Comfort and Complexity: Unmanageable Bedfellows?

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This paper looks at complexity in office buildings and the consequences it poses for those who have to work there. The concept of uncertainty is introduced to help explain the problems. Uncertainty is a mixture of partial and complete uncertainty: the former is the result of limited knowledge before the event, the latter is the result of limited knowledge after the event. Uncertainty is also a mixture of exogenous and endogenous uncertainty: the former is the result of external events, the latter is the result of internal events. Uncertainty is also a mixture of certain and uncertain events: the former are the result of events that can be predicted with certainty, the latter are the result of events that cannot be predicted with certainty.

In simple cases uncertainty arising from exogenous sources can be handled by estimating the probabilities of these events and taking appropriate action. In complex cases uncertainty arising from endogenous sources cannot be handled in this way and it is necessary to develop new approaches to deal with them. These approaches involve the use of adaptive systems which are able to make decisions in the face of uncertainty.

The more complex the system, the more difficult it is to make decisions. In complex systems, decisions are often made on the basis of incomplete information and the results are often unpredictable. In simple systems, decisions are often made on the basis of complete information and the results are often predictable.

In reality, these requirements usually pull in opposite directions. Increased variety in usable space tends to bring with it a greater uncertainty and complexity in the user management dimension. On the other hand, trying to simplify the management requirement can reduce spatial carrying capacities below reasonable performance thresholds.

A successful strategic approach will consider both design and management and will aim to recognise and resolve these inconsistencies by:

1. Examining the likely effects of actual and potential constraints imposed by the spatial properties of the building.
2. Ensuring that these spatial constraints create as few obstacles as possible for the occupier.

These obstacles can be as physical as possible for people to manage and change. Two basic dimensions are concerned with the physical work environment and the management environment, and the management processes over time - fundamentally affect the performance and satisfaction of office occupants.

The first type of complexity arises from how systems and sub-systems are organised physically in space into different "levels", see Figure 1. Office buildings usually have six to eight, depending on how spaces (and their management) are subdivided. The more levels there are, the more complex the building become, and the more difficult it is to operate. In a complex system, it is difficult to organise (both spatially and managerially) so that it works well in all respects.

Complexity comes from the ways in which physical and human systems interact together: by creating new relationships, which are not intuitive. A successful strategic approach to maximising the chances of things going right.

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Uncertainty and Time

A: probable

B: idealised

Space

Useful variety

A: actual, with normal resource levels

B: idealised

Useful variety

Time

Uncertainty

High

Low

Figure 2i
Complexity from the designers’ point of view

Figure 2ii
Complexity from the managers’ point of view

Figure 2iii
Designers’ J-curve and managers’ inverted U-curve

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The J-curve comes from the constraints imposed by the system of managing the built environment, the inverted U-curve from management constraints. A building in use must respond to the J-curve and the inverted U-curve. To the left of the diagram, uncertainty increases with useful variety, but the payoffs may nevertheless be reasonable if management constraints are not too high. The building designer hopes (and may even claim) to create infinitely useful space for little extra management cost, as shown by curve B.

Curve A, the more probable situation, is J-shaped because of discontinuities resulting from the physical properties and functions of the building system as a whole. For example, when building depth exceeds the limits of simple natural ventilation, the additional systems required significantly increase the complexity (and thus the uncertainty in use) of the building. In the past, these additional systems have often included air-conditioning but today’s attempts to include natural (or combinations of natural and mechanical) ventilation in deeper and more spatially complex buildings are also tending to do the same thing. Unless these additional systems are extremely robust and stable in their operations, functions, and their functions are readily understandable by users, facilities managers and maintenance staff, then uncertainties arising from their operations (which may often be small-scale and seemingly trivial) may accumulate and create the possibility of larger-scale failures.

The shape of the management curve (2ii) is different because the major constraints are not primarily the physical properties of the building, but the constraints imposed by the organisation and the people within it. In its culture, goals, objectives, budgets, mission and ways of working. At first useful variety increases with uncertainty, but then declines as the space becomes increasingly difficult to control relative to the other constraints, particularly those on time management, alteration and maintenance costs, and speed and effectiveness of internal communications. Essentially, the demands of managing the features which were intended to provide the variety themselves become the management problem.

For some people, “simplifying” a building may mean increasing usable spatial variety with the risk of increasing conflicting functions; others may wish to reduce uncertainty. Knocking down walls and partitions and making spaces deeper and more open is often thought to both increase usable variety and reduce uncertainty, but may do exactly the opposite by restricting individual choice and increasing management burden. Physical “obstructions” like walls and partitions can discipline a space and make it more self-managing.

Change

Much of the uncertainty dimension is concerned with how people require, trigger, make and respond to change. This again works at different levels, each with different frequencies and magnitudes of requirement and effect.

Recent work [Reference 3] suggests that the speed with which a building can respond to changes at the different levels has a significant effect on occupant comfort, and consequently health and productivity. For example, to work best for the occupants, physical systems should not only maintain reasonable comfort conditions but also be able to respond rapidly and unambiguously when occupants think that conditions are unreasonable. When the building fails them in this respect, people become frustrated and uncomfortable.

One of the best-kept secrets of comfort research is that comfort is defined as the absence of discomfort. A logical consequence of this is that good buildings should have both comfort provision and discomfort alleviation strategies. While - at least
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In theory - air-conditioned offices tend to have better systems for comfort provision, naturally-ventilated offices have richer and more diverse in-door environments for design and work performance. However, this is not always the case. Many problems experienced in office buildings can be traced to constraints passed down the hierarchy (Figure 1) with the tacit assumption that either they will be "solved" at the next level down or that there is a plug-in-and-go technological solution waiting somewhere to resolve any problems that develop. The effects too often surface only when people at their workplaces start complaining about discomfort, ill-health, or go absent. Often, the root causing is that the building is too complicated for the management resource which can reasonably be made available to look after it.

Bulding

This section illustrates some of the consequences of increasing complexity, using recent evidence about people, their work performance and the indoor environment. There is much interest in the subject but little data to substantiate claims. Some routine tasks, like lighting, ventilation, and workstations, have already been well described. But the area of controls and comfort issues are still very embryonic. This section will consider how controls and comfort issues are related to each other.

Evidence into discovering why certain office buildings seem to create chronic ill-health in occupants. The answer for this often comes in the form in which the problem is stated: for example, ventilation can be traced to constraints passed down the hierarchy (Figure 1); and:

- b) "baseload" capability which suits the organisation's main requirements - this can vary greatly with the organisation and the type of work they are carrying out.

Buildings which work best usually meet baseload functional requirements without being extravagant, have enough "clarity" in management and control systems to respond to change in a positive and direct way, and are not swamped by uncertainty.

Lack of understanding of control-making strategies

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Controls

People say that control over heating, ventilation, lighting and noise is important to them, but the actual levels of control that they perceive are often much lower than they think they should be. This is because people have become more aware of the effects of the workplace environment on their health and well-being. For example, poor lighting can cause eye strain and headaches, while poor ventilation can lead to sick building syndrome. These problems can be costly for employers, as they result in decreased productivity and increased absenteeism.

Control over heating and cooling seems to be more important than control over lighting or noise. Many people in our surveys have expressed a desire for more control over these systems. This is likely because these systems have a direct impact on comfort and productivity. For example, if the temperature is too hot or too cold, employees may find it difficult to concentrate on their work. This can lead to decreased productivity and increased errors.

Control over lighting and noise is also important, but typically less so than control over heating and cooling. Lighting can affect mood and productivity, while noise can cause stress and fatigue. However, people often feel that they have less control over these systems than they would like.

Conclusion

In summary, control over heating, ventilation, lighting, and noise is important to people, but they often feel that they have less control over these systems than they would like. This is likely because many factors influence these systems, such as weather, building design, and maintenance policies. To improve comfort and productivity, employers should consider investing in more control over these systems and providing training to employees on how to use them effectively.
Control and Depth in sealed, air conditioned offices.

Perceptions of control decrease as spaces get deeper and spatial properties on the one hand, and users' behaviours and expectations on the other. They can never be removed completely or avoided, as many would like to think. Removing physical constraints frequently creates operational ones.

Control and Productivity

Relationships in the data

Control and complexity:

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Figure 3 Perceived productivity and perceived control over temperature, ventilation and lighting


Figure 4 The relationship between temperature and thermal comfort under constrained (dashed line) and unconstrained conditions in houses

Source: Nigel OSLELAND Reference 10. See also De Dear et al Reference 6 Figure 3.17, p64.
It is now probably unrealistic to think that most types of office can properly satisfy all the required theoretical constraints. Outcomes are not just sub-optimal with respect to all criteria, but may only meet a subset of criteria. Consultants hired to increase management options may unwittingly reduce them because they fail to appreciate how constraint-bound buildings are. Space planners, for instance, may re-plan an office floor on the basis of furniture configuration and layout alone, without considering how the new arrangements affect control and servicing for heating, ventilation and lighting. This can be an expensive way of increasing occupant discomfort and energy costs.

Furniture planners often find that constraints such as grid dimensions, floor depths, circulation routes, cabling and location of services restrict their options. The resulting layouts then, in turn, affect individual users' capacities to fine-tune their workstations as their own requirements change in response to varying conditions. For example to avoid glare, they may wish to change the orientation of their computer screens as the sun moves round the sky, but may be prevented from doing so by the fixed workstation and the VDU itself, and so lose a means of discomfort alleviation.

Countless similar examples, many of which seem too trivial or anecdotal to bother about, can add up to a significant failure of design to meet need.

This paper has put some recent evidence about people and their performance in office buildings in a wider strategic framework of complexity, design and management.

Two types of complexity have been identified: one concerned with usable space, which is primarily related to the physical performance of the building; and the other with the ability of people to carry out their tasks, which is related to reducing uncertainty in operation, and attempting to create predictable, responsive outcomes when people want to make interventions or changes. The first type is underpinned by spatial considerations like density, conflicts between competing functions and variety; the second by time considerations in relationship to decision-making, especially uncertainty, risk and speed of response.

Commonly, one type of complexity is exchanged with the other leading to opposite effects to those intended. For example, large, open, more densely occupied spaces with more activities in them may introduce uncertainties and management inefficiencies which make them less usable than anybody anticipated.

In order to cope with all this, office buildings must become more demand-responsive. In the terms described in this paper, this means bringing the designer’s J-curve and the manager’s inverted-U-curve into one strategic briefing scheme.

However, this can inhibit the ability of people and their performance in office buildings in a wider strategic framework of complexity, design and management.

Figure 5 Perceived control and room size

<table>
<thead>
<tr>
<th>Room size</th>
<th>Perceived control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Low control</td>
</tr>
<tr>
<td>3-4</td>
<td>Medium control</td>
</tr>
<tr>
<td>5-9</td>
<td>High control</td>
</tr>
</tbody>
</table>

Figure 6 Perceived productivity and ill-health symptoms

- Symptom of chronic ill-health. Symptoms are based on reports of chronic ill-health symptoms. Productivity is self-assessed on a 9-point scale. As damage of 2 or more symptoms, a likely indicator of overall productivity loss.

Figure 7 The best buildings...

- Respond rapidly and positively to triggers of change at all spatial levels (individual, workgroup and department).
- Have enough management resources to deal with adverse or unpredictable consequences of physical or behavioral complexity.
- Are comfortable and safe for the occupants most of the time, but use the properties of 1. if they become uncomfortable or unsafe.
- Optimise relationships between physical and human (managerial) systems at all life-cycle stages (such as briefing, design, commissioning, use).
- Are economical of time in operation for all user types (individuals at their workplaces, workgroups and visitors).
- Keep resource inputs to a necessary minimum, as well as minimising undesirable effects which potentially infringe the rights of others.
- Allow higher levels of functional integration to be retrofitted, if needed.
- Do not introduce irreversible failure pathways.
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References:


12. Figure 7 is developed in more detail in LEAMAN AJ and BORDASS, WT, Design for Manageability: Results from a decade of research into occupied buildings, London, Euroforum, 1995, April 25. Also LEAMAN, AJ, Strategic facilities planning: pointers from a decade of use research, National Conference of the Faculty Management Association of Australia, Sydney, 30 November - 2 December, 1994.

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