.
- Energy management, however, was not so good, with split management responsibilities.

One of the noteworthy features was the low journey to work mean time (20 minutes compared with a UK average of about 45) and 77 per cent of staff either walking or cycling to work. Cambridge is one of the most cycle-friendly cities in the UK, but these are still exceptionally high.

Pointers

Post-occupancy evaluation currently has many advocates but few practitioners. Although it may be obvious that feedback from buildings in use should be an integral part of the design and construction process - just as it is in most other industries as part of taken-for-granted quality control - this rarely turns out to be so.

Even the most technically advanced design practices and construction companies struggle to embrace it, even though they may wish to. These are some of the reasons:

- Occupied buildings are complex systems which are a challenge to study. There are hundreds of topics which might potentially be embraced. It is hard to distinguish between topics which are "nice-to-have" or "need-to-know" especially for the inexperienced or those working under the guidance of e.g. research project steering groups (who are myopic and usually ask for much more than can realistically be delivered).
- Whereas studies of single buildings are relatively easy, it is much harder to maintain them over larger samples of (say) ten or more. "Meta-data" (the management and organisation of the full multi-building data set which provides the benchmarks) defeats all but the most stoic. This is mainly because research funds usually do not support meta-data activities, but also because research organisations normally do not take the skills required (e.g. computer programming, statistics, web management, continuity between projects, in-house learning, continous professional development) seriously enough.

- POE projects are often enthusiastically supported at lower levels in organisations, but vetoed higher up. Corporate decision makers tend to perceive POEs as risky and hostages to fortune, especially when they have never seen or understood what value POEs provide. Those who use POE understand this value and embrace it thereafter. This is self-fulfilling. The better managers are prepared to deal with consequences, which in turn help to improve their skills and awareness. This puts POE at the "top" of the market because it embraces the very skills that got organisations to the top in the first place! This, also, means that POEs tend to report on the better performing buildings.
- Designers and managers from their different perspectives find it hard to extract useful information from POEs. Reports are too verbose. They tend to deal too much with academic, research and professional sub-agendas (like design quality) rather than immediately useful results. Although this is easily said: in fact, it is formidably difficult for the POE author (especially those doing it for the first time) to meet all needs and requirements, especially when a wide spectrum of topics are involved.
- POEs by their nature are multi-disciplinary. They have to deal with topics from the supply industry's perspective (e.g. the designers and construction team) and from the user side (e.g. clients, building occupants, developers and managers). All these want different things from POEs and can get impatient if they don't immediately see their special topic in the findings.
- POEs work best in multiple. One or two may tell you about individual buildings' quirks and features, but they do not tell you about the bigger picture. It became obvious in Probe that, as more buildings were done, the story emerging from them became consistent and the strategy clearer. But funding almost always sacrifices strategy in favour of short-termism or even tokenism.

Lastly, what has knowledge gained from POEs told us about strategy? These were some of the overview points from Probe.

Ends

Strategy first: Don't confuse means and ends. Be clear about objectives. Be prepared to test objectives in a POE.

Establish the essentials: Concentrate on good quality baseline requirements, then decide what you want to forget about. Don't procure what you can't manage later on.

Targets are always moving: Constantly review objectives and don't become complacent about "solutions". Don't commit to a design too early in a project . Give the time dimension as much emphasis as space. Be aware that cures may be worse than diseases.

Feedback

Keep hold of reality: Manage the brief. Don't let prescription trump performance. Identify risks and possible downsides. Don't be myopic about risk.

Share your experiences: Be brave, go public. Learn on the job. Be honest. Feedback internally and more widely. Use different mechanisms for attributable and unattributable items.

Adopt open source data: Use the same definitions, formulae and protocols as everyone else. Avoid "not invented here". Use licenses. Acknowledge useful work of others.

Means to ends

Get real about context: Identify constraints (site, budget, money, time, people, culture …) then manage them realistically. Look at risk/relevance trade offs. Work to the occupiers' true capacities.

Own problems, don't hide them: Don't export problems onto somebody else. Sort out which professional tasks should be owned by whom. Give occupiers' management more ownership of key area (like noise) that can't be solved by design alone. Give more leeway to individual occupants and what can reasonably be left to them (e.g. personal control).

Less can be more: Now a design cliché but still true notwithstanding. Make essential features of intrinsically efficient options. Seek simplicity. Avoid unnecessary complication. Do not create more problems than you can solve!

References

1 The author would like to thank George Baird and staff of the Victoria University School of Architecture, Wellington, New Zealand for help with the preparation of this paper.

2 No-one seems to know exactly who coined the phrase "post-occupancy evaluation". Wolfgang Preiser and Gerald Davis both say they did not, despite many thinking that one of them did. Bob Bechtel says that some used the term "post-occupancy assessment" because they thought "evaluation" would be too threatening to architects. He says the term was current by about 1972. Gerald Davis thinks that such assessments/evaluations got going in the second half of the 1960s, but that the term POE did not come into regular use until the early 1970s. Joanna Eley interviewed facilities managers in the UK in 2002 and got: "POE is what happens after we've gone", an ironic definition which was first heard in the USA in the 1970s.

[This information was kindly provided in an e-mail exchange by members of the Environmental Design Research Association (EDRA) in August 2002].

For a review of POE in the USA see Federal Facilities Council, Technical Report 145, Learning from our buildings: a state-of-the-practice summary of post-occupancy evaluation, Washington: National Academy Press (2001).

For a review of cases and techniques see Baird G., Gray J., Isaacs N., Kernohan D. and McIndoe G. (eds) (1996), Building Evaluation Techniques, McGraw-Hill.

For downloadable POEs in the public domain go to www.usablebuildings.co.uk

3 Building Performance Research Unit (1972), Building Performance (London, Applied Science Publishers)

4 Baird G, Donn M, Pool F, Brander W and Aun CS, Energy Performance of Buildings, CRC Press Lyd, Boca Raton, Florida, 1984, p7.

5 BPRU see [3]

6 In the USA, the term 'building' tends to be used to mean just the physical artefact and its enclosed spaces, whereas 'facilities' is used to cover the whole building in use over time. This terminology has not caught on elsewhere. Outside the USA 'facilities' is usually taken to mean the services that are provided in buildings (e.g. restaurant, cleaning, lifts, toilets etc.), and 'building' can mean either just the physical artefact or the building in use.

7 BORDASS W. (2002) Learning more from our buildings - or just forgetting less? Review for Building Research & Information Journal of Federal Facilities Council, Technical Report 145, Learning from our buildings: a state-of-the-practice summary of post-occupancy evaluation, Washington: National Academy Press (2001).

8 ROBSON C., Real World Research, Oxford: Blackwell, 1993

9 CPBR List of Techniques complied by Harry Bruhns. Chapter 8 of Baird G., Gray J., Isaacs N., Kernohan D and McIndoe G (eds) (1996), Building Evaluation Techniques (New York, McGraw-Hill)

10 Feedback. A Partners in Innovation project to encourage clients and the industry to undertake feedback, William Bordass Associates, London, 2003

11 Probe studies were published in Building Services: the CIBSE journal from 1997-2002. A special issue of Building Research and Information (vol 29, number 2, March/April 2001) is also devoted to Probe. Probe material may also be downloaded from www.usablebuildings.co.uk.

12 CIBSE Technical Memorandum 22, Energy Assessment and Reporting Methodology: the Office Assessment Method. London: CIBSE (1999).

13 BUS questionnaires may be obtained via licence: visit www.usablebuildings.co.uk

14 CIBSE Technical Memorandum 23, Testing Buildings for Air Leakage, . London: CIBSE (2000).

15 Building Performance Assessment Centre, Building Research Establishment

16 The pre-visit questionnaire was first used in-house by William Bordass Associates and then by Probe. It is now available for a modest licence fee. Apply via www.usablebuildings.co.uk

17 The Probe studies were carried out in three phases: 1: Probe 1-8; 2. Probe 9-16; 3. Probe 17-20.

18 Cohen R., Standeven M., Bordass W. and Leaman A., Assessing Building Performance in Use 1: the Probe Process, Building Research and Information (vol 29, number 2, March/April 2001), pps 85-102.

19 Adapted from Bordass W., Learning more from our buildings - or just forgetting less? Review for Building Research & Information Journal of Federal Facilities Council, Technical Report 145, Learning from our buildings: a state-of-the-practice summary of post-occupancy evaluation, Washington: National Academy Press (2001)., (unpublished draft 2002).

20 Although simple in structure they should contain fields which use common or standard definitions so that the data may be cross-referenced if required.

21 Building Use Studies has a sample of UK buildings which is large enough for comprehensive occupant benchmarks. Samples of buildings in Australia and New Zealand are approaching the size required for robust benchmarks.

22 Organisational factors like changing staff morale or management quality may affect POE outcomes. People may use criticism of the building as an indirect way of getting at management they dislike. These factors may be detected, but are often hard to study directly. It may be wiser to avoid subjects like job stress or staff morale in a POE questionnaire, for example, because they give management an excuse for

denying you access to the study building. It is best to stick to topics in POEs which are directly building-related.

23 Cohen R., Field J. and Leaman A, Probe 20: Barclaycard headquarters , BSJ 37-42 (March 2000).

24 The Probe Team, Probe 22: Centre for Mathematical Sciences , BSJ 57-62 (July 2002).

25 For a range of downloadable papers on this topic visit www.usablebuildings.co.uk

26 Probe #20 Centre for Mathematical Sciences included a journey to work survey which is now a standard part of the BUS occupant survey method.

27 Not only can a survey be carried out in a day or less, but managers and staff do not usually perceive it as an intrusion.

28 Or perhaps ignored altogether by using a standardised approach or a design template ("one sized firs all")

29 Also called a "revenge effect" by Edward Tenner.

30 The term "sick-building syndrome" is another that does not work properly. "Building-related illness" is better. People get ill, not the building.

31 Hughes A., O'Carroll D. and Uys E., BT 'Workstyle' Brentwood, Essex, Arup Journal 1/2002, pps 13-18.

32 15,000 m^2 net of office space on three floors with restaurant and 'winter garden' conservatories.

33 Charlotte Square has 2940 m^2 of net usable area and Hope Street Lane 627 m^2, giving a total of approximately 4200 m^2 gross. About 180 staff work in the offices, with 10 in support and 30 (including shiftworkers) in the gallery, shop and restaurant.

34 M Standeven, R Cohen, W Bordass and A Leaman, Probe 14: Elizabeth Fry Building, BSJ 37-41 (April 1998).

35 Published material on One Bridewell Street includes Energy Efficiency in Offices, Good Practice Guide Case study no 21, One Bridewell Street, Energy Efficiency Best Practice Programme (May 1991); J Eley, Proving an FM Point, Facilities Management World, 1, 11-13 (1996)

36 Available in pdf format from www.usablebui ldings.co.uk. Permission Trustees National Centre for Early Music. R McMeeking, National Centre for Early Music Project Evaluation, York Early Music Foundation, York, 2002.

37 M Standeven, R Cohen and A Leaman, Probe 6: Woodhouse Medical Centre, BSJ 35-39 (August 1996)

38 R Asbridge and R Cohen, Probe 4: Queens Building, de Montfort University, BSJ 35-41 (April 1996).

39 The Probe Team, Probe 22: Centre for Mathematical Sciences, BSJ 57-62 (July 2002).

Adrian Leaman runs Building Use Studies which carries out studies of building performance, primarily from the users' point of view.

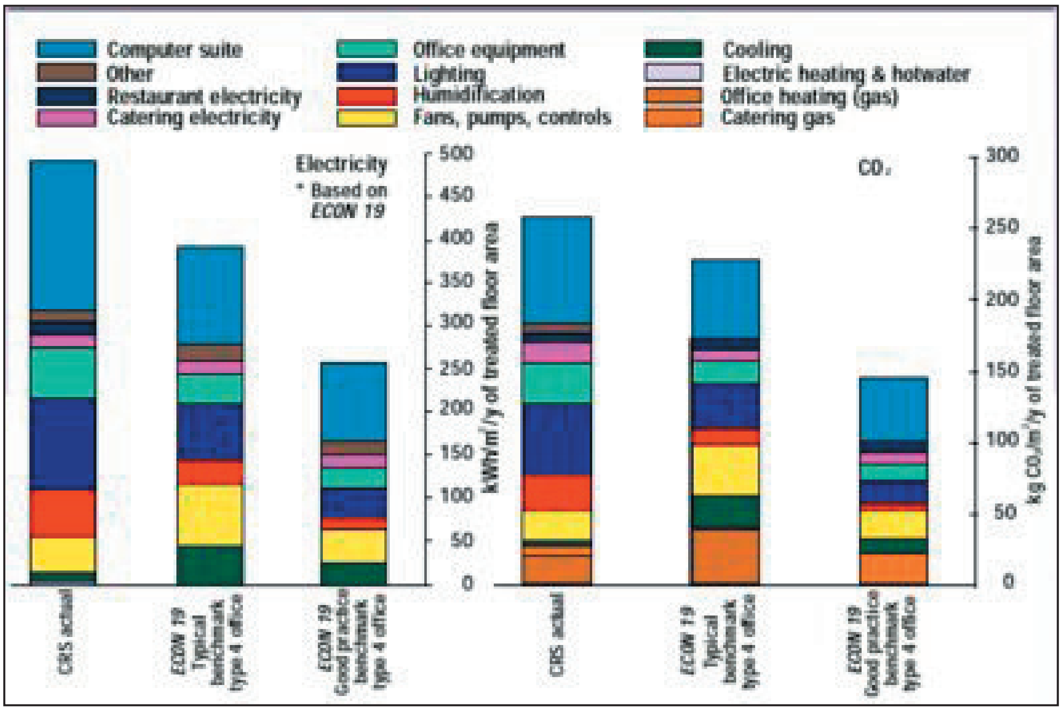
Box 1: Landmarks in post-occupancy evaluation

Seminal works in POE	Date	Topic	Building types		Indicative reference
Tom Markus, Tom Maver and others	1972	Appraisal techniques	Mainly schools	UK	Building Performance Research Unit (1972), Building Performance (London, Applied Science Publishers)
Philippe Boudon	1972	Architecture	Housing at Pessac	France	Boudon P, (1972), Lived-in Architecture (London, Lund Humphries)
Oscar Newman	1973	Crime prevention	Urban housing	US	Newman O. (1973), Defensible Spaces: Crime Prevention Through Urban Design (New York, Colliers Books)
Alison Ravetz	1970s	High-rise housing	Urban housing	UK	Ravetz A., Model Estate: planned housing at Quarry Hill, Leeds, Croom Helm for Rowntree Trust.
John Zeisel	1984	Methods	Various	US	Zeisel J, (1984) Inquiry by Design, Tools for Environment-Behaviour Research (Cambridge, University Press)
Wolfgang Preiser	1988	POE methods	Mainly offices	US	Preiser W, Rabinovitz H and White E (1988), Post-occupancy Evaluation (New York, Van Nostrand Rheinhold)
Alan Hedge, Sheena Wilson	1987	Health in buildings	Offices	UK	Hedge A and Wilson S, The Office Environment Survey (London, Building Use Studies)
Jaqueline Vischer	1989	Environmental quality	Mainly offices	US	Vischer J (1989), Environmental Quality in Offices (New York, Van Nostran Rheinhold)
George Baird, John Gray and others	1996	Methods and cases	Various	NZ	Baird G., Gray J., Isaacs N., Kernohan D and McIndoe G (eds), Building Evaluation Techniques (New York, McGraw-Hill)
Rod Bunn, Paul Ruyssevelt, Adrian Leaman, Bill Bordass and Robert Cohen	1997-2002	Probe series of 20 buildings	Various	UK	Building Services Journal 1997-2002, Building Research and Information Special Issue March 2002

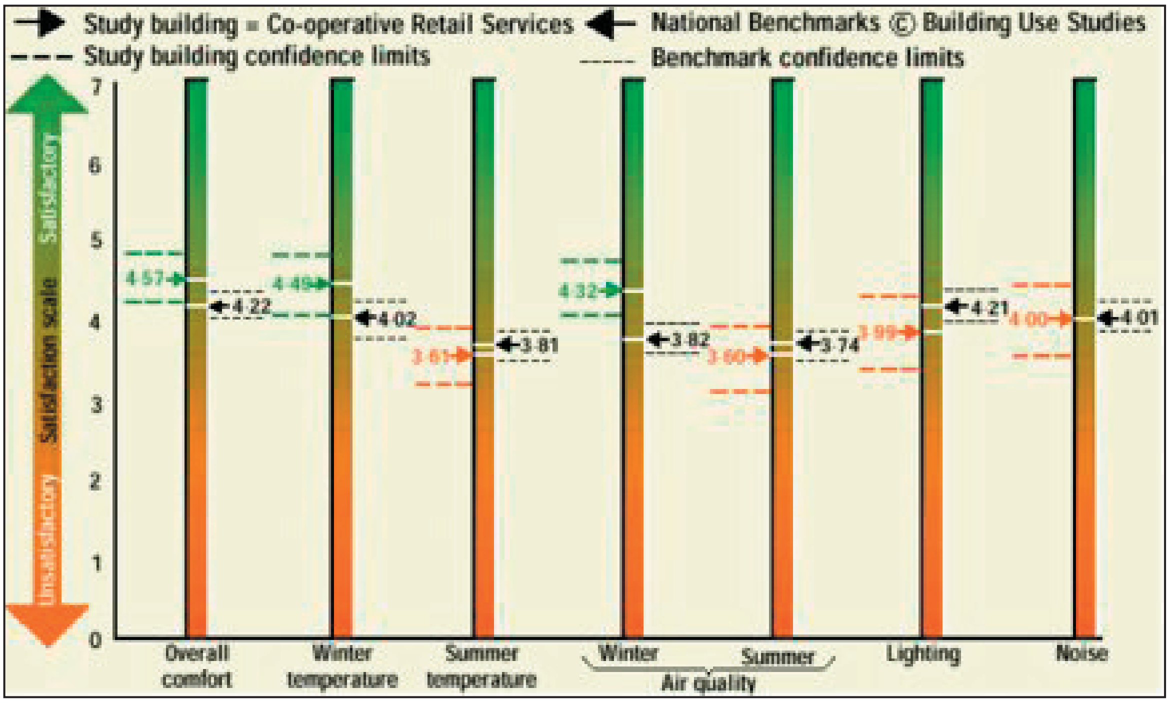
Box 2: Real-world research

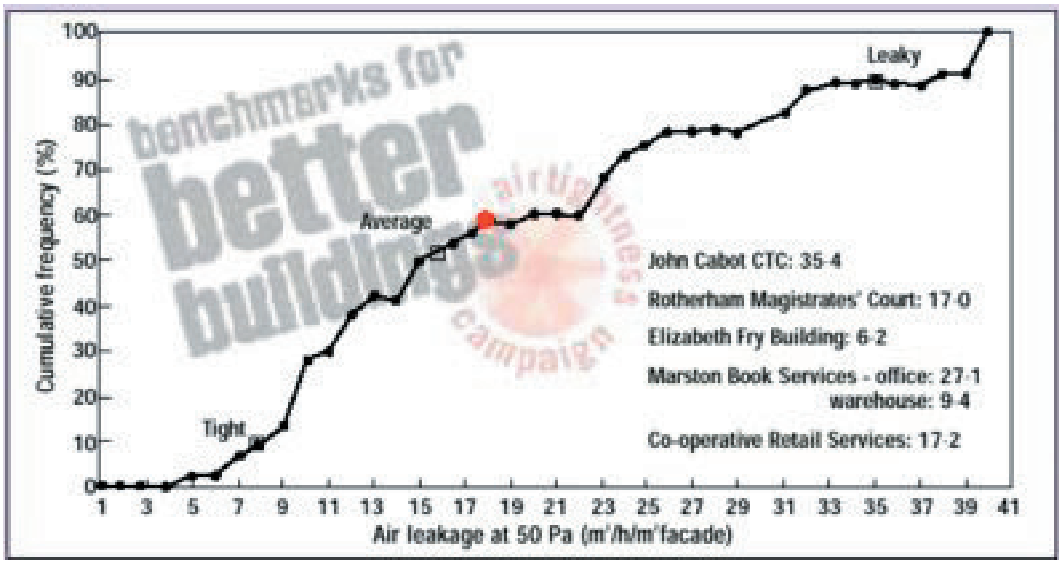
Solving problems	… rather than …	Just gaining knowledge
Predicting effects	… rather than …	Finding causes
Looking for robust results and concern for actionable factors	… rather than …	Statistical relationships between variables
Developing and testing services	… rather than …	Developing and testing theories
Field	… rather than …	Laboratory
Outside organisation (e.g.business)	… rather than …	Research institution
Strict time and cost constraints	… rather than …	R&D environment
Researchers with wide-ranging skills	… rather than …	Highly specific skills
Multiple method	… rather than …	Single method
Oriented to client	… rather than …	Oriented to academic peers
Viewed as dubious by some academics	… rather than …	High academic prestige

Box 3: EARM benchmarks



Box 4: Building Use Studies benchmarks





Case 1: BT Brentwood, Essex

Case 2: National Trust for Scotland, Edinburgh

Case 3: Elizabeth Fry Building, Norwich

Case 4: One Bridewell Street, Bristol

Case 5: National Centre for Early Music, York

Case 6: Woodhouse Medical Centre, Sheffield

Case 7: De Montfort Queen's Building, Leicester

Case 8: Centre for Mathematics al Sciences, Cambridge