PROBE 15: Productivity the killer variables

What aspects of buildings and workplaces influence human productivity? Are organisations shaped by their buildings? If so, can the design and management processes be optimised?

BY ADRIAN LEAMAN AND BILL BORDASS

Tanfield House – a building in which the negative features of deep planning and large work groups have been effectively counteracted by thoughtful and imaginative design, coupled with responsive management.

Although designers try to design buildings within a narrow thermal comfort band, research continually shows that the relationship between occupant satisfaction and operative temperature is not clear-cut. Designers and building managers certainly strive to create conditions which bring out the best in people and add value to investments and services. However, the perversity of human behaviour means that building occupants can report that their environment is unacceptable despite it falling within industry-standard comfort guidelines.

This simple example demonstrates that aspects of buildings which are anticipated by the client and/or the design team to be virtuous can, in practice, interact more viciously. Elements that collude to compromise occupant satisfaction can even reduce workforce productivity.

In the language of computing, a killer variable describes anything which has a critical influence on the overall behaviour of a system. The same process has been found to operate in buildings. Research indicates that building-related killer variables tend to fall into four clusters, each of which represents a group of features which have more connections among themselves than with others.

In no order of priority, these areas are personal control, responsiveness, building depth and work groups.

Personal control

Research in the 1980s into sick building syndrome (now building-related sickness) confirmed that peoples' perception of control over their environment affects their comfort and satisfaction. People are more tolerant of conditions as the perception of personal control – windows, switches and blinds etc – increases.

In study after study, people say that lack of environmental control is their single most important concern, followed by lack of control over noise. Many people, some almost instinctively, oppose the idea of open-plan working because they will lose control and privacy, and their working environment will be noisy.

Environmental control operates at the interface between the occupants and a building's physical and technical systems. Control can be manual or motorised, but is often automatically controlled by a bems and generally invisible to the user.

Why is this? Perhaps seduced by the promise of technology rather than by its delivered performance, designers tend to assign more functions to automatic control than are usually warranted. Knowingly or not, they also make the interfaces obscure.

Next, designers fail to explain the management implications of the technology to the client, and fail to find out whether those implications are acceptable.

The eventual solution is to seek more robust systems, which are far simpler to use and have greater opportunity for user intervention to override settings. Better feedback on what is supposed to be happening and whether or not the system is actually working is also required.

In addition, the process of building design inherently works against personal control. First, it is split into architectural and building services tasks, often with surprisingly little integration. Second, poor attention to detail in what controls have been provided usually hints at an incomplete design and specifica-

tion process, and gaps between professional responsibility. Part of this is due to the lack of suitable specification and briefing tools, along with a concurrent lack of suitable standard components and systems.

Often, designers do not fully appreciate the important difference between comfort provision and discomfort alleviation. For example, the ability to alter workstation position – a seemingly trivial feature – can be crucial to office users' overall comfort.

By making tiny changes to their immediate environment to avoid the worst effects of, say, glare from the winter sun, occupants can turn tolerable conditions into marginally tolerable ones without management intervention.

Note that most control adjustments will be at the thresholds of discomfort, triggered by something experienced as uncomfortable, rather than in anticipation. The absence of this capability to fine-tune – especially in space-planned offices with fixed furniture systems and little or no user control – can make the difference between tolerable comfort and dissatisfaction.

In spite of the research and occupier evidence that high perceptions of personal control bring benefits like better productivity and improved health, designers, developers and even clients seem remarkably reluctant to act on it. There are many reasons for this, including the absence of thorough cost-in-use analysis in the calculation of future payoffs, and the problem of who actually receives the benefit. Sadly, few building occupiers are motivated enough to take the bull by the horns and gain control of the systems which are troublesome.

Excellent facilities management strategies and careful energy management at One Bridewell Street has led to unusually high levels of both occupant satisfaction and energy efficiency.

Responsiveness

To many people, the relationship between better personal control and human performance is common sense. So too is the cluster of variables related to responsiveness.

Many of the buildings which work well in post-occupancy studies appear to have the capability to meet peoples' needs very rapidly, either in anticipation or as they arise. This applies to personal control, but it also works at other levels: the ability to reconfigure furniture, the adaptability of spaces in order to accommodate change, or the speed of response by the facilities management department to end-user complaints.

High user satisfaction scores have been recorded during the post-occupancy surveys of buildings like Tanfield House[1] and One Bridewell Street, where the facilities management response to complains of discomfort was exceptionally fast. The facilities managers also learned to anticipate and deal with common problems – often before anyone noticed.

Personal control in both buildings was not high. At One Bridewell Street, the users had only infra-red controllers for the lights and limited ability to change workstation position.

Figure 1 shows the results of research by Building Use Studies into the speed of response to complaints and perceived occupant productivity. While admittedly this is based on a small sample, the results are positive and significant – eight out of 11 buildings show a significant positive association (the data also show that the strength of association between quickness and productivity actually increases as a given building's overall performance decreases).

By definition, responsive control delivers rapid response. Conversely, if designers try to add responsive controls to a complicated building which lacks management resources, their efforts may well be defeated. The client will be unable to manage the added complexity, which will induce chronic failures.

In situations like this, one suspects that it has been incorrectly assumed at the design stage that building services technology will automatically deliver what the occupants require without undue extra management intervention or, alternatively, that management will be superhuman.

Instead, designers and managers should consider both personal control and response time implications, rather than think they are the same. That means considering real-time responsiveness in the briefing and specification process, and setting different response time standards for different occupier needs.

For example, glare and overheating needs to be dealt with immediately, whereas a three-day threshold could be used for the replacement of components – simple things like blinds, chairs and luminaires.

Building depth

Post-occupancy research suggests that overall satisfaction and productivity will decrease with increasing depth of the building. Hence a depth of 12 m across the building seems to be about optimal for human performance variables.

Shallower plan forms tend to cost more and are less space efficient. However, shallower-plan buildings may lend themselves to cheaper, more domestic envelope construction, cheaper services and lower management costs.

Unfortunately, cost calculations often find it difficult to consider such trade-offs. Economic calculations tend to be more precise at minimising envelope-to-floor area ratios than building services costs, perhaps due to lack of information about services at that stage.

Although the Building Use Studies dataset of 40 buildings shows that air conditioned buildings produce poorer perceived productivity scores than naturally ventilated buildings, that does not mean that natural ventilation is better than air conditioning.

Instead, occupants tend to prefer natural ventilation as the default state for winter, spring and autumn, and air conditioning during hot and humid summers.

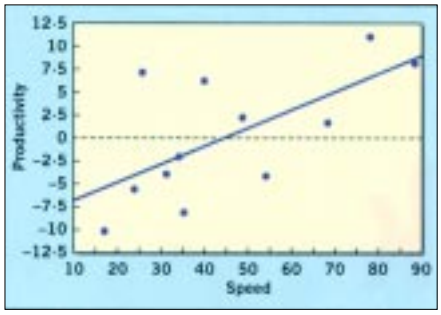
Building depth is also a correlate for complexity. Buildings seem to become disproportionately more complicated as they get bigger and deeper.This is not just a matter of building services like ventilation, but also involves spatial and behavioural complexity. There are more activities and a much greater likelihood of conflict in bigger floor plates with higher staff numbers, plus a higher dependence on technology and management.

Work groups

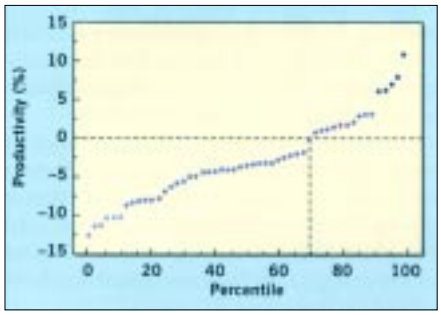
Work groups, along with personal control, is one of the least understood topics in modern buildings. Generally, perceptions of productivity are higher in smaller and more integrated work groups.

Admittedly, there is little research data to back this up, although the preference for cellular offices for individuals or small work groups is well known. Confidence about work group size being a killer variable comes from research carried out in 1987[2], where room size was shown to be a correlate of perceived control for temperature, lighting and ventilation – perceived control declining with work groups bigger than five people.

From a design and management point of view, work groups are desirable for space



LEFT, FIGURE 1: The relationship between perceived speed of response in dealing with heating, lighting and ventilation complaints and perceived productivity for 12 study buildings. The horizontal axis shows the percentage of staff complaining who thought that the speed of response by the management was satisfactory. The vertical axis is a statistical measure of perceived productivity.



BELOW LEFT, FIGURE 2: Perceived productivity scores for the 50 most recent buildings surveyed by Building Use Studies. About 70% of the sample falls below 0% on perceived productivity scores. 10% of buildings have scores better than +5%. The cluster of buildings top right are the 'super virtuous' buildings, while the cluster bottom left can be described as 'super vicious'. The percentile score is an average of occupant survey scores on overall comfort, temperature, air quality, lighting and noise.

saving reasons and for better communication between colleagues. Evidence indicates that well integrated work groups of four to five people will be acceptable, but the risks of lower productivity in bigger work groups can increase proportionately.

To support the claimed business benefits it is necessary to put in a much higher level of expertise in building and services design and facilities management. Clients may recognise this, but the degree of improvement required can be much higher than they expect.

Three things can happen. First, the mapping between environmental controls, services zones and activities can disintegrate. For example, the lighting may be switched for the whole area, rather than for specific work groups. Second, building occupants have to consider their colleagues' wishes when they want to make changes. As a result, the likelihood that everyone will be satisfied with prevailing settings will reduce as the work groups increase in size.

Third, long-distance effects will become important, such as glare from a remote window, or draughts of uncertain origin owing to complex air movements in both air conditioned or naturally ventilated spaces.

Countering the killer variable of work group size requires:

☐ keeping work groups as small and well-integrated as possible;

☐ making sure that activity zones map onto the services zones, especially for productivity killers like irrelevant noise, glare and draughts;

☐ keeping sources of unwanted distraction down to a minimum – in open-plan offices, up to 60% of staff report being close by a source of random distraction like doors squeaking and banging, the photocopier and / or tea area; but:

☐ do not interfere with sources of wanted information that are relevant to work tasks within earshot and lines of sight;

☐ design and manage the overall work setting so that the default setting is reasonably comfortable, safe and healthy and does not require excessive amounts of technology or management to make it work.

Creating the virtuous building

Buildings, especially offices, work best for human productivity when there are:

☐ many opportunities for personal control, providing a background for healthy, comfortable and safe operation and adaptive comfort;

☐ rapid response environments – not necessarily just for personal control, but for other aspects of a building's operation that might compensate for absence of personal control, such as an excellent complaints monitoring and feedback system;

☐ shallow-plan building forms, preferably demanding less technically complex and less management-intensive systems;

☐ activities which properly map on to the services designed to support them, such as the zoning of heating, cooling, lighting, ventilation, noise and privacy.

Ideally, simple, shallow-plan forms, small work groups, robust and manageable controls and domestic levels of servicing work best. However, the trend has been towards intensification of building use, with much larger floor plates and deeper spaces.

Such bigger and more complex buildings demand subtler strategies for managing this complexity, and different design strategies and technologies to support them.

Early findings from the PROBE studies suggest that mixed-mode designs can offer better occupant satisfaction and environmental performance, and that occupants can detect the differences. Mixed-mode offices can not only give performance advantages through better thermal comfort and better perceived ability to perform work, but are also better for perceived air quality and overall workplace satisfaction (figure 2).

By monitoring the switching behaviour in mixed-mode buildings[3], researchers have found that a control-rich, naturally ventilated environment is the preferred default, and that this is only abandoned on the minority of occasions when both temperature and humidity exceed tolerance thresholds.

MEASURING PRODUCTIVITY

Accurate measurement of human productivity is notoriously hard to pin down. What studies do exist often miss the differences between buildings, their management and their operation.

People also act differently depending on whether they are in groups or in isolation.

It is more difficult to link human productivity to the space conditions, but questionnaire data from post-occupancy building studies have shown perceived differences in productivity of up to 25% between comfortable and uncomfortable staff (figure 1). The uncomfortable staff questioned showed consistently lower perceived productivity, although the association is weaker where overall satisfaction is higher.

Whatever the actual figures, the data shows that some of the management, design and use characteristics which improve perceptions of individual welfare contribute towards better energy efficiency, thereby closing the loop on a potential virtuous circle.

Sadly, the majority of occupied buildings do not exhibit such self-reinforcing qualities, and many are unmanageably complex due to negative relationships (figure 2).

With the present state of knowledge we can 'guesstimate' that losses or gains of up to 15% of turnover in a typical office organisation might be attributable to the design, management and use of the indoor environment.

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This article is based on the paper 'Productivity: the killer variables', delivered at the Workplace Comfort Forum , October 1997. Research into killer variables for other aspects of building performance is ongoing. *Building Services Journal* will return to the subject in due course.

References

[1]Bordass W, Ruyssevelt P *et al,* 'PROBE 1: Tanfield House', *Building Services Journal*, 9/95.
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Further reading

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