Impact of Workspace Design in Indian Context on Occupant's Behavior, to Enhance Efficiency and Comfort

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Abstract: The environmental psychology of a workspace is a rich and diverse field of study that is growing fast and gaining popularity. The indoor environmental factors in workspaces should follow functional as well as behavioral requirements as the spaces are designed as per the user's requirements, needs and aspirations. These play a major role in achieving behavioral impact on the user, as sense of well-being in the environment and physical comfort in the space enhances the productivity and efficiency of the user of the space. The slow and gradual importance of this issue in workspace design with Indian context, post occupancy evaluation can be adjudged as a permanent tool for improving indoor environment in buildings. Occupants should be used as a benchmark of evaluation, showing correlation of physical measurements and subjective parameters. It also suggests recommendations to improve quality of indoor environment in office buildings with analytical study, an important step in post occupancy evaluation. The objective of the paper is to inquire how people experience environmental psychology of the workspace as the determinants are efficiency, productivity and comfort. The success of any design depends upon the degree to which it creates an interface between the user and the environment.

Key words: Workspace, physical measurements, behavioral parameters, efficiency, comfort, quantity, quality.

1. Introduction

Any physical space, an enclosure or built environment strongly influences human behavior and has a quality to be imparted to Ref. [1]. A quality space can be perceived, realized, understood ultimately enhancing, or reducing the comfort level of the user of the space. Each individual responds uniquely when confronted with some situation or experience. The sociological determinants refer to privacy, personal interaction levels and territoriality [2]. The psychological human response or determinants relate to the psychological needs and concerns of the occupants. The physiological needs include functionality, ergonomics, life safety and health concerns [3]. The positive and negative impact of office design on employer's efficiency and comfort has

been referred to in this study [4]. The concept of environmental psychology initially originated in USA, then UK, in India, though the designers are considering all the norms to accomplish functional as well as aesthetical environs, a serious thought is rarely given as far as the behavioral concerns of the user of the space. The effort is to deduce a methodology to understand the physiological, psychological and sociological needs of the user of the workspace, correlating them to actual measurements of physical parameters via post occupancy evaluation. This can become a strategic level decision making process and can be emphasized as continuous activity in environmental evaluation [5].

2. Literature Review

The literature study establishes a correlation between workspace design and its impact on user, the design needs to follow various parameters and a thorough quantitative (objective) and qualitative (subjective) analysis is dealt systematically and

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efficiently. This leads to comfort and efficiency of the user. The productivity and performance is individual, group or organizational, which leads to positive or negative impact. Positive is imposed speed and accuracy of the task performed. Negative is higher error rate, slower time for task completion and adverse effect on health of the workers [6]. Individual performance: Workspace desk, micro environment, lights and visual conditions, variations in temperature and humidity, furniture, ergonomics and acoustics. Group performance: Work group size, proximity of team members shared space, floor layout and furniture, height and density of workspace partition, furniture design and dimensions. Organizational performance: Ease of access, common facilities and manageable distances [7].

The environmental aspects of the workspace include ambient conditions [8]. The comfort and efficiency are functional as well as psychological. The literature review deals with the major functional comfort criteria objectively and subjectively. The psychological and behavioral parameters as motivation, job satisfaction and participation are also equally important to achieve desired results. The final outcome conducted by an independent research firm on U.S. workplace environment suggested that businesses can enhance their productivity of work by improving their workspace designs [9].

About human responses to built environment for comfort and functional efficiency, as suggested by Jon Lang in his substantive theory of environment and behavior different patterns of built environment afford different behavior settings [10]. A behavior setting is standing pattern of behavior and the milieu and congruent relationship between the two. The processes of environmental knowing and assessing are not only limited to physical features but also to the attitude an individual has towards a particular space. It is essential to establish proper correlation between functional parameters and feelings, expectations and beliefs and values of the user of the space, resulting into improved task performance and team effectiveness [11]. Based

on the literature review the relationship between office design and comfort and efficiency can be conceptualized on the basis as depicted in Fig. 1. These parameters create an impact on the individual in terms of increased or decreased efficiency.

3. Method

Post occupancy evaluation study was done of a selected workspace of city of Nagpur, 2nd capital of state of Maharashtra, India. The author's objective was to determine the occupant's satisfaction and perception level in the workspace in terms of indoor environment, to establish a correlation between objective and subjective variables, to suggest and recommend ways to improve office indoor environment. As per the methodology chart depicted in Fig. 2, data was collected through survey.

The data collection was done through a survey, categorized as quantitative, qualitative, observations and interviews of the employees. In quantitative (objective) data, actual physical measurements of indoor and outdoor climatic conditions were taken. Ambient temperature, surface temperature, air velocity, relative humidity and Lux levels were measured with laboratory precision with a gap of 3 h. Mean levels of ambient and surface temperature, humidity, air velocity, and lux were calculated. Anthropometric data was collected for spatial arrangements.

Instruments used were LM-8000, anemometer for ambient temperature, air velocity relative humidity and lux levels. IR non contact thermometer was used for surface temperatures. Qualitative aspects related to the parameters were collected through five pointer questionnaire as how the occupants perceive the space. The questionnaire covered three major aspects as physiological, psychological and sociological focusing on spatial arrangement, furniture, air and thermal, lighting and sound. General information about occupant's demographic and anthropometric characteristics such as age, height, weight and gender were collected. The occupants were interviewed about

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Fig. 1 Conceptual framework.

Fig. 2 Methodology chart.

their working pattern, profile, experiences, expectations and attitude towards their work. They were thoroughly observed for a period of two weeks at the time of maximum hot climatic conditions.

3.1 Nagpur's Climatic Environment and Meteorological Conditions during the Survey

The climate of Nagpur city is characterized by a hot summer and desired as arid zone. The well-distributed rainfall in the rainy season and dryness follows a

typical seasonal weather pattern. The cold season is from December to February and is followed by the hot season from March to May. The southwest monsoon season is from June to September while the period October to November constitutes the post-monsoon season. May is the hottest month with the mean daily maximum temperature at 42.7 °C (108.8 °F) which may even reach up to 48 °C. The survey was conducted in peak summer which is the critical period for the place. Maximum outside temperature was varying between 41 °C to 43 °C.

3.2 Office Pattern, Occupant's Profile

The selected workspace, a part of commercial complex is located on national highway, the road having commercial establishments on both sides. Originally an apartment of 920 Sq. Ft. area is converted into an office space. The activities are reception, main cabin, cabins for administrative staff, storage, meeting room, pantry and a toilet. As a custom clearing agency, it comprises of one proprietor and nine staff members as shown in Fig. 3. As a business of product import and export, the responsibility of the company is to carry out a smooth transportation of goods from one place to another. Custom clearances, documentation and necessary certification are to be taken care of. The office has a link with excise office and container depot. The standing pattern of behavior suggests 60% of staff located in office premises and 40% are on the field. The trend of working shows maximum use of telephone, mobile and internet. Staffs who are in office premises are proprietor, manager, marketing manager, accountant, and documentation in charge, operation in charge and attendant. Warehouse operator and two runners are 80% of their time on the field.

The arrangement is partially an open plan office as two to three employees are sharing the cabin space, except for the proprietor who has a private cabin. Internally the rooms are provided with 1.2 m heightened partitions creating personal spaces for the staff. The

Fig. 3 Plan of selected workspace.

office is located on first floor and oriented in an east-west direction. The external walls are on western, southern and northern sides. Walls are with window openings with sizes as $1.5 \text{ m} \times 1.2 \text{ m}$ and $0.9 \text{ m} \times 1.2 \text{ m}$. Wall surfaces are painted along with a 0.75 m heightened wooden paneling. The window openings are covered with vertical blinds.

The internal partitions and furniture are out of reconstituted wood and glass with laminated finish. Flooring is polished marble. Ceiling is plain RCC (reinforced cement concrete) slab. Air cooling is provided with one air outlet in each room supported by a ceiling fan.

4. Discussions

As mentioned in the objectives and methodology, an individualized approach was adopted to understand the correlation between physical measurements of the space occupied by them and behavioral parameters on the basis of questionnaire answered by the occupants. This has helped in working out the factors responsible for either enhancing or reducing the efficiency and comfort of the employees as their working pattern has been studied thoroughly. It is imperative to state that the observed lux levels at working locations in the selected workspace were at considerable low levels as compared to the standards specified by BEE (Bureau of Energy Efficiency, India) code lighting [12]. Table 1 shows responses given by the occupants for subjective parameters.

4.1 Main Cabin: Proprietor

The cabin is located in the south west corner of the building, with only one window opening, kept closed at the time of peak summer as depicted in Fig. 4. The proprietor's response on a five point scale has rated the subjective parameters between 80% and 85% except the air/thermal sensitivity parameter which is 68% as given in Fig. 5 and Table 1. As an independent cabin, the rating for spatial planning is 80%, visual connectivity with the staff is 25% to 30%, which suggests that privacy is maintained.

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Fig. 4 Plan of main cabin.

Fig. 5 Subjective responses of proprietor.

Table 1 Subjective rating of the occupants.

Occupant	Spatial (%)	Furniture (%)	Air thermal (%)	Lighting (%)	Sound (%)
Proprietor	80	80	68	80	80
Marketing	92.5	66	64	62	68
Manager	70	69	68	80	72
Accountant	82	75	64	85	88
Documentation	75	75	84	80	60
Operation	80	82	72	82	60
Attendant	77	72	72	75	56

Occupant	Social psychological spatial planning (%)	Social psychological air thermal (%)	Job motivation (%)
Proprietor	82	80	85
Marketing	80	85	92
Manager	88	80	85
Accountant	85	75	89
Documentation	75	75	79
Operation	72	72	85
Attendant	82	60	77

As per observations and spatial layout for the proprietor, the physical distance to access his staff is in the range of 12 m to 15 m daily. As per the physical measurements in Table 2 and Fig. 6, the mean of

illumination levels is 146.67 lux, which is less as compared to standards given in BEE (Bureau of Energy Efficiency India) of 400 lux to 450 lux lighting.

Though the cabin is facing southern side much

Table 2 Physical measurements main cabin.

Sr. No.	Time	Ambient temperature mean	Relative humidity mean	Air velocity mean	Lux level mean
1	10:30	32.93	55.65	0.95	147
2	12:30	32.23	54.18	2.925	146
3	15:30	31.95	52.45	0.825	147

Fig. 6 Lux levels on main table.

variance is not seen in the ambient temperature and surface temperatures which is in the range of 31 °C and 32 °C, as is shown in Figs. 7 and 8. The reason being compactness of the room and southern side is in shade due to the presence of tall buildings in the vicinity Fig. 9. In a personal interview with proprietor, it was revealed that he is highly successful in motivating the staff and believes in giving freedom and autonomy in taking decisions.

4.2 Staff Cabin I: Marketing Manager

The cabin is placed in the southeast corner of the building. The eastern side has a full length balcony. Designed for three persons, but occupied by single person as per Fig. 10. As a highly motivated person, he has rated the subjective parameters, especially spatial planning as 92%. Air/thermal sensitivity factor is rated as 64% as depicted in Fig. 11.

The marketing manager, as his standing pattern of behavior needs space for keeping computer, printer, telephone, has to entertain outside guests, the furniture arrangement and spatial design is provided with 3.5 m². area as his personal space. Opined as congested space, rating given for furniture is 66%.

Though visual connectivity is 20% to 25%, the connectivity with the staff members has been rated very

high. A 15 m to 18 m physical movement keeps him connected over the day with the other occupants. The

Fig. 7 Mean of temperature and humidity of main cabin.

Fig. 8 Mean of surface temperature of main cabin.

Fig. 9 Main cabin.

Fig. 10 Plan of cabin I.

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Fig. 11 Subjective responses of marketing manager.

thermal sensitivity rating is 64%, the relative humidity is very high due to less air velocity as per the physical measurements, creating physical discomfort as depicted in Fig. 12. Only 60% rating is given for lighting which is supported by mean lux levels on the table occupied by the manager as 54 lux as per Table 3 and Fig. 13. The worktop is 2.5 m away from window and with partition resulting in poor availability of natural light. The ambient temperature shows an increase by approximately 1 °C at noon hours. Surface temperature is 32.8 °C on wall No. 1 in Fig. 14, slightly higher than ambient temperature is due to the external wall even though having full length balcony.

4.3 Staff Cabin II: Manager, Accountant

Located centrally, separated from the reception with a partly glazed and paneled partition as in Fig. 15. The manager, second in command, coordinates with the

staff and the proprietor, the behavior setting demands a constant interaction with the staff, spatial organization disturbs her privacy.

Visual connectivity is 50% as the benefit of central location. 69% satisfaction with the furniture and ergonomics arrangement was given in Fig. 16 and Table 1. As manager has to accommodate a computer, printer, telephone, files and everyday cash, the kind of milieu does not suffice her anthropometric needs. The air/thermal sensitivity rating is 69%, as the windows are kept closed there is no scope for natural air and ventilation. Having only one external wall there is no cross ventilation added with low air velocity and high humidity, shown in Fig. 17. Accountant has given 85% rating for lighting as having a benefit of natural and artificial lighting. The reason attributed is benefit of operating window for natural light and ventilation. The unoccupied table has low lighting levels in the range of 60 lux and is not a preferred table for seating. Occupants are rating high due to adaptability factor as depicted in Table 4 and Fig. 18.

As the room is compact with seating for three creating a congested effect and hot air pockets in Fig. 19, the ambient temperature is 32 °C at noon, whereas the surface temperatures are at a higher range as 32.8 °C in Fig. 20, both the occupants have spent nearly 10 years in the office, highly motivated, satisfaction and sense of belonging shows a rating of 90% (Table 1).

Fig. 12 Mean of temperature and humidity of cabin I.

Table 3 Physical measurements staff cabin I.

Sr. No.	Time	Ambient temperature mean	Relative humidity mean	Air velocity mean	Lux level mean
1	10:30	32.23	54.6	1.73	53.3
2	12:30	32.5	52.7	1.43	57.00
3	15:30	32.05	51.7	2.00	51.8

Fig. 13 Lux levels on main table.

Fig. 14 Mean of surface temperature of cabin.

Fig. 15 Plan of staff cabin II.

Fig. 16 Subjective responses of occupants.

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Table 4 Physical measurements staff cabin II.

Sr. No.	Time	Ambient temperature mean	Relative humidity mean	Air velocity mean	Lux level mean
1	10:30	31.8	54.9	1.55	104
2	12:30	32.03	53.6	1.6	113
3	15:30	31.7	52.8	1.53	106

Fig. 17 Mean of temperature and humidity of cabin II.

Fig. 18 Lux levels on main table.

Fig. 19 Staff cabin II.

Fig. 20 Mean of surface temperature of cabin II.

4.4 Staff Cabin III/Storage

Documentation and operation in charge located in the north east corner of the office, has the advantage of cross ventilation. The room accommodates seating for two people, storage for files and electronic gadgets as Xerox machine, typewriter, printers and other accessories as per Fig. 21.

Spatial planning shows extreme satisfaction as far as rearranging and flexibility of the furniture is concerned. Visual connectivity is 25%, still 75% happy about behavioral factors as connectivity, interaction and sense of belonging with the office staff are concerned. As per observations and spatial layout for the proprietor, the physical distance to access his staff is in the range of 12 m to 15 m daily. As compared to other cabins the air/thermal sensitivity rating is 80% as in Fig. 22, though relative humidity is high, low air

velocity and ambient temperature is on a higher range of 33 °C in Table 5 and Fig. 23.

Accessibility to switches and control on operation of windows and adaptability to clothing also adds to the comfort level and energy saving techniques. Lux levels are on a higher range as shown in the physical measurements. Mainly due to good natural light and north facing, clearly supported by 80% voting for this parameter shown in Table 1 and Fig. 24. The surface temperature is in the range of 33 °C, only one external wall (wall No.1) shows 35 °C, even though facing north Fig. 25.

The paper has investigated the physical and behavioral parameters through a five point questionnaire, supported by actual physical measurements which have shown considerable correlation in the ratings given by the occupants. The

Fig. 21 Plan of staff cabin III.

Fig. 22 Subjective responses of occupants.

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Fig. 23 Mean of temperature and humidity of cabin III.

Table 5 Physical measurements staff cabin III.

Sr. No.	Time	Ambient temperature mean	Relative humidity mean	Air velocity mean	Lux level mean
1	10:30	32.23	54.55	1.73	204.30
2	12:30	31.98	54.03	0.95	161.75
3	15:30	31.98	51.80	1.20	104.50

Fig. 24 Lux levels on main table.

Fig. 25 Mean of surface temperature of cabin III.

linking of behavioral parameters as satisfaction, motivation, sense of belonging and functional parameters as efficiency and comfort through ambient environmental conditions (spatial, furniture, air/thermal, lighting and sound) does help in giving concrete outline measures such as improvement in task performance and team effectiveness, as clearly

mentioned in the flow chart.

5. Results

As depicted in the Table 1, the rating given for physical and behavioral parameters below 75% has been considered as moderate and a detailed study of these parameters is done with physical measurements

as well as the occupant's personal experiences, attitude and their perception towards the space they are using [13]. In totality it is observed that 90% of the occupants except from cabin III/storage have rated the thermal sensitivity parameter between 64% and 72%. The reasons attributed are peak summer, low air velocity, high relative humidity and the occupants have opined for natural ventilation for a pleasurable indoor environment [14]. They have suggested change of seat for better thermal conditions. The occupants face headache and feel exhausted while working in those conditions. They have given a positive response for clothing change as per the climatic conditions. 82% rating is given by occupants of cabin III for thermal sensitivity factor as the room is north facing with cross ventilation providing natural air and ventilation. Furniture and anthropometric parameters rating given by manager and the marketing manager is between 66% and 72%. Though the spatial planning does permit visual connectivity 25% to 30% with the staff the open plan layout provides good connectivity and interaction with the staff. Privacy and concentration levels are not disturbed due to open plan office as opined by them. Documentation in charge is extremely satisfied with the flexibility of furniture arrangement. The third parameter as illumination acts as one of the prime functional comfort criteria as it creates a direct impact on the health and well-being of the occupant. Overall the mean lux levels show a range between 108 to 160 lux, which is less as per the standards given in BEE for task lighting in a workspace as 400-450 lux. Despite the readings the occupants have rated between 75% and 85% with an exception of marketing manager who has rated only 65% with due reasons mentioned earlier. The discomfort is due to poor lighting arrangement resulting in to fatigue and strain on eyes and poor concentration levels. 85% is rated by accountant as having an added advantage of natural as well as artificial light and facility of operating windows. One of the most consistent findings from user's survey is high rating given for behavioral factors of connectivity

and interaction with the staff. Every staff member is having high sense of belonging. Motivation factor shows a range between 80% and 95% as participation in decision making process, acknowledgement for work, consulted for the opinion and autonomy for work. Based on summary exhibits in Table 1, majority of the respondents are in comfort level in terms of spatial planning, furniture and ergonomics sound and lighting conditions and related psychological factors. However, the highest percentage indicated as uncomfortable environment in the office is in terms of cooling system, provision of air movement and also quality of indoor ventilation (64%), lighting (68%) (Table 1).

6. Conclusions

Based on the survey findings, it can be concluded that visual comfort, indoor air movement and ventilation constitute the highest factors in terms of occupants comfort ability and efficiency [15]. Therefore, several ways are recommended to mitigate the problems associated with indoor environment in workspace. Cooling system (air conditioning): Allow staff to have control of the cooling temperature. The centralized cooling system should be replaced to split unit as the gross floor area is not very spacious. Visual comfort (day lighting): provide day lighting integrated with electric lighting controls in several area provisions. Lux levels should be calculated as per the standards and provided to enhance the visual comfort and efficiency of the work. Spatial comfort (furniture): The standing pattern of behavior should be studied individually and accordingly a proper milieu should be provided for comfortable performance of day to day activities.

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