Environmental quality and the productive workplace

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ABSTRACT
A good working environment will help to provide the user with a good sense of well-being, inspiration and comfort. The main advantages of good environments is in terms of reduced upgrading investment, reduced sickness absence, an optimum level of productivity and improved overall satisfaction. Individuals respond very differently to their environments and research suggests a correlation between worker productivity and well-being, environmental, social and organizational factors. Research shows the occupants who report a high level of dissatisfaction about their job are usually the people who suffer more work and office environment related illnesses which affect their well-being, but not always so. Well-being expresses overall satisfaction. There is a connection between dissatisfied staff and low productivity; and a good sense of well-being is very important as it can lead to substantial productivity gain. If the environment is particularly bad people will be dissatisfied irrespective of job satisfaction. This paper describes research showing how environment affects productivity.

INDEX TERMS
Productivity; Occupational stress indicator; Analytical hierarchical process; Building quality

INTRODUCTION

It is a much higher cost to employ people than it is to maintain and operate a building; hence, spending money on improving the work environment is the most cost effective way of improving productivity because a small percentage increase in productivity of 0.1–2% can have dramatic effects on the profitability of the company. The current state of knowledge on this subject is described in CIBSE (1999) and Clements-Croome (2000). Practical application of some of this knowledge is described by Oseland and Bartlett (1999). In terms of sustainability, gains in productivity offer energy reductions many times those offered by operation, construction and design respectively (Evans, 1998; Lovins, 2000). Healthy buildings tend to increase productivity; save energy but require good facilities management.

Surveys in several office buildings have shown that crowded work spaces, job dissatisfaction and the physical environment are the main factors affecting productivity. The data was produced and analysed using an occupational stress indicator in conjunction with the analytical hierarchical process. Thermal problems, stuffiness, sick building syndrome factors and crowded work spaces were the most frequent complaints. The results suggest that the productivity could be improved by 4–10% by improving the office environmental conditions.

METHODS OF MEASUREMENT

Ilgen (1991) classified the methods of performance measurement into three categories: (1) *Physiological;* (2) *Objective* and (3) *Subjective*. The rational for using *physiological methods* is based on the reasoning that physiological measures of activation or arousal are associated with increased activity in the nervous system which is equated with an increase in stress on the operator. However, physiological measures of work load have received wide criticism regarding their validity, as well as the sensitivity of measures to contamination and the intrusive nature of the measures themselves. *Objective measures* (O'Donnell and Eggemeier,

1986) are frequently used to infer the amount of workload, both mental and physical. A further class of measures of workload comprises *subjective measures* (Cyfracki, 1990). Subjective measures of workload are applied to gain access to the subjects' perceptions of the level of load they are facing in task performance. Rating scales, questionnaires and interviews are used to collect opinion about the workload. While these methods may not have the empirical or quantitative appeal of physiological or objective measures, it is often argued that subjective measures are more appropriate and realistic since individuals are likely to work in accordance with their feeling regardless of what physiological or behavioural performance measures suggest. Wyon (1996) classified six types of productivity metrics.

FIELD STUDY ON PRODUCTIVITY AND ENVIRONMENT

Li and Clements-Croome (2000) have carried out environmental surveys in several office buildings which have shown that crowded work spaces, job dissatisfaction and the physical environment are the main factors affecting productivity. The data was produced and analysed using an *occupational stress indicator* in conjunction with the *analytical hierarchial process*.

This research focused on the relationship between productivity and the indoor environment in offices and took into account the fact that productivity depends on other factors by using an *Occupational Stress Indicator* (OSI) (Arnold, 1998; Cooper, 1988). OSI is a job satisfaction scale involving questions or statements, asking respondents to state what they think or feel about their job as a whole or specific aspect of it. The occupational stress indicator is designed to gather information about groups as well as individuals and it attempts to measure the major sources of occupational pressure; occupational stress; coping mechanisms and individual differences which may moderate the impact of stress (Cooper, 1988). An environmental dimension has been built into this indicator covering temperature, ventilation, humidity, indoor air quality, lighting, noise, crowded work space and is referred to as EPOSI (Clements-Croome, 1995) which has been used to gather information about the occupants in the buildings that have been surveyed. Semi-structured interviews were carried out to establish more details about attitudes and reasons behind the responses. The questionnaires were answered by occupants across various work grades and tasks and were designed to elicit.

Office Survey

A detailed environmental survey was carried out at an office in Reading in 1996. The questionnaire was in five sections:

Section A of the questionnaire asks the occupants to judge the physical factors in the environment covering temperature, stuffiness and draughts, dryness, indoor air quality, sunlight, lighting, noise and vibration, and crowded workplaces. Questions were also asked about personal health; job stress; job satisfaction; an overall opinion about the indoor environment; including questions about five categories of sick building syndrome covering sensory irritation; skin irritations; nervous problems; nasal and odour complaints.

Section B of the questionnaire concerned subjects views on how they liked the offices layout and decoration as well as questions about their job in relation to productivity. They are also asked to rate how much personal control they felt they had over temperature and lighting.

Four questions were asked to determine self assessed productivity covering the amount of work accomplished; quality of work; feeling of creativity; and degree of responsibility.

Section C of the questionnaire was concerning information which describes the characteristics of the organization, workplace and some personal information. Occupants were then asked about human factors such as well-being; ability to perform; motivation; job satisfaction and technical competence. Finally, there was a group of questions concerned with indoor environment; weather; outdoor view; organizational factors; occupational factors; facilities and services; personal factors.

Section D was based on information gathered using EPOSI and five major *human factors* were identified which influence productivity (*well-being, ability to perform, motivation, job satisfaction, technical competence*). Six *system factors* (*indoor environment, weather and outdoor views, organizational aspects, occupational issues, facilities and services, personal aspects*) were examined to see how thy influenced the human factors.

Section E covered interactions between sick building sickness symptoms and an array of personal, occupational and environmental factors.

ANALYSIS OF RESULTS

Analysis of the data shows that the level of productivity by self assessment reduces as the workspace becomes more crowded, as job dissatisfaction increases and as overall dissatisfaction of the indoor environment increases. The results lead to the overall conclusion that on average the self assessed productivity could be improved by about 10% by improving the office environmental conditions.

The Spearman rank-correlation coefficient, r_S, was used to assess measures of association between any two variables. The statistical analysis of the results is given in detail by Li (1998). It was shown that a significant rank-correlation exists between self-assessed productivity and environment, job dissatisfaction and job stress, as shown in Table 1.

Table 1 The association between self assessed productivity, environment and job factors

Factor	Associated factor	Spearman rank-correlation coefficient
Self-assessed productivity	Unsatisfactory indoor environment	–0.49
	Job dissatisfaction	–0.36
	Job stress	–0.21
Unsatisfactory indoor environment	Job stress	+0.31
	Job dissatisfaction	+0.43
Job stress	Job dissatisfaction	+0.36

There is a unique relationship between the individual, the environment and the building they inhabit. Satisfaction with the environment arises from a number of issues apart from personal health ($r = 0.34$), sick building syndrome symptoms ($r = 0.35$), visual and aural problems ($r = 0.36$), thermal problems ($r = 0.49$), and crowded work space ($r = 0.50$). The correlation coefficients were statistically significant for $p < 0.01$.

Regression analysis was carried out and gave significant positive correlations between job dissatisfaction and overall unsatisfactory environment; job stress and overall satisfactory environment; job dissatisfaction and job stress; crowded workspace and overall unsatisfactory environment; and thermal problems and an overall satisfactory environment.

Regression analysis also showed that self-assessed productivity reduced with unsatisfactory environment; job dissatisfaction; crowded workspace; and the number of people in the room. The result for crowded workspace agrees with that of Raw (1989).

Multiple regression and correlation analysis was carried out using a computer programme (SPSS).

Statistical F tests and multiple correlation coefficients R were established according to Anderson (1990). The regression equation for an overall unsatisfactory indoor environment was shown to be:

$$\mathrm{En} = -0.7211 + 0.5997 * \mathrm{Th} + 0.4082 * \mathrm{SBS} + 0.3222 * \mathrm{CS}$$
$$(r = 0.6546, F = 36.99 > F_{\alpha} = 0.01\ [3, 152] = 3.92) \quad (1)$$

This indicates that subjects who suffer from physical environmental factors will suffer an increase in overall unsatisfactory environment which is positively related to thermal problems, crowded workspace and sick building syndrome symptoms.

The multiple regression equation for job satisfaction was found to be:

$$JD = 1.2055 + 0.3157^{*} JS + 0.2572 * En + 0.1023 * CS$$
$$(r = 0.5367, F = 19.56 > F_{\alpha} = 0.01\ [3,149] = 3.92) \quad (2)$$

This shows that high job dissatisfaction results from job stress, crowded workspace and an overall unsatisfactory environment.

For self assessed productivity, the regression equation was developed using a stepwise regression procedure:

$$P = 6.8510 - 0.3625^{*} En - 0.1542 * JD - 0.1329 * CS$$
$$(r = 0.5083, F = 14.86 > F_{\alpha} = 0.01\ [3, 132] = 3.94 \quad (3)$$

The principal factors which affect self-assessed productivity in the offices surveyed were an overall unsatisfactory environment, crowded workspace and job dissatisfaction.

A distinction was made between *direct* effects (i.e. those effects that do not result from any other variable in the model) and—*secondary* or *indirect* effects which arise from the interaction between one or more variables in the model (Cohen, 1983). For example, an overall unsatisfactory environment has a direct effect on self-assessed productivity, but there is also an indirect effect because it also affects job satisfaction which in turn also affects self-assessed productivity. The total indirect effect is estimated by the product of the effects of an overall unsatisfactory environment on job satisfaction, and job satisfaction on self-assessed productivity. The total effect of environment on self-assessed productivity is then the result of combining the direct and indirect effects.

Further analysis showed that the most common complaints about unsatisfactory environments were those connected with high or low temperature variations; stale and stuffy air; dry or humid air.

CONCLUSIONS

The lifetime cost ratios described by Evans (1998) dramatically emphasizes the need to consider the impact of the buildings we design on the performance of people in the workplace, and hence the benefits that accrue from good design to improve effectiveness of business organizations. It is possible to assess productivity in the workplace. There is also a need to agree a building quality assessment programme similar to the one described in this paper. The next part of our research programme in this area will examine how we can model this information in a way that is amenable to clients in order to enhance their understanding of value and its impact on life cycle costs.

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