PART ONE

Introduction and Overview
The evolution of building performance evaluation: an introduction

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Editorial comment

Building performance evaluation (BPE) is an innovative approach to the planning, design, construction and occupancy of buildings. It is based on feedback and evaluation at every phase of building delivery, ranging from strategic planning to occupancy, through the building’s life cycle. It covers the useful life of a building from move-in to adaptive reuse or recycling. BPE came into being as a result of knowledge accumulating from years of post-occupancy studies of buildings, the results of which contained important information for architects, builders and others involved in the process of creating buildings – information that is infrequently accessed and rarely applied in most building projects. How then to systematize not only the research activities needed to acquire feedback from users at every stage, but also to ensure that such feedback is directly applied to the building delivery process, such that it is incorporated throughout?

BPE is a way of systematically ensuring that feedback is applied throughout the process, so that building quality is protected during planning and construction and, later, during occupation and operations. In this chapter, BPE is described, and reasons are given for why the building industry should make more use of this approach. The chapter traces the history and evolution of BPE from post-occupancy research, and outlines some of the methods available to the performance evaluation approach, many of which are illustrated in the chapters that follow.

1.1 Introduction

A rational building design process using feedback from ongoing evaluation can be conceptualized as a loop, whereby information fed back through continuous evaluation leads to better informed design assumptions, and ultimately, to better solutions. By using such a
process, decision-makers are able to make better and more informed user-oriented design decisions. They are able to access building type-specific information gathered from evaluative research that is stored and updated in databases.

Different theoretical approaches to BPE were first presented in the book *Building Evaluation* (Preiser, 1989). Since then, there is not only increased interest and activity in this area of concern, both in the private and public sectors – for example, *Learning From our Buildings* (Federal Facilities Council, 2001) – but post-occupancy evaluation also continues to expand in the United States and other, mostly industrialized, nations around the world. Examples from four continents are included in this book. In addition, the National Council of Architectural Registration Boards (NCARB, 2003) has published a book on *Improving Building Performance*, which allows every architect in the USA to study and be tested in this field of endeavour, as part of professional development and continuing education.

The theoretical foundation of BPE is adapted from the interdisciplinary field of cybernetics, which is defined as ‘the study of human control functions and of mechanical and electronic systems designed to replace them, involving the application of statistical mechanics to communication engineering’ (Infoplease Dictionary, 2003). A systems model is proposed that is appropriate for this field because it holistically links diverse phenomena that influence relationships between people, processes and their surroundings, including the physical, social and cultural environments. Like any other living species, humans are organisms adjusting to a dynamic, ever-changing environment, and the interactive nature of relationships between people and their surroundings is usefully represented by the systems concept. Specifically, the systems approach to environmental research studies the impact of human actions on the physical environment – both built and natural – and vice versa. BPE has built on this tradition.

**Figure 1.1** Basic feedback system.
*Source: Architectural Research Consultants, Albuquerque, NM.*
The evolution of building performance evaluation: an introduction

It is multi-disciplinary and it generates mostly applied research that, until recently, lacked a coherent theoretical framework.

The nature of basic feedback systems was discussed by von Foerster (1985). In the context of the building industry (Preiser, 1991, 2001), the strategic planner, programmer, designer, or other process leader is the effector or driver of the system (see also Figure 9.4 in Chapter 9). In the context of BPE, this can be personnel responsible for any or all phases of building delivery, including the evaluator, who makes comparisons between outcomes which are sensed or experienced by users, and the project goals expressed as performance criteria. In the case of building design, goals and performance criteria are usually documented in the functional programme or brief, and made explicit through performance language, as opposed to specifications for particular solutions and hardware systems, the selection of which are the domain of the designer.

1.2 Performance levels: a hierarchy of users’ needs and priorities

The human needs that arise out of users’ interactions with a range of settings in the built environment are redefined as performance levels. Grossly analogous to the human needs hierarchy (Maslow, 1948) of self-actualization, love, esteem, safety, and physiological needs, a tripartite breakdown of users’ needs and their respective performance criteria parallels the three categories of criteria for evaluating building quality postulated centuries ago by the Roman architect Vitruvius (1960). These are firmness, commodity, and delight. This historic approach to setting priorities on building performance has been transformed into a hierarchical system of users’ needs by Lang and Burnette (1974), and synthesized into the ‘habitability framework’ by Preiser (1983) and Vischer (1989), among others. Three levels of priority are depicted in Figure 1.2 below. They are:

1. health, safety and security performance;
2. functional, efficiency and work flow performance;
3. psychological, social, cultural and aesthetic performance.

Each category of objective includes sub-goals. At the first level, one sub-goal might be safety; at the second level, a sub-goal can be functionality, effective and efficient work processes, adequate space, and the adjacencies of functionally related areas; and, at the third level, sub-goals include privacy, sensory stimulation, and aesthetic appeal. For a number of sub-goals, performance levels interact. They may also conflict with each other, requiring resolution in order to be effective.

As the three-part Figure 1.2 shows, the three hierarchical levels also parallel the categories of standards and guidelines available to building designers and professionals. Level 1 pertains to building codes and life safety standards projects must comply with. Level 2 refers to the state-of-the-art knowledge about building types and systems, as exemplified by agency-specific design guides or reference works like *Time-Saver Standards: Architectural Design Data* (Watson, Crosbie, and Callender, 1997), or the *Architect’s Room Design Data Handbook* (Stitt, 1992). Level 3 pertains to research-based design guidelines, which are less codified, but nevertheless equally important for designers.

This hierarchical system relates the elements of buildings and settings to building users and their needs and expectations. In applying this approach, the physical environment is
Introduction and Overview

considered as more than just a building or shell because of the focus on settings and spaces for particular activities engaged in by users. System elements, in effect building performance variables, can be seen as ascending hierarchies from small- to large-scale, or from lower to higher levels of abstraction (see Figure 1.3).

![Figure 1.2](source: Jay Yocis, University of Cincinnati.)

![Figure 1.3](source: Wolfgang F.E. Preiser.)
The evolution of building performance evaluation: an introduction

For each setting and user group, performance levels for sensory environments and specific quality performance criteria need to be established: e.g. for the acoustic, luminous, olfactory, visual, tactile, thermal, and gravitational environments. While it cannot be sensed by human beings, the effect of electro-magnetic radiation on the health and well-being of people, both from a short-term and a long-term perspective, is also relevant.

In summary, the performance evaluation framework for BPE systematically relates buildings and settings to users and their environmental needs. It represents a conceptual, process-oriented approach that accommodates relational concepts and can be applied to any type of building or environment. This framework can be transformed to permit phased handling of information concerning person-environment relationships; for example, in meeting the need for acoustic privacy at the various phases of programming, developing specifications, building design, and hardware selection.

1.3 Evolving evaluation process models: from POE to BPE

Building performance evaluation is the process of systematically comparing the actual performance of buildings, places and systems to explicitly documented criteria for their expected performance. It is based on the post-occupancy evaluation (POE) process model (see Figure 1.4) developed by Preiser, Rabinowitz, and White (1988). A comprehensive review of POEs at various environmental scales can be found elsewhere (Preiser, 1999; Federal Facilities Council, 2001).

Figure 1.4 Post-occupancy evaluation (POE) process model.
Source: Jay Yocis, University of Cincinnati.
Introduction and Overview

Post-occupancy evaluation (POE), viewed as a sub-process of BPE, can be defined as the act of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time. The history of POE started with one-off case study evaluations in the late 1960s, and progressed to system-wide and cross-sectional evaluation efforts in the 1970s and 1980s. Early POEs focused on the residential environment and the design of housing for disenfranchised groups, especially as a result of rapid home construction after the Second World War. Many urban renewal projects in North America, and new town construction in Western Europe, created large quantities of housing without thorough knowledge of the needs, expectations, behaviour or lifestyles of the people they were being built for. The kinds of social and architectural problems that subsequently arose led to an interest in systematic assessment of the physical environments in terms of how people were using them (Vischer, 2001). The approach was later seen as a mechanism for collecting useful information for the building industry on the impact of design and construction decisions over the long term. POEs have since targeted hospitals, prisons, and other public buildings, as well as offices and commercial buildings.

Several types of evaluations are made during the planning, programming, design, construction, and occupancy phases of building delivery. They are often technical evaluations related to questions about materials, engineering or construction of a facility. Examples of these evaluations include structural tests, reviews of load-bearing elements, soil testing, and mechanical systems performance checks, as well as post-construction evaluation (physical inspection) prior to building occupancy. POE research differs from these and technical evaluations in several ways; it addresses the needs, activities, and goals of the people and organizations using a facility, including maintenance, building operations, and design-related questions. Measures used in POEs include indices related to organizational and occupant performance, worker satisfaction and productivity, as well as the measures of building performance referred to above, e.g. acoustic and lighting levels, adequacy of space, spatial relationships, etc.

POE is a useful tool in BPE that has been applied in a variety of situations. In some cases, results are published and widely disseminated; in others, they are uniquely available to the architect, to the client, or to the stakeholder who commissioned the study. The findings from POE studies, while primarily focusing on the experiences of building users, are often relevant to a broad range of building design and management decisions. Many of the building problems identified after occupancy have been found to be systemic: information the engineer did not have about building use; changes that were made after occupancy that the architect did not design for; or facilities staff’s failure to understand how to operate building systems.

The BPE framework was developed in order to broaden the basis for POE feedback to include a wider range of stakeholders and decision-makers who influence buildings. This has enabled POEs to be relevant earlier in the design process and applied throughout the building delivery and life cycle. The goal of BPE is to improve the quality of decisions made at every phase of the building life cycle, i.e. from strategic planning to programming, design and construction, all the way to facility management and adaptive reuse. Rather than waiting for the building to be occupied before evaluating building quality, early intervention helps avoid common mistakes caused by insufficient information and inadequate communication among building professionals at different stages.

While POE focused primarily on users’ experience of the performance of buildings, the most recent step in the evolution of POE towards building performance evaluation is one that emphasizes a holistic, process-oriented approach toward evaluation. This means that
not only facilities, but also the forces that shape them (organizational, political, economic, social, etc.) are taken into account. An example of such process-oriented evaluations is the Activation Process Model and Guide for Hospitals of the Veterans Administration (Preiser, 1997). Process-oriented evaluations are the genesis of BPE and its theoretical framework.

Many stakeholders, in addition to designers and engineers, participate in the creation and use of buildings, including investors, owners, operators, maintenance staff, and, perhaps most importantly, the end users, i.e. the actual persons who occupy and use the building. The term 'evaluation' contains the word 'value', therefore occupant evaluations must state explicitly whose values are invoked when judging building performance. An evaluation must also state whose values predominate in the context within which a building’s performance is measured. A meaningful evaluation focuses on the values behind the goals and objectives of all stakeholders in the BPE process, in addition to those who carry out the evaluation.

Finally, it should be noted that there are differences between the quantitative and qualitative aspects of building performance and their respective performance measures, i.e. data that are collected on-site and from building occupants in order to carry out an evaluation. Many aspects of building performance are in fact quantifiable, such as lighting, acoustics, temperature and humidity, durability of materials, amount and distribution of square footage, and so on. Qualitative aspects of building performance pertain to the ambiance of a space, i.e. the appeal to the sensory modes of touching, hearing, smelling, kinesthetic and visual perception, including colour. The qualitative aspects of building performance, such as aesthetic beauty (i.e. the meaning of buildings and places to people) or visual compatibility with a building’s surroundings, can in fact be the subject of consensus among the public. From a planning standpoint, this is evidenced in the process called design review (see Chapter 5), which has resulted in standards for review and guidelines (Scheer and Preiser, 1994). Research consistently shows that the experts and the public disagree on aesthetics and meaning, and that while expert decisions do not lead public taste, public opinions have been shown to be stable over time (Nasar, 1999).

1.4 The conceptual basis for BPE

In 1997, the POE process model was developed into an Integrative Framework for Building Performance Evaluation (Preiser and Schramm, 1997), comprising the six major phases of building delivery and life cycle, i.e. planning, programming, design, construction, occupancy and facility management, and adaptive reuse/recycling of facilities. One of the main features in the evolution of this approach was taking into consideration the varying requirements of the process at different points in time, as well as specifying internal review/troubleshooting loops in each of the six phases.

The integrative framework, which is described in detail in Chapter 2, attempts to respect the complex nature of performance evaluation during building delivery as well as during the building’s life cycle. This framework is oriented to an architect’s perspective, showing the cyclic evolution and refinement of the process while it aims at a moving target: that is, achieving better building performance overall, and better quality as perceived by building occupants (see Figure 2.1 in Chapter 2).

At the centre of the model is the building’s actual performance, both measured quantitatively and experienced qualitatively. It represents the outcome of the building delivery cycle, and its performance during the life cycle. Each of its six sub-phases has internal
reviews and feedback loops. Furthermore, each phase is connected with its respective state-of-the-art knowledge, which is contained in building type-specific databases, as well as in global knowledge and the published literature. For BPE to become viable and truly integrated into the building delivery cycle of mainstream architecture and the construction industry, it is critical to integrate BPE into these disciplines and to demonstrate to practicing professionals the viability of the concept through a range of exemplary case study examples.

1.5 An example of the user feedback cycle in BPE: Building-in-use assessment

In order for the BPE approach to work effectively, data-gathering and analysis activities are necessary at every stage. These can be carried out in a variety of ways including, but not limited to, using traditional social science research techniques.

In view of the fact that the performance criteria at each stage are constituted of both quantitative and qualitative performance evaluation, it is necessary to utilize qualitative and quantitative research. For instance, expected building performance in an area, such as temperature levels inside a building, can be compared with levels of thermal comfort as rated by users. For this comparison to be effective, both the expected and actual performance must use the same or comparable units of measurement. In some fields this can be complicated. For example, expected acoustic performance is usually given in the form of construction materials specifications – distance on centre of wall studs, sound absorption coefficient of ceiling tile. But actual acoustic comfort of users is mostly expressed in the form of a general satisfaction rating, and users’ levels of satisfaction or dissatisfaction can only secondarily be compared to measures of expected performance.

One of the challenges of the BPE approach is, therefore, to encourage more precise measures of users’ experience of environmental comfort than have conventionally been used. Asking people whether they are satisfied is a rather broad and general outcome measure that tends to include far more than the performance criterion under consideration. Vischer (1989, 1996, 2003) has proposed a technique for approaching users with more direct questions about their comfort levels in relation to various building systems, in order to derive a more specific equivalent to objective environmental measures. The Building-in-use (BIU) assessment system is a validated and reliable standardized survey that can be administered to occupants of any office building in order to collect simple reliable measures of their comfort in regards to seven key environmental conditions. From the responses, scores on the seven comfort conditions can be calculated and compared to a typical or average office building standard derived from a large, user-response database. Thus, deviations from the norm for each of these conditions, in both a positive and a negative direction, provide a quantitative rating of what is essentially a qualitative measure.

The seven conditions addressed by the building-in-use assessment system are: air quality; thermal comfort; spatial comfort; privacy; lighting quality; office noise control and building noise control (Vischer, 1999b). Results of a more recent study indicate that the modern office worker, who must access a variety of equipment and perform a variety of tasks, also evaluates comfort in terms of sense of security, building appearance, workstation comfort and overall visual comfort (Vischer et al., 2003). The results of a BIU assessment survey are typically used by facilities managers who must make operating and budgetary decisions; by design professionals who seek to assess an older or about-to-be replaced environment;
The evolution of building performance evaluation: an introduction

in a new building soon after a move; and by building owners and business managers to determine a baseline comfort level for employees in their buildings (Fischer and Vischer, 1998).

One advantage of the BIU assessment system is that it permits comparison between measured and perceived levels of performance. In parts of the building where certain areas of comfort are below the norm, instruments can be applied to measuring conventional performance parameters and determining whether or not standards are being met. User feedback provides a diagnostic data point that permits a wide variety of follow-up actions. However, it is not always possible to determine a direct correspondence between user feedback and the data provided by calibrated measuring instruments (Vischer, 1999a). This is not surprising, in that a number of factors influence the building users, and their experience of one may affect their judgement of another. An important stage of BIU assessment is following up on user feedback by using other measurements to determine performance problems and likely technical causes of low comfort ratings.

There is an ever-increasing variety of diagnostic measuring instruments available for gathering follow-up data on building performance in areas such as indoor air quality and ventilation performance, thermal comfort and humidity, lighting and visual comfort, and noise levels and acoustic comfort. In each of these cases, the researcher must determine how to approach measurement: data-logging over a extended time period, usually in a limited number of places; or spot checks in a compressed time period, but over a larger geographical area. A further issue is how to calibrate the instrument, in terms of its baseline standard or comparator. The human comfort rating is usually the summing up of a wide variety of perceptions and judgements over a given time period; on the other hand, a new situation, or one that causes particular concern to users, may be subjected to short-term judgement that is not indicative of the long-term operation of the building. Finally, no single type of follow-up measurement is mandated: in addition to measuring instruments, evaluators may interview users, question them on psychosocial factors, such as employer-employee relations, and on the requirements of their tasks, which are typically far from uniform.

Other techniques of introducing feedback into the building design and construction process are through checklists, building codes and standards requirements, and design guidelines emanating from other sources. However, this is not to say that in each of these cases some discretionary judgement on the part of the evaluator is not required to ensure that the process moves forward. For data-gathering techniques in BPE to be valid and standardized, the results need to become replicable. The ultimate goal of the International Building Performance Evaluation (IBPE) Consortium (Preiser, 1995) is to create a standardized ‘universal tool kit’ of data-gathering instruments, which can be applied to any building type anywhere in the world (Preiser and Schramm, 2002). A preliminary ‘tool kit’ is therefore provided in the Appendix to this book.

1.6 Economic and sustainability issues

Since a major concern of practitioners in the construction and real estate industry is the cost of time, innovative techniques that could be applied to programming, design and construction are often considered too costly for a typical building project’s time-frame and budget. As a result, proposals to incorporate additional information in the form of user feedback or sustainability recommendations, especially after a project has started, are typically rejected by project managers, even if they may improve the outcome. However,
shortcut methods, such as BIU assessment, Serviceability assessment (see Chapter 10) and the Balanced scorecard approach (see other examples in Chapter 9), have been devised to allow researchers/evaluators to obtain valid and useful information in a much shorter timeframe than was previously possible. Understanding the BPE sequence enables them to apply information quickly and at appropriate points in the process. This enables evaluation to become cost-effective and to respect time constraints.

Each information loop in the BPE process offers an opportunity for incorporating environmental and sustainability concerns into building design and construction. Normally viewed as an ‘add-on’ in conventional building projects, environmentally responsible technology and materials can be a financially viable alternative if they are introduced as options from the beginning and consistently included throughout the process. By systematically collecting feedback and using the life cycle perspective, the right information is available at the right time for each key decision, thus increasing building quality without affecting project time and costs adversely.

1.7 Conclusions

Criteria for designing and building new environments should be based on the evaluation of existing ones, and modified when appropriate in the context of the design process. The crucial point in every evaluation is to identify the significance of results and how best to apply them constructively. Product evaluation and quality control, in terms of product performance and customer satisfaction, is an accepted procedure in most industries. Product improvement is ongoing and forms an integral part of the price calculation. It would seem both natural and economical in the long run to thoroughly investigate the possibilities of user-oriented 'product' evaluations in the complex industry of design and construction.

While the constructed environment cannot be called a ‘product’ in the strictest sense, because it is dynamic and changing over time, feedback and evaluation costs can be included in the life cycle costing of buildings as an ‘extra’ that might be written off against taxes as an investment in the future. Building the costs of building evaluation into construction projects would enable large-scale environmental research to be funded, and thereby launch an ongoing national evaluation research programme. Demographic change and an aging population place new requirements on such sectors as housing in urban and non-urban areas, including the large retirement communities of the ‘Sunbelt’ states in the USA. Applying the BPE framework to large-scale residential construction could not only improve the cost and quality of such housing, but it would also ensure that the environments occupied by these users meet criteria of environmental quality, cost-effective construction practices, and other social needs.

In the remaining chapters of this book, architects, planners, programmers, and researchers elaborate on the different phases of BPE, and provide case study examples of how some of the different stages have been implemented. The first phase is strategic planning, and the review loop case study example demonstrates effectiveness review; the second phase is programming, also known as briefing, with a programme review loop providing examples of how to complete this critical stage properly. The design phase has design review as its loop, and an example is presented of major renovations at a manufacturing company. This is followed by the construction phase and its commissioning review loop, an important process in quality assurance in buildings. Once the building is occupied, concerns with quality become even more important. Later chapters address the difficulties of routinely
implementing POE in managed buildings and explain how the BPE approach is a tool at several different levels for facilities managers, whose responsibilities for management and maintaining quality in buildings range from technical maintenance to user satisfaction to ecological sustainability.

In Part Two, chapters discuss various approaches to BPE in other cultural contexts, with examples of methodologies and approaches from Brazil, Canada, Germany, Israel, Japan, and the Netherlands. In addition, BPE is linked to universal design and facility performance evaluation, as well as to responsible humanistic decision-making and sustainability. Finally, two chapters outline ways of ensuring that innovative technology, as well as innovative user participation processes, are integrated into the BPE approach.

Learning and appreciating how to apply the conceptual framework for building performance evaluation to future building design, construction and operation is an exciting new frontier in an industry that is slow to embrace change. The energy and enthusiasm of practitioners and researchers in this field are creating a wealth of data and knowledge that it is no longer possible to ignore. It is comforting to contemplate that as traditional building practices change, so our buildings will become more comfortable and more humane, as well as more environmentally responsible. This book is a critically important step in this direction.

References


Introduction and Overview


