LEARNING HOW BUILDINGS WORK IS CRUCIAL TO BETTER GREEN DESIGN

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ABSTRACT

Building designers need far better feedback on how well their buildings work. Existing buildings offer a wealth of opportunities for designers to learn, and to improve future designs. A more comprehensive understanding of how existing buildings develop and change over time, and meet, or fail to meet, user expectations offers designers the opportunity to learn from existing buildings. Also, feedback loops are needed to ensure that designers learn lessons from built projects and apply them to future designs.

In addition, there is a particular need to understand whether claimed "green buildings" really do meet the needs of occupants and reduce their environmental impacts. Assessing real building performance from both a technical and social perspective is one way of both raising the profile of issues that are important to building occupants, and of improving understanding of real building performance.

Several new mechanisms have been proposed in recent years that offer the opportunity to re-establish some of the missing feedback mechanisms for designers. These can provide direct information on the performance of their designs potentially leading to better performing buildings environmentally, economically and socially. This can minimise problems and utilise those design features that work successfully, applying the laws of survival of the fittest. This paper reviews some of the recent initiatives to establish better feedback mechanisms.

INTRODUCTION

Learning how our buildings work is essential to better design, and to better design education. Without feedback loops that inform designers of the performance of their designs, every building becomes to a large extent a prototype and the knowledge that could be learnt from each building is lost. Yet historically designers have not generally made much effort to get routine feedback on their projects. They hand over one job (often less profitable than anticipated) and the next project beckons. The users are left to struggle with the problems of the completed building. Usually, only in the event of problems do the designers get involved after completion. As far back as 1962, the Royal Institute of British Architects report—The Architect and His Office (RIBA, 1962)—stated:

> "Although many architects maintained an interest in their buildings after they had been handed over, it was generally a casual one. . . . There was a noticeable lack of systematic activity in this field. . . . We think that the study of buildings in use, from the technical and cost points of view as well as in terms of design, could be carried much further by the majority of offices to the great benefit of the profession and the community. The ability to learn lessons systematically from experience is the key to technological progress and social influence."

Despite this report and the interest in the 1960s and 1970s in experimental psychology, the study of buildings in use failed to establish itself other than for limited research purposes. In the UK, the 1962 edition of the RIBA Plan of Work (RIBA, 1963) included a Stage M: Feedback, which was intended to encourage architects and their clients to inspect and review the finished buildings two or three years after practical completion. Stage M was later removed, probably for the pragmatic reason that it was not related to any fee payment stage of the Architects Agreement and the RIBA did not wish to create the impression that architects would do it for nothing. In North America, early work by Van der Ryn at the University of California at Berkeley (Malin, 2003) was followed by some interest in post occupancy studies in the 1960s and 1970s but mainly involving

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the research community, and providing little direct feedback for design practitioners.

Key findings from a recent literature review (Bordass, 2003) concluded that the construction industry is still slow to learn from its completed products, particularly from the experiences of the users and feedback loops for designers are still largely missing today. Feedback needs to become routine: as quality control in the more repetitive projects, as a necessary part of hypothesis-testing in innovative ones, and to increase awareness of chronic problems and changing requirements (FFC, 2001).

THE PAST

Throughout most of human history, design of the man made environment was embedded into the culture of communities and shared by all through simple participation in the life of the community. Local design knowledge would accumulate over time and be shared by the community so that all members knew the appropriate approaches to design problems they commonly encountered. As a result, people lived with their own design decisions, and were quickly aware of any shortcomings. This created short feedback loops based on first hand experience if any problems occurred or inappropriate decisions were made. Unsuitable designs were quickly weeded out, and the laws of survival of the fittest applied to design ideas as well as to other areas of evolution.

More recently, demands on our buildings have increased as they have evolved into far more complex cultural symbols and technical solutions to ever more complex functional requirements. This has resulted in increasing complexity in the built environment, and in the technical solutions used in buildings. As a result, much of the responsibility for the design of our environment has been transferred to "professional" designers with higher levels of expertise, distinct from the users. Consequently, design knowledge that was previously shared by the community has become exclusive and not available to the majority; it has a commercial value. Thus, the link between the designer and direct experience of the building is generally no longer present. Designers often have very little day to day experience of their designs and so they are unaware of the problems and lessons that could be applied to future designs. This has been accompanied by a trend to replace freely or locally available resources such as solar radiation, daylight, natural ventilation, local building materials and local skills, with resources that are collected from a much wider area. This further extends feedback so the designers and building users are not aware, or do not directly experience the negative impacts and many chronic problems of their decisions (particularly on the wider environment), which occur later in time, or on a wider geographical scale.

EVOLUTION OF BUILDINGS

We also forget that design problems do not stay constant over time, and the requirements placed on a building throughout its life change and evolve. For example, the typical London Georgian terraced house type may have originally been a family house, but this building type has since been used for many other functions during its lifetime such as apartments or offices. In that time, many new technologies for heating, lighting, plumbing, drainage, communications, insulation, glazing, etc., have been incorporated, as well as countless changes in layout, decorative fashions, furniture, etc. Similarly, with most other buildings, even enduring types such as churches or municipal buildings, new or changing uses constantly place new demands on them which lead to evolving buildings. Those that can evolve in an effective manner are likely to last while others are prematurely replaced if they cannot encompass change. Some of this change may be minor and involve only the users in small adaptations such as changing furniture layouts, while others may lead to major renovations or adaptations involving designers. But the ability to adapt is fundamental to a sustainable building (Croxton, 2003):

> "If a building doesn't support change and reuse, you have only an illusion of sustainability. You may have excellent building orientation and other energy-saving systems, but the building must also be able to be flexible to meet a change in curriculum."

However, designers like to think of their buildings as finished products, which have been perfected, and should remain unchanged. As a result, buildings are rarely designed to accommodate significant change and development over their life, and there is little guidance about how to design to allow buildings to

FIGURE 1. This simple building is flexible enough to have served several different functions over the last 30 years, including a bar, workshop, shop, restaurant, and storage.

evolve over time. Yet, just like human beings, buildings need to be allowed to develop over time, to mature, grow and evolve, otherwise they often deteriorate. Stewart Brand talks about "blue jeans buildings"—buildings that age honestly and elegantly with time (Brand, 1994). This requires acceptance of a building as an evolving entity where the design and construction phase is just the start of a long process over the life of the building.

> "The point is to arrive at an architecture that, when users decide to put it to different uses than the one originally envisaged by the architect, does not get upset and consequently loose its identity. Architecture should offer an incentive to its users to influence it wherever possible, not merely to reinforce its identity but more especially to enhance and affirm the identity of its users." (Hertzberger, 1991)

Designers must recognise this dimension of time and how it affects their proposals. They need to consider that a building is likely to undergo many changes over its lifetime. Designers can begin to learn about how time affects buildings by studying existing buildings and how users experience and adapt them over time. Feedback about building performance can help to develop an appreciation (and possibly a respectful attitude) by the designer of the ongoing life of the building where the designer may have little control. Analysis of how buildings are used, how they function, and how users wish to change them can provide designers with an insight and respect for time. As a result, their designs may become more durable and capable of being adapted for changing requirements. A desire to learn from buildings and to establish feedback loops that will inform their future designs can instil a culture of respect for users, continuous learning, and improvement loops. Feedback systems are far more effective when those actually working on projects can see their usefulness rather than being imposed from above. Sir Andrew Derbyshire in a recent paper quotes a comment of his own from the 1950's:

> ". . . the architect who believes that his work is done as soon as the building is finished must be made to look as ridiculous as the scientist who believes that his experiment is complete as soon as he has assembled the apparatus." (Derbyshire, 2004)

CONTINUOUS LEARNING PROCESS

As clients and governments today become more interested in the performance of their buildings for reasons of sustainability, efficiency and workplace productivity, leading design firms are realising that a better understanding of how their buildings actually perform is no longer an option but essential to their survival. Additionally, some enlightened designers of "green" or "sustainable" buildings are using new strategies, technologies and systems, and they need to know how effective these have been to reduce environmental impact while creating comfortable spaces. In recent years, greater interest in feedback systems and how to consider the whole life of buildings has led to a number of techniques that are applicable at various stages of the procurement process. These can improve how buildings work, and how we can improve the process of delivering new buildings by learning from existing buildings (see Leaman, 2004; or Preiser, 2005). The following is a short review of some of these ideas:

Interdisciplinary design

A feature of the complexity of modern buildings is that many fragmented design professions shape the environment, and it is often their concerns and priorities that are given precedence over those of the users, or of the society and community as a whole. The diversification in design, construction and education roles has created conventional building procurement processes with confrontational structures and barriers between areas of expertise. These are often underpinned by mistrust, reducing the likelihood of effective team working. Addressing both the sustainability agenda and in particular issues of occupant satisfaction requires a more effective dialogue between all participants involved in the production of buildings, and with occupants.

The integrated design process (IDP) is based on the well-established observation that changes and improvements in the design of a building are relatively easy to make at the beginning of the design process, but become increasingly difficult, expensive and even disruptive as the process unfolds. IDP encourages a collective responsibility and leads to sharing of information and a greater understanding by all of how the building works. The IDP process can help develop an understanding of the problems that other professions face creating a far more conducive environment for feedback loops. Contact with users and other designers can lead to an appreciation of the importance of communication; with clients, within the design team and with potential users, and the need for collaboration at all stages.

One of the key findings of the Probe studies into building performance in the UK is "*the need for more strategic briefing, greater clarity of discussion, and the assessment of the options and solutions for usability, robustness and manageability*" (Bordass et al, 1999). By increasing awareness of user needs and building functioning problems IDP can develop an appreciation of the importance of the briefing (programming) stages of a project and allocation of responsibilities, so that it is clear who "leads" on which problems, and what are the full implications of design decisions. This requires clear objectives which can be used to assess the design at various stages. In Canada, IDP has been developed as part of the C2000 program demonstrating that significant improvements in environmental performance can be achieved with little additional cost when the design team work in a structured and integrated way (Larson, 1998). As a result, IDP is now used for all projects that receive funding through the Canadian Commercial Buildings Incentive Program (CBIP).

Full building commissioning

Although commissioning of HVAC services is in theory a requirement in most buildings, the reality is that full and effective commissioning of HVAC rarely occurs, and many buildings go through their life with poorly functioning systems. Furthermore, with more complex and innovative cladding systems and the desire to achieve well insulated and airtight building envelopes there is an increasing need for building envelopes, and indeed whole buildings, to be properly "commissioned". Lemieux and Totten (2004) amongst other have advocated building envelope commissioning, particularly for green or innovative buildings. They claim that many performance problems that occur in green buildings are linked to poorly performing building envelopes and could be avoided by proper commissioning procedures. The process of commissioning an envelope is established, and covers many of the same aspects as other systems commissioning and allows problems to be anticipated and eliminated prior to construction. Additionally, it allows the links between HVAC and envelope performance to be explored.

Building Sea Trials

It has been argued by Bordass and others that perhaps buildings should no longer be seen as practically complete when they are physically complete and it may no longer be practical for them to be completely trouble free at the day of handover (Bordass et al, 2004). Perhaps it is time to accept that complex buildings require some initial settling in period before they function at full efficiency. In a world of changing customer requirements, rapid innovation, and sophisticated information and control systems, these systems need fine-tuning. Suppliers, designers and users need to work together to understand each other and to improve performance. A strategy is required for the first years of occupancy to ensure a smooth transition from construction into operation and to ensure that the necessary information is available for future change and evolution of the building as needs change. Just as important, the strategy should ensure that the designers and contractors get the necessary feedback on performance of the building so that they can learn the lessons of the project for future benefit. Without this, designers will continue to repeat the same mistakes from the past due to a lack of knowledge that their buildings are not functioning well.

When complex projects are undertaken by other industries they usually plan some form of testing and refinement of the final product before it is finally handed over to the client. With increasing complexity in buildings it has been proposed that there is often a need for post completion test running or "Sea Trials" for a building, where the design team are involved in running the building for the first period of operation. For example, Cambridge University and design firm RMJM have developed "Soft Landings," a follow-through procedure which focuses on aftercare and feedback in the first few months and years of occupancy (Bordass et al, 2004).

In the UK, a study considered how best to address the first year of occupancy to ensure a smoother transition from construction into operation and to prepare for any necessary occupancy studies (see section on POE) such as technical, occupant and energy surveys. The main outcome was a manager's checklist, now incorporated within a BRE Digest 478 entitled *Feedback: getting started.* (Jaunzens et al, 2003)

Building log books

Currently most buildings have bulky and inaccessible O&M manuals that few people use. Clients then complain because they do not have the information they need to know to operate them successfully. When you buy a car you get a simple handbook and somewhere to log the maintenance history. In the same way there is a need to set down, in simple terms, how a building is meant to work and to log performance and maintenance. Recent changes to the building codes in England & Wales—Part L of the Building Regulations (2002)—introduced requirements for "Building Log Books" in new and refurbished buildings which are intended to provide the building owner or occupier:

> ". . . with details of installed building services plant and controls, their method of operation and maintenance, and other details that collectively enable energy consumption to be monitored and controlled". (DETR, 2000)

The log book should be an easily accessible focal-point of current information for all those working in the building that summarises the philosophy, energy performance, maintenance performance, occupancy and alterations to the building and its services. It has four main functions (CIBSE, 2003):

- *Summary of building*—information about the building including the original design, commissioning and handover details and information on its management and performance, including the designers estimates of building energy consumption.
- *Key reference point*—single document in which key building energy information is kept.
- *Source of information and training*—key source of information for the daily management or operation of the building and for carrying out work on the building. Also relevant to new maintenance/facilities management staff and contractors and consultants.
- *Dynamic document*—it is a place to log building performance and operation, and changes to the building.

Building log books can improve understanding of buildings amongst the staff working in the building, those running the building and external contractors or consultants that are new to the building. They can help prevent random alterations to buildings that might damage the overall design intent and could save time in searching for key information. Log books also provide a clear mechanism for monitoring building energy, water and other performance to highlight potential wastage (Jones, 2004). At the end of the life of the building the information on specifications of structural, HVAC and other components will help to enable them to be more easily reused.

Post Occupancy Evaluations—business benefits or better buildings

Post occupancy evaluation (POE) has been defined as "*examination of the effectiveness for human users of occupied design environments*" (Zimmerman & Martin, 2001). It generally involves some form of surveys of building occupants and may also include some measurement of environmental conditions and assessment of energy and water use and usually occurs a year or two after building completion, or before a refurbishment. Cooper (2001) has identified three separate agendas for POE activities:

- POE as a design aid—as a means of improving building procurement.
- POE as a building management aid—to aid organisational efficiency.

- POE as a benchmarking aid—to help understand, measure and compare performance.

POEs can have a range of benefits for designers over different timescales. Problems identified during a POE can often be overcome or alleviated by immediate minor modifications and repairs thereby improving performance and occupant experience. Once problems are highlighted it is generally in the owners interest for these to be addressed. The POE survey can ask occupants where problem occur and a more detailed investigation can focus on the relevant areas of concern. In the medium term, designers and repeat clients can use the knowledge gained from one project to improve subsequent projects. Feedback to issues such as: did we do this effectively? did it go well? and was it the right thing to do in the first place? can help designers in future decision making. Finally, in the longer term, POEs can be used to generate improved guidance and design education that improves design processes and procurement programs.

For the building user, other questions related to how the building contributes to business aims, such as efficiency of operation, satisfaction of staff and productivity, are relevant. Many years of research have focused on human and organizational factors that affect the success of organizations and their efforts to develop and change. However, corporate organizations have been slow to recognize the importance of physical space on an organization's performance. Senior management generally wish to concentrate on core business and consider buildings as nuisances which they would prefer to ignore. In 2001, MIT and the Gartner Group estimated that fewer than 5% of the corporations in the US were actually linking the workplace to their corporate strategy, and using the workplace as a tool for improving performance (Bell et al, 2001). The past decade has seen the publication of several books on the workplace (see Duffy, 1997 or Horgen et al, 1997) and recognition is growing within business that the physical workplace can provide a platform for organizational change and business innovation. Some organizations are now becoming concerned about this because research shows that there are significant linkages between the workplace environment, job satisfaction and worker productivity and thus the corporate bottom-line.

Thus, a primary driver for post occupancy evaluation of workspace in recent years has been to identify whether organizational and workplace goals have been achieved. Some large organizations have implemented feedback systems to improve building functioning, and sometimes to provide information when a building is to be renovated. For example, the National Board of Public Buildings in Sweden collects information about specific buildings including occupant surveys, and Public Works Canada collects data on technical and operational performance of buildings from occupants and staff. However, such POE research focuses on *business goals* rather than *design feedback*. It is also rarely made publicly available for perceived reasons of commercial sensitivity and potential liability issues, and often does not involve the building designer so there is little benefit in feedback to the design process. However, there have been a few recent initiatives to collect information through POE activity that aims to provide design feedback and inform the profession about chronic industry problems. Some of these have been publicly disseminated. These include:

- The *Probe* studies (Bordass et al, 1999) in the UK, which were a unique collaboration between researchers, designers, government and a publisher. Post occupancy evaluation (POE) studies of 16 buildings were published based on assessments developed by Building Use Studies and included occupant surveys, measurement of performance and assessment of energy use data. The studies addressed a wide range of issues relating to efficient operation of buildings.
- The series of POEs carried out by Keen Engineering on buildings in British Columbia using the CBE occupant survey described below (Hydes et al, 2004).
- The *Workplace 20*20* (Kampschroer & Heerwagen, 2004) initiative by the U.S. General Services Administration which focuses on the links between workplace design and business goals and organizational effectiveness in the federal sector. The research uses the Balanced Scorecard framework developed by Kaplan and Norton (1996) to assure that measures have business value.
- The *Office Productivity Network* survey developed by the Building Research Establishment and SBS in the UK focuses on the operation of a workspace for satisfaction and productivity (Oseland, 2004).

- The web based *Occupant Satisfaction Survey* developed by the Center for the Built Environment (CBE) of University of California at Berkeley covers thermal comfort, indoor air quality, acoustic quality, visual privacy, lighting quality and aspects such as furniture (Zagreus et all, 2004).
- The *Overall Liking Score* (Levermore, 1994) used by ABS Consulting which focuses on occupants perception of the working environment to aid facilities management and considers occupant feedback as a "key performance indicator" of the building (Ure & Hampton, 2004).

Student POEs

Carrying out POE assessments of buildings can bring students closer to the feedback loops that are provided by experiencing buildings firsthand. It can help develop an appreciation of the importance of the users and of considering the ongoing lifecycle of a building. Students can focus on a range of issues such as occupant satisfaction of spaces or amenities and satisfaction of the building design by carrying out user surveys, and/or they can use measurement tools to assess the quality of the thermal, acoustic and lighting environment. The *Vital Signs* and subsequent *Agents of Change* programs in North America (see http://aoc.uoregon.edu) are leading the way by training teams of architecture faculty and teaching assistants in building performance evaluation methods and expanding the knowledge base of field-based case studies. The Canadian Mortgage and Housing Corporation run a competition for students to carry out a technical appraisal of an existing building, where students are encouraged to collect extensive data about an existing building and carry out an appraisal of its performance. At present this is limited to technical issues but could be expanded to include operational and functional issues.

Benchmarks of good performance

When we buy a car we expect good information about its technical specification and expected performance so we can compare with other models and make informed choices. If the car does not meet the expected performance we expect action to rectify the problem. The same could be expected of buildings yet there is little information about how buildings are expected to perform or even agreement on what is a good building, and there is often lack of agreement about how to measure performance. This has resulted in market ignorance on the part of both suppliers about how to deliver buildings that meet certain standards, and consumers about how to demand buildings that will satisfy their needs and requirements.

Without benchmarks it is difficult to know what good practice is. Publications such as ECON19 (DETR, 1998) in the UK show the energy used in different types of UK offices and provide very useful context for energy use figures. The recent European Union Energy Performance Buildings Directive (EU, 2002) will help to instigate a culture of assessment and comparison by requiring major buildings to have regular energy audits and declare their energy performance in the form of publicly displayed energy performance certificates.

The *Leadership in Energy and Environmental Design* (LEED) green building rating provides an attempt to measure the "greenness" of a building. It is nevertheless largely based on an assessment of the design intentions of the design team and attempts to ensure that much of this is translated into the built form. Nevertheless, rumours abound of the poor performance of LEED certified and other high profile green buildings. It is important that both lessons are learned from LEED certified buildings and that these buildings can be seen as exemplars that are respected and copied. For this to happen, there is a need for good information about how the buildings work in practice, and what lessons can be learned from them.

Design Quality indicators (CIC)

Amidst some controversy, *Design Quality Indicators* (DQIs) have been developed in the UK to "provide a tool kit for improving the design of buildings" by "capturing perceptions of design quality embodied in buildings" (Gann et al, 2003). They are designed to be used by anybody involved in the production of the built environment and set out to capture a wide range of criteria of quality so that the impact of differing priorities can be accommodated. The UK DQIs are divided into three main parts based on an intellectual framework that aims to modernize the Vitruvian concepts of *Firmness*, *Commodity* and *Delight*, by proposing that the quality of a building can be ascertained by measuring functionality, build quality and impact.

Functionality concerns the disposition, quality and inter-relationship of space and the manner in which a building is designed to be useful. Build quality relates to technical performance, including the quality of integration, co-ordination and performance of the structure, fabric, finishes and fittings. Impact refers to a building's ability to engage both the mind (memory and intelligence) and the senses, to create a sense of place and to impact positively on the local community and environment.

The DQIs are designed to be used through inception, design, construction and again when the building is in use, and allow clients to clearly establish their requirements in the brief (program) and evaluate the extent to which their intentions have been met. The main purpose of the tool is to allow comparison between different respondents' results and between different projects. Initial responses from users of the DQI tool suggest that it is most helpful as a design process aid, stimulating discussion about client and design objectives at the start of the project and reviewing these throughout the process. It thus helps to generate a comprehensive program and agreed goals. There are however concerns about its appropriateness as a measure of quality. Also, the feedback mechanisms help to understand the different perspectives of users, facilities managers, visitors, etc but they are viewed as too complex, producing a confused picture.

CONCLUSIONS

In today's world there is a pressure on architects from clients and media to produce iconic or "wow" buildings leading "*to a tension between the need to design rationally and the ambition to produce large scale sculpture*" (Derbyshire, 2004). But architectural design with its wide ranging social, environmental and technical implications is not simple. It must combine rational thought with intuitive/emotional creative ideas. The benefit of greater feedback in the design of buildings seems self evident, yet considerable barriers exist. These include the following categories that have been identified by various authors (Bordass et all, 2004; Hydes et al, 2004; Zimmerman & Martin, 2001):

- Standard practice in the building procurement process does not recognise the concept of continual improvement.
- The division of functions of the delivery/construction team and the management/maintenance team.
- Lack of R&D focus of the industry.
- Lack of integration into traditional education of construction design professionals
- Split incentives—fragmentation of the industry with each actor having different incentives and goals.
- Liability—both from the designers perspective and from the building owners perspective.
- Uncertainty about what feedback techniques are available, how they are best used, what they cost, and what value they add.
- Resources—who should pay? Clients do not see why they should pay designers to undertake POEs on recently completed buildings, as this would benefit future clients more than themselves. Designers are unwilling to take on this additional workload without compensation.
- Knowledge management systems tended to be poor for most of the construction industry so feedback information stays on the shelf and never gets used.

Building procurement and management has been categorised as disjointed, cost-driven, time-limited, conflict ridden and ignorant (Preiser & Vischer, 2005)! The result is an increasing awareness that feedback mechanisms are required to improve the industry knowledge base. Several authors (Preiser & Vischer, 2005; Derbyshire, 2004) have proposed conceptual frameworks for building performance evaluation that relate the various available tools into a portfolio of feedback techniques which offer advantages at different stages in the process of procuring and operating a building. The initiatives described in this paper are all part of an overall culture of continual learning that is needed in design consultancies, contractors, building owners and in the construction industry as a whole. They are all related and should engender a culture of feedback and continuous improvement (Figure 2). POE should become easier, quicker & cheaper as a result of the information available in building log books, and as more POE data is available better quality benchmarks should emerge. Building sea trials will establish longer term relationships between building designers and management/maintenance teams. Commissioning will

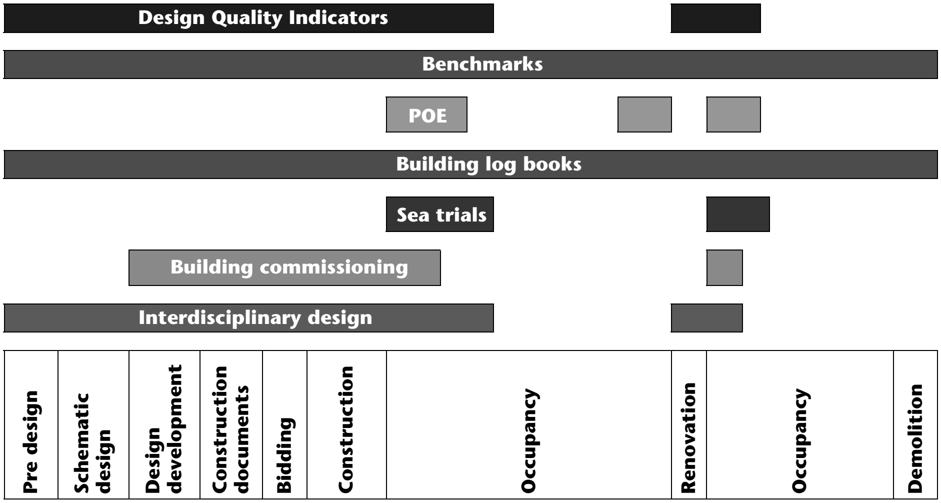

FIGURE 2. The various feedback mechanisms are relevant at different stages of the building lifecycle.

increase the data available for the log book. POE and log books might become closely linked, with mutual selling opportunities that could help the market for both to develop.

There are also some common themes that are emerging from the experience of implementing the initiatives described in this paper. These include:

- Where buildings work well it is often due to good communications between the design team with involvement of a wide range of expertise early in the design stage of the project. Interdisciplinary design approaches can help.
- Clear strategic objectives for the design team are important. Tools such as DQIs and use of benchmarks can help to establish objectives which can be regularly reviewed against the needs of occupants.
- Simple designs carried out well are more likely to work—avoid unnecessary complication and pay attention to detail.
- The relationship between procurement and management is central. Building management structures appropriate to the building type and its complexity are crucial. Tools such as log books can help.
- The need for collaboration and data sharing—in the design team and industry—benchmarking.
- Education of design professionals needs to adopt less of a bunker mentality. Professions need to be educated to work together. Here the Agents of Change initiative is a start but more emphasis is needed on students from various disciplines studying together with greater cross curricula activities. In the longer term, students who are exposed to a feedback culture at an early stage in their career will be more open to new ways of working in the future.

Feedback mechanisms are particularly relevant to green and innovative buildings. First of all they can provide hard evidence of improved performance. But perhaps more importantly, lessons need to be learned from innovative systems and technologies, and there is a need to understand how occupants react to new approaches. It is essential to understand what works and what does not; which technologies actually save energy or reduce water use for instance, and which technologies are less successful. We then also need to explore why some technologies are more successful than others. The culture of green design needs to include continuous learning and feedback.

Nevertheless, any changes to building procurement processes are likely to be resisted. Questions such as "who pays?" and "how can these mechanisms be integrated into conventional procurement processes?" will take some time to overcome. But as the potential benefits of these processes become apparent it may be difficult to resist demands for change particularly from clients and building owners who have a critical role to play in stimulating change. Already, enlightened and repeat clients are beginning to ask hard questions about what is in their long term benefit. If clients can be convinced of the benefits of insisting on feedback mechanisms the industry is far more likely to move forward. From this point of view the support for some of the UK initiatives by client groups is encouraging. Also, the proposed re-introduction in the UK, of Stage M (Feedback) of the RIBA Plan of Work is hopeful. This recognises the importance of feedback in the project delivery process, and the potential benefits of engaging the supply side, providing the better follow-through and customer service. The RIBA are now considering the practicality of this move which could be difficult to implement in practice as feedback is now seen as something that occurs throughout the life cycle of a building and a project, and not just at one point in time. In the USA, the Federal Facilities Council (2001) had reached a similar conclusion after finding that if post occupancy evaluations were done at all, they usually took place within a year or two of handover. Changes later in the life of a building can be more difficult, but certainly many of the tools described are relevant to major renovation of existing buildings.

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