

CONFERENCE THEME

Case Study

INDOOR ENVIRONMENTS, DESIGN, HEALTH AND PRODUCTIVITY

Associate Professor John Bell

QUT

j.bell@qut.edu.au

Professor Lidia Morawska

QUT

l.morawska@qut.edu.au

Nur Demirbilek

QUT

n.demirbilek@qut.edu.au

Veronica Garcia-Hanson

QUT

v.garcia-hanson@qut.edu.au

John Ashley Mabb

QUT

j.mabb@qut.edu.au

Robert Bergman

QUT

r.bergman@qut.edu.au

Ned Wales

QUT

n.wales@qut.edu.au

ABSTRACT

This report focuses on the research published on the topic of indoor environments and the impacts on worker productivity and health.

Traditional research on work spaces emphasizes the study of human factors, or ergonomic design of objects with relation to the human body, and human capabilities. In addition, research undertaken at a broad level of analysis in Environmental Psychology, or the study of transactions between individuals and their physical settings. In these transactions, individuals change the environment and the environment changes their behaviour and experiences.

Human factors or Ergonomics is an empirical science. The central approach of human factors is the application of relevant information about human capabilities and

behaviour to the design of objects, facilities, procedures, and environments that people use (Sanders and McCormick, 1992).

The work environment can be considered not only as a collection of physical stimuli (noise, light, temperature, etc.) but also as a physical structure (size, furniture, architectural design, etc.) and as a symbolic artifact (the meaning or image of the work setting). Fundamental psychological processes are invoked by employee/environment interactions: arousal, overload, affect, adaptation, personal control, and so on. This leads to outcomes that, in general, may be categorized into performance (or productivity), health (or stress), and satisfaction (or moral and interpersonal relations).

A clear conclusion drawn from this report is the need to undertake more research in an Australian context, in terms of both physical, cultural and social conditions, with the aim of verifying and quantifying the impact of key indoor environment variables on productivity and health.,

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In much of the literature reviewed for this paper the concept that rates of office worker productivity have a direct correlation to worker psychological satisfaction is well established. Other factors also play into account such as management style and organizational behavior (Gifford, 1997). In the analysis of physical environments a number of interesting case studies have revealed interesting outcomes. The case study outcomes will be discussed in more depth later in this review. In concluding this paper recommends more focused research be undertaken within the Australian context of indoor environments. The work would be well suited to a collaborative research effort between industry and public sector agencies.

The Indoor Environments: Design, Productivity and Health report was written with funding from the Collaborative Research Centre for Construction Innovation and summarizes studies already undertaken in the field of indoor environments (worker productivity and health in buildings). In this report a wide range of areas are covered. An extensive literature review was undertaken to more clearly understand the diversity of fields of study, which overlap under subject of Indoor Environments. The four main areas reviewed here are; indoor air quality, thermal, visual and acoustic comfort. From this material the team that compiled the report has made key findings in gaps and opportunities for further research work needed to better understand the nature of encouraging higher productivity and work satisfaction.

Findings of the research reviewed here indicate that substantial improvements in productivity strongly correlate with improvement within an indoor environment (see ref: p. 35 of the report). Unhealthy indoor environments or “sick buildings” are accountable for a hidden health cost. A study undertaken in the United States shows that loss to productivity and hidden cost to be in excess of \$200 billion per year (Fisk, 2000).

Retrospective

The western world has progressed in the past century with a general movement away from labor-intensive activities. In the past twenty-five years the service economy has strengthened and driven a demand for commercial office space. Through the process of industrial restructuring we now have far greater numbers of people in urban centers than at any other time. This shift has meant a significant increase of people working in indoor environments. New theories of work place interactions and organizational ecologies have revealed important connections (Becker and Steele, 1995).

The character of work and the economies of tall office buildings have meant a growing importance of worker satisfaction and higher productivity relationships being more clearly understood. This project's focus is on the physical setting as a result of the development industry. This prospective are parts of the integrated system known as high performance workspaces. Results of these new research findings indicate designing and creating environmental conditions aimed to enhance the work experience, increase in work performance and worker satisfaction can be extrapolated

The nature of office work has changed over the years. A century ago the running and administrations of factories was carried out in centralized locations within the realm of the factory where the majority of the tasks were

those of paper handling. This predominantly passive mode of work took place in rudimentary spaces. Today, office work is increasingly concerned with the generation, recording and dispersal of ideas. With the aid of technology workers manage and analyze large databases of information, which is used to improve the most efficient and profitable interests of the organization. As a consequence of this historical shift office spaces have become the most integral part of the organization (Sanders, McCormick, 1992).

Current and Future Trends

In contemporary times office environments need to be designed as a responsive environment where work spaces encourage productivity and enhance task performance. This can be achieved by supporting user needs, by facilitating meaningful communications, healthy work relationships and a stimulating organizational climate. In the knowledge economy, the nature of work that is performed in offices is becoming more cognitive in character (Fried Y, 1990). Smart technology encourages a more refined role where workers analyze, conceptualize, and communicate with others and other machines. The ability to provide an attractive environment for more highly skilled workers is now in the best interests of the organization. (Florida, 2002) To be functional, office environments must support the physical activities and such as space, light and furniture as well as psychological environments of users which are perceptual, social and cognitive activities.

In the knowledge economy, workspaces are one component of integrated aspects of the overall output potential and productivity. In order to accurately evaluate the optimum work environment a number of areas of research should be undertaken. One of these is the analysis of the socio-physical perceptions of individual user groups. This is undertaken with six interdependent sub-systems: the type of people who work in the office; the work activities performed; the interaction and communication relationships; the organizational structure and culture; the type of technology used and the over all designed office environment.

Reporting Objectives

The objectives of the project were two fold; firstly, to gain understanding of the work performed to measure impact of indoor environments on productivity; and the other to gain specific knowledge relating the indoor environmental impacts on worker productivity. Over 500 literature resources have been reviewed in the report. Considerations within the literature review were made for the focus of the study, the research methods being applied in the study and the qualities of the building. In order to ensure legibility in the system a "literature Classification Scheme" was put forward. The six main classifications devised are; Geographic Location, Building Types, Data Types, Outcome Focus, Building Attribute, and Detailed Attributes. This system of classification became the basis of the methodology to manage the data.

In addition to this, the use of a "Data Type" classification was deemed necessary because of the high number of resources available concerning this topic. The different types of studies within the database vary from qualitative observational studies to detailed analyses of specific parameters of the indoor

environment. Six topics are used to help distinguish the study focus into areas such as health, productivity, comfort, response and well being. There are also categories that identify energy usage, maintenance and environmental aspects of the building design and operation. It is interesting to note that many of the studies did not lead to a specific outcome focus.

Maslow's Hierarchy of Needs

The majority of theories on productivity are found on worker and employee motivational relationships. A commonly used model is the motivational theory put forward in Maslow's Hierarchy of Needs, illustrated with a pyramid of hierarchy with Self-Actualisation at the pinnacle and Self-Esteem Needs, Social Needs, Safety Needs and Physiological Needs in descending order. This theory is based on the fundamental approach that individuals satisfy lower order needs before they move onto higher order needs. Application of this theory to productivity in buildings may or may not meet the higher or lower order needs of the occupant which in turn impacts on occupant productivity.

As it will become clear in this paper, the measurements of productivity and health outcomes is not a straightforward task. To better assess the impact of numerous variables it becomes difficult to discern between worker productivity, environmental impacts, work ethics and inter-corporate dynamics. In order to better define these variables the research group developed a graphical representation of the overall approach. Within the report on page 11, a diagram is provided to indicate what research has already been undertaken. In this we begin to see the emergence of a critical relationship between indoor environments and building occupants under a holistic approach. Understanding the inter-connectivity of these variables is essential when developing a methodical approach to the project objectives.

Effects of Building Related Illnesses and Indoor Air Quality

In discussing indoor environments of office buildings the term "Sick Building Syndrome" (SBS) is the term used to represent a collection of temporary variables that impact on occupant health. The symptoms of SBS can be sore throat, fatigue, dizziness, headaches, problems in breathing and other influenza type symptoms. SBS's are different from "Building Related Illness (BRI), which is a clinically verifiable diseases that can be attributed to a specific pollutant as the cause agent. Also the Multiple Chemical Sensitive (MCS) problems are generally thought to be acquired through contact with particular volatile organic compounds present in the workspace. These pollutants are of concern to organizations due to potential risk management for occupational health and safety standards, potential worker illness and corporate liability.

There is extensive research that has been undertaken to better understand the role that good indoor air quality plays in increased productivity. The universal conclusion for much of the research indicates that buildings need to be designed, built and maintained in ways to reduce the impact of airborne pollutants, provide sufficient exhaust and clean air ventilation by natural means.

Importance of Light

There is an important connection to be made between visual comfort and thermal comfort. The light levels provided within indoor environments can add heat to internal spaces due to the amount of energy required to provide the light source. This can be analyzed through determining the ratio of light output to the total power input. For example sunlight is one of the most efficient sources of light rating 94.2 lm/W (Illuminate Engineer Society, 1995). This concept is important to consider as lighting accounts for 15% of total energy used in Australian commercial buildings. Perhaps even more importantly this demand on energy generates 21% of the total greenhouse gas emission for commercial buildings in Australia (Australian Greenhouse Office, 1999).

Considerable research has been undertaken evaluating the relationship between luminous environments and productivity. Studies on the topic date back to the 1920's where research into the link between factory unit output and illumination were conducted by behavioral scientist. The literature review and report go into far greater detail on this subject. Examples of the types of factors impacting on the field of study are: spectral distribution, glazing type, diurnal illuminate variation, glare and color rendition. Much of the work carried out has been in school and office buildings.

In the literature reviewed, it has been strongly indicated that forms of data measurement, such as questionnaires, need to have well informed motives. By becoming familiar with the amount of research already undertaken there is an opportunity to create structures of measurements which are adequately developed and tested. The report offers several good examples of methodologies found in the literature review, in particular the PROBE studies (Leaman and Bordass, 2001). However these programs need updating and evaluating.

Conclusion and Recommendations

The report concludes with a number of recommendations for further research to be undertaken. The findings here expose a significant shortage of data in Australia and in particular field studies. It is estimated that only 8% of the literature found in this project was carried out in Australia. Although some studies are relevant to Australia there are a couple of reasons why work needs to be undertaken here: climate change and solar lamination levels are unique to this region of the planet; and cultural differences and the significance of social space and administrative nuances that are unique to Australian organizational behavior.

Further research is required in real working environments. It would be ideal to have the study take place in a climate of extremes such as Melbourne or Brisbane. The use of subtropical or Mediterranean climates may offer higher correlation to quantify the benefits of improved indoor environmental quality. A study may exist which measures the statistical significance of environmental pollutants before and after an office renovation, or one that measures indoor air quality, thermal comfort and lighting. Conducting a post occupancy evaluation in winter and summer to determine if there are changes from the participants could follow these up.

The underlying benefits from further exploration into this work can lead to a balanced outcome of lower overhead cost per workers and higher levels of moral and feelings of satisfaction. This combination will contribute to increases in productivity. Buildings can influence the Indoor Environmental Quality in ways where the overhead and capital cost come down as productivity increases (lower number of sick days claimed). More efficient technologies with effective applications (i.e. intelligent buildings) reduce cost associated with building operation and maintenance.

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