

The Effect of Environmental Factors on Staff Productivity in Office Space; Case Study: Information Technology Companies of Iran

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ABSTRACT

Growing productivity and interaction between employees are of the most important goals discussed in the office design phase. Most of the studies regarding the relationship between office space and productivity are concerned with physical conditions in the workplace. But, when examining the factors affecting office productivity, the variables that represent both the physical environment and the behavioral environment should be considered. Studies have shown that improving physical (layout and comfort) and behavioral (interaction and focus) conditions of the workplace increase productivity. The most important aim of this study is to understand the relationship between these variables through a questionnaire to more closely examine the effect of environmental factors on productivity in office spaces. The effects of gender, education, and job position are also investigated in the study of the effect of these variables on productivity. The questionnaire consists of four main sections: "personal information and general information on the workplace", "working patterns", "design variables" and "perceived productivity". Based on the obtained data, collected from 384 respondents from 10 IT companies, four variables of focus, comfort, interaction, and layout are the most important design factors affecting staff productivity in office space, respectively. Data analysis showed that comfort and interaction were more effective for women than men. It was also found that the academic degree of the staff influences the effectiveness of design variables on their productivity, while their job status does not.

Keywords: Environmental Factors, Staff Productivity, Office Spaces.

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1. INTRODUCTION

Today, in developing and developed societies, more than half of the workforce are in office environments and spend a significant portion of their daily lives in these spaces (Brill, Weidemann, & Associates BOSTI, 2001; Haynes, 2009). On the other hand, the workforce is the most important asset of any organization and usually costs the most. Therefore, productivity is a key factor in all organizations and determines their profits and losses.

Gensler's (2006) studies indicate that improving workplace conditions improves employee morale and increases productivity by up to 50%. Employers are constantly asking why they should be concerned about providing the best environmental conditions for their employees, while studies show that even slight improvements in ambient light will increase employee efficiency (Roethlisberger & Dickson, 1939). Research showing that employee satisfaction with their work environment leads to job satisfaction and higher productivity doubles the significance of environmental factors in office spaces (Sundstrom & Sundstrom, 1986).

New analyzes of employment costs prove the value of a better workplace. Brill et al. (2001) calculated that in the lifetime of an office building, 82% of the costs related to the salaries and benefits of employees, 10% related to the technology used in the occupation, 5% to the initial costs of furniture and 3% to the maintenance costs. Therefore, investing in improving the work environment, if it results in more productivity of employees, is reversible and beneficial, and despite costs that are only for individuals (such as training, bonuses, etc., it is sustainable over time and even with the arrival of new employees.). It will be (Neftzger & Walker, 2010, p. 488). Reducing energy consumption by up to 50 percent is not as important as improving 1 percent of staff productivity (Lan, Wargoeki, & Lian, 2011, p. 1060).

Although the existence of appropriate physical conditions in the workplace is effective in improving employee health and productivity (Hensley & Cooper, 1987), healthy buildings do not necessarily lead to higher productivity and it must be emphasized the role of good, creative design and all aspects of office space. On the other hand, the success of an organization is not just related to the good design of space and more important factors such as the clarity of goals and how to manage them play a role in it, but the design can either enhance or weaken these factors. But reducing the cost of a proper design under the pretext of costs related to equipment and employee salaries is very short-sighted because productivity and job satisfaction are directly affected by the workplace quality.

What and how many environmental factors affect the staff productivity in office spaces, have been the subject of much research and remains a challenging and extensible topic.

2. THEORETICAL FOUNDATIONS

The theoretical foundations try to provide a model for understanding the theory and practice in the field of research. In this section, existing studies are reviewed to select a model for studying environmental factors affecting productivity in office space.

2.1. Productivity and Measurement of it in Office Space

Productivity is the rate at which an organization (individual, industry, country) converts input resources (labor, materials, machines, etc.) into output resources (goods and services). Although in production environments one can easily obtain the ratio of output to the input of products to work efficiency, in office spaces the subject is very complex and varied; because different processes are done in these environments and more emphasis is on employee knowledge-based activities (Haynes, 2007, p. 158).

Research on measuring productivity in office space dates back to the 1930s (Roethlisberger & Dickson, 1939). Then, extensive studies have been conducted in this area, in particular by the British Building Productivity Research Institute (Haynes, Suckley, & Nunnington, 2017, p. 111). Examining these studies shows that researchers use a variety of methods to measure staff productivity in office spaces, such as self-reported productivity, cognitive performance testing (job memory, speed of work, etc.), monitoring computer usage, staff attendance, sick leave, job satisfaction, job commitment, and resignation rates.

Although studies show that there is no definitive and accepted method for measuring productivity in office spaces, it seems that using "self-reported productivity" as a person-centered approach is the most appropriate method in these environments (Oseland, 1999; Leaman & Bordass, 1999; Clements-Croome, 2006; Haynes, 2008).

2.2. Determining Environmental Factors Affecting Productivity in Office Spaces

In today's office space, inspecting the impact of environmental factors on staff is a challenging topic because it is difficult to define inputs and outputs in such environments (Haynes, Suckley, & Nunnington, 2017, p. 112). Numerous studies conducted over the last three decades have identified 25 indicators as environmental factors affecting office productivity (Zweers, Preller, Brunekreef & Boleij, 1992; Leaman & Bordass, 1999; Ilozor & Oluwoye, 1999; Ilozor, Love, & Treloar 2002; Mawson, 2002). In order to better understand the relationships between these factors and provide a valid theoretical framework, Haynes (2007) conducted a very extensive study on 1418 UK public and private sector administrative staff. He used mathematical methods of factor analysis, exploratory factor analysis, confirmatory factor analysis, principal component

analysis and varimax rotation on the obtained data. The result was the combination of these 25 indices into 4 main variables (Table 1).

Table 1. Variables and Sub-Variables Affecting Productivity in Office Space

Variable	Sub-Variable
Comfort	Air Conditioning, Temperature, Natural Light, Artificial Light, Cleaning, Physical Security, Furniture
Layout	Informal Meeting Areas, Informal Meeting Areas, Quiet Areas, Privacy, Private Wardrobe, Public Wardrobe, Work Desk, Commuting Space
Interaction	Social Interactions, Work Interactions, Creative Environments, General Atmosphere, Location Relative to Colleagues, Location Relative to Equipment, Overall Layout of Environment
Focus	The Distraction Caused by Equipment, Bustle, Noise

(Haynes, 2008)

Haynes suggested that the physical environment be divided into “physical environment” and “behavioral environment” to examine it more closely. The physical environment refers to the components through which people physically interact with the environment, while the behavioral environment refers to the components that connect employees and influence their behavior. He introduced “layout” and “comfort” as indicators of the physical environment and “interaction” and “focus” as indicators of behavioral environments affecting

productivity and presented a valid model for studies of productivity in office spaces (Fig. 1). Knowing what variables of office space are having the utmost impact on staff productivity helps architects and facility managers to design their work environment via acceptable cooperation. In the majority of studies, interaction has been mentioned as the most important factor affecting productivity in office spaces and then focus comfort, and layout (Haynes, 2007, 2008, 2009; Gensler, 2013, 2015; Samani, 2015).

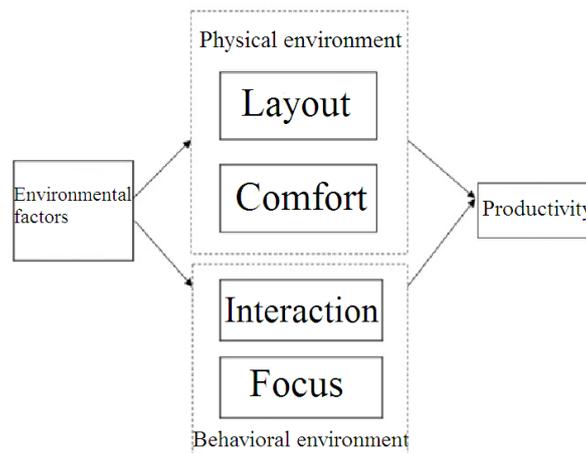


Fig. 1. Theoretical Research Framework for Studying Environmental Factors Affecting Productivity in Office Space
(Haynes, 2009)

The present study, in addition to testing the aforementioned theoretical framework, seeks to develop the concept of environmental impact on staff productivity and prioritize the effect of its variables according to Iran’s working environment. Also, in this study, we examine the effect of gender groups, educational degrees and job positions on the effect of these variables on productivity, as areas that have been underestimated so far, especially in Iran. The target population in this study is companies and organizations active in the field of information technology.

3. METHOD

Since the target population was the staff of the country’s

IT and e-commerce department (programmers, network engineers, system managers, sales managers, etc.), a questionnaire based on the Gensler Institute (2015) standard questionnaire as well as articles on the effect of office space design on productivity was used a structured manner to collect information more extensively and optimally (Leaman & Bordass, 1999; Haynes, 2007, 2008, 2009) and, using Google’s form technology, the questionnaires were provided electronically (online) and in Persian. The main purpose of this questionnaire was to examine the independent variables (layout, comfort, concentration, and interaction) and the research dependent variable (staff productivity).

On the other hand, since the target population was not exactly known, according to Morgan's table, we needed at least 384 respondents to validate our statistical framework, which fortunately was collected from 10 IT companies and organizations within two months through the questionnaire website. Table 2 shows the percentages of gender, age, academic degree and job position of respondents. The advantage of using an internet questionnaire (especially the free Google Forms service) is that it can be used to gather information and answer initial analysis and save a lot of time compared to the conventional method

(paper questionnaires). Likewise, using the online questionnaire made it possible to properly target the statistical population without worrying about their geographical distribution (IT companies) and to be able to communicate with them in their everyday language (Internet). According to the written and verbal feedback from the respondents, this was a factor in completing the questionnaires more quickly and accurately, and as we stated, one can observe the data analysis and the process of their formation as the questionnaires are completed.

Table 2. Percentage of Respondents by Gender, Age, Education and Job Position

Percentage (384 People)		
Gender	Male	42
	Female	58
Age	16-24	18
	25-30	38
	30-40	41
	40-50	3
	>50	1
Education	Associate Degree	6
	Bachelor	55
	M.A.	37
	Ph.D.	2
Occupation	Expert	67
	Manager of a Department	25
	Deputy	6
	CEO	2

The questionnaire consists of four key sections (45 questions). The first section (9 questions) collects personal information as well as general information about the work place and provides the frequencies of 4 variables of gender, age, education, and job position. As mentioned, these data are used to more closely examine the impact of independent research variables on productivity. The second part (6 questions) examines the working pattern and type of work offices of the respondents. The data obtained in this section help us identify the nature of employees' work, prioritize their environmental needs and analyze the impact of independent research variables. In the third part of the questionnaire, information on environmental variables affecting productivity (independent variables of layout, comfort, focus, and interaction) is collected based on a 5-point Likert scale (23 questions). Lastly, 7 questions (part 4 of the questionnaire) examine the effect of these variables on staff productivity as perceived productivity based on the 5-point Likert scale.

4. FINDINGS

Data were analyzed using IBM SPSS 22 software and statistical tests of correlation coefficient, independent T-test, analysis of variance and linear regression equations. Also, to complete and confirm the information obtained through questionnaires, field observations of some of the companies and organizations studied and interview with their employees were conducted.

4.1. Validity and Reliability of the Questionnaire Used

The validity of the questionnaire indicates whether the questions can measure the desired attribute and the reliability depends on the extent to which the measuring instrument yields the same results under the same conditions. The questionnaire was initially provided to a number of experts and managers of technology companies and its validity was confirmed in content. Reliability was calculated using Cronbach's formula. Valid values for the reliability of the questionnaire were those greater than 0.7. Here, for each of the research variables, this value was obtained, as listed in Table 3.

Table 3. Cronbach's Alpha Coefficient Of Research Variables

Variable	Number of Questions	Cronbach's Alpha	
Physical Environment	Layout	6	0.78
	Comfort	9	0.89
Behavioral Environment	Focus	5	0.85
	Interaction	3	0.78
Productivity		7	0.72

As the values in Table 3 show, the Cronbach's alpha coefficients for each of the 5 research variables were greater than 0.7 and the reliability of the questionnaire was confirmed. As a result, it can be said that the questionnaire items were able to measure the subject under discussion.

4.2. Working Pattern and Type of Work Office

The information obtained from the respondents' working pattern questions shows that they are mostly full-time employees working on software design and production and computer network management that require a great deal of focus along with interacting with their peers. Similarly, while in their office, they spend most of their time behind their desk and informal meetings with colleagues. Also, the data collected from the questions about the type of office space indicate that most of the respondents are working in open and semi-open office.

4.3. The Relationship between Independent and Dependent Variables

Correlation coefficient and linear regression models were used to investigate the significance of the relationship between independent and dependent variables.

4.3.1. Correlation Coefficient Test

Table 4 shows the correlation coefficients between the variables of productivity and the four variables of layout, comfort, focus and interaction and P-value. According to the P-value of each test and compared with 0.05, it can be said that all variables have a significant relationship with productivity. Now, considering the magnitude of the correlation coefficient, environmental variables with the most effect on staff productivity in the statistical population (IT industry staff) are concentration, comfort, interaction, and layout. respectively.

Table 4. Correlation Coefficients between Dependent Variable of Productivity and Independent Variables of Layout, Comfort, Focus, and Interaction

Relationship	Correlation Coefficient	P	Relationship Result
Layout - Productivity	0.220	0.000	Significant
Comfort - Productivity	0.379	0.000	Significant
Focus - Productivity	0.452	0.000	Significant
Interaction - Productivity	0.223	0.000	Significant

4.3.2. Linear Regression Model Test

To test the linear regression model, the following model is estimated:

$$Y_i = \alpha_0 + \alpha_1 A_i + \alpha_2 B_i + \alpha_3 C_i + \alpha_4 D_i + \epsilon_i \quad (1)$$

Where Y is the dependent variable (productivity) and

A (focus), B (interaction), C (comfort) and D (layout) are independent model variables for the hypothesis. The null hypothesis (H_0) and the alternative hypothesis (H_1) are expressed as follows:

$$H_0: \alpha_i = 0 - H_1: \alpha_i \neq 0$$

Table 5. Values of the Regression Model and F Statistic

Model	Sum of Squares	df	Mean of Squares	F	P
Regression	36.165	4	9.041	28.444	0.000
Residual	120.468	379	0.318		
Total	156.633	383			

Table 6. R, R², and Adjusted R² Correlations

Adjusted R ²	R ² (Coefficient of Determination)	Correlation R
0.223	0.231	0.481

Table 7. T-statistic Values of the Constant Variables

Model	α_i	Standard Error	t	P
Constant Coefficient	2.364	0.230	10.276	0.000
Layout	0.075	0.053	1.998	0.047
Focus	0.475	0.056	8.435	0.000
Interaction	0.102	0.051	2.050	0.039
Comfort	0.089	0.041	2.189	0.029

The value of F statistic (28.444) in Table 5 shows the overall significance of the regression fitted model at the error level of 0.05. The coefficient of determination of the model is 0.231 (Table 6). This indicates that about 23% of the changes in productivity gain are explained by independent model variables. The coefficient of estimation and t-statistic for all variables (Table 7) were statistically significant ($p < 0.05$) and the estimated linear relationship is as follows:

$$\text{Productivity} = 2.364 + 0.475 (\text{Focus}) + 0.102 (\text{Interaction}) + 0.089 (\text{Comfort}) + 0.075 (\text{Layout}) \quad (2)$$

4.4. Comparison of the Effect of Independent Variables on Productivity between Two Gender (Male and Female) Groups

Independent t-test was used to compare the effect of independent variables on productivity in male and

female sex groups. The hypotheses of zero and contrast for the test are as follows, where μ_1 and μ_2 are the mean of the test variables in the male and female groups, respectively.

$$H_0: \mu_1 = \mu_2 - H_1: \mu_1 \neq \mu_2$$

According to the values of Tables 8 and 9 and comparing P-value with 0.05, it can be concluded that the focus and layout variables were not significantly different between the two groups of males and females (values greater than 0.05) but it is different for the other variables for both males and females. So that the mean of comfort variable for males (3.216) was lower than females (3.388) and the mean interaction variable for male gender (3.557) was lower than the female gender (3.721). Similarly, the mean productivity variable for the male gender (3.590) is lower than the female gender (3.769).

Table 8. Mean and Standard Deviation of Independent and Dependent Variables in the Two Male and Female Groups

Variable	Gender	Number	Average	SD
Layout	Male	162	2.9694	0.86577
	Female	222	3.0941	0.57166
Comfort	Male	162	3.2169	0.68234
	Female	222	3.3885	0.66417
Focus	Male	162	3.4185	0.50871
	Female	222	3.3486	0.65638
Interaction	Male	162	3.5574	0.80168
	Female	222	3.7212	0.67867
Productivity	Male	162	3.5906	0.67467
	Female	222	3.7699	0.60293

Table 9. T-Value, Degree of Freedom, P-Value and Mean Difference for Independent and Dependent Variables in Two Male and Female Groups

Variable	T	df	P	Mean Difference
Layout	-1.697	382	0.091	-0.124
Comfort	-2.472	382	0.014	-0.171
Focus	1.130	382	0.259	0.069
Interaction	-2.162	382	0.031	-0.163
Productivity	-2.735	382	0.007	-0.179

4.5. Comparison of the Effect of Independent Variables on Productivity among Education Groups

To compare the effect of independent research variables on productivity in different educational groups analysis of variance was used.

Table 10 shows the frequency, mean and standard deviation of respondents' qualifications.

The null hypothesis and its alternative hypothesis are tested as follows:

H_0 : Employees' education degrees do not affect the extent to which independent research variables affect their productivity.

H_1 : Employees' education degree affect the extent to which independent research variables affect their productivity.

Table 10. Frequency, Mean and Standard Deviation of Respondents' Degree of Education

Degree	Count	Average	Standard Deviation
Associate Degree	21	2.754	0.792
Bachelor	211	3.751	0.608
M.A.	144	3.741	0.562
Ph.D.	8	3.860	0.010

Table 11. Analysis of Variance To Compare The Effect Of Environmental Factors On Productivity Among Different Education Degree Groups

	Sum of Squares	df	Mean Squares	F	P
Between Group	19.685	3	6.562	18.208	0.000
Within Group	136.974	380	0.360		
Total	156.633	383			

the P-value of Table 11 is significance at 0.05 level, which means that the degree of the staff is involved in the effectiveness of the independent variables of the research on their productivity and its effect from the highest to lowest is as follows: Ph.D., Postgraduate, Bachelor's and Master's degrees.

the effect of independent variables on productivity in different job positions.

The frequency, mean and standard deviation of the respondents' job position are shown in Table 12.

The null hypothesis and its alternative hypothesis for the analysis of variance analysis are as follows:

H_0 : Employees' job positions do not affect the extent to which independent research variables affect their productivity.

H_1 : Employees' job positions affect the extent to which independent research variables affect their productivity.

4.6. Comparison of the Effect of the Independent Variables on Productivity among Different Job Positions

Analysis of variance was used in order to compare

Table 12. Frequency, Mean and Standard Deviation of Respondents' Job Position

Occupation	Count	Standard Deviation	Mean
CEO	9	3.775	0.278
Deputy	24	3.737	0.636
Manager of a Department	94	3.789	0.614
Expert	257	3.652	0.656

Table 13. Analysis of Variance to Compare the Effect of Environmental Factors on Productivity among Different Job Positions

	Sum of Squares	df	Mean Squares	F	P
Between Group	1.396	3	0.465	1.139	
Within Group	155.237	380	0.409		0.333
Total	156.633	383			

According to the P-value of Table 13, the test is not significant at the 0.05 level, meaning that the

employees' job position has no effect on the extent of independent research variables on their productivity.

4.7. Information Obtained from Field Observations and Interviews

Field surveys of some of the surveyed companies and organizations and interviews with their staff show that most of the spaces according to traditional conditions, and the assumption that employees must be behind their desks and in their rooms at regular business hours have been designed and built. The result is that, according to observations and interviews with staff and senior executives, we often lack meeting rooms, while desks with more than 50 percent of office time are vacant.

Interviews with staff also show that people's ability to concentrate on office spaces is diminishing, and they prefer to concentrate outside the office or at home. On the other hand, most of them have more than one task and have to interact with their colleagues in their daily work, which is a double-edged sword, and, according to them, their workplace has failed to respond well to this need.

Interviews with staff designated that one of their needs was access to quiet spaces to be able to go there for a short time during the day and relax. They are also paid attention to their choice of time, place and how they do it, and see it as a positive factor in their productivity. In this regard, we can refer to research conducted at Cornell University on 320 small companies (2014). The results of this study indicated that those who give their employees the right choice in how they do their job receive up to four times job searches (recruitment) like many companies like others.

5. CONCLUSION

Statistical tests of correlation coefficient and linear regression model on research data confirmed the theoretical framework of research and it was found that environmental factors have a significant effect on staff productivity and four factors such as layout, comfort, interaction, and focus are environmental variables affecting productivity. This result was also found in other researchers' studies, but most of them focused on the interaction variable and then the focus (Haynes, 2008; Gensler, 2015) and the comfort variable was in the later stages, while the results of the present study prioritized The arrangement focuses on comfort, interaction, and layout. One response to this pattern may be to focus on the work of information technology activists (programmers, network engineers, and so on), which has prioritized focus. Another reason is the lack of standard design of office spaces in our country, especially for staff in this area. This has left the comfort needs of employees unavailable and suffering from temperature, light and noise problems, and after focusing on comfort, secondarily affecting their productivity, while in advanced countries, comfort issues The environment is one of the earliest resolved issues in the design of the work environment, which is why in the studies

conducted in these countries, the interaction of employees with each other has been ranked higher.

42% of the respondents were male and 58% were female. The largest number of women employed in the IT and e-commerce sector in the country (although according to official statistics, there are still more men in the field), as a reflection of the increasing number of female students in recent years in universities; needs a closer look at office designers and planners reveals the differences and preferences between men and women in office spaces and their impact on design, which is addressed in this research and is one of its achievements (Lack of these researches is evident in the design of office spaces, especially in the interior). Independent T-test for comparison showed that interaction and comfort variables effect on productivity is higher for women than men. Paying attention to this fact can be especially helpful in designing spaces where the workforce is predominantly women (such as call centers).

Analysis of variance showed that the staff's education degree is effective on the degree of influence of design variables on productivity and is highest for Ph.D. holders. This is especially important when designing spaces where most staff have this degree (such as advanced telecommunications and technology research centers) because they are highly sensitive to environmental issues, space layout, and any distractions. In these cases, it will have a more negative impact on their productivity.

Finally, regarding the importance of focus variable on staff productivity, it is suggested that adequate and effective staff space be provided when designing. These spaces should be functional, minimize noise levels, and have a beautiful and comfortable design. Today, long working hours, small spaces and distractions from new technologies threaten productivity in office spaces. Likewise, the tendency to use open plans in design is expanding, and in some cases, so much interaction is emphasized that focus is neglected. Designing large private spaces in open plans to avoid crowding and thinking is one way to counteract the effects of these kinds of plans on focus. Also designing spaces as a secondary work area so that if someone needs more focus to easily enter, close the door and accomplish their task, other ways to increase the focus on office space are.

On the other hand, it must be possible to engage without sacrificing concentration. This can be done by creating meeting rooms adjacent to the main space and not disturbing other employees. It is best to have meeting rooms in order to increase collaboration in a company or organization, open their doors or have glass walls. As a result, meetings for the whole organization are transparent and useful and knowledge is not limited to one point. Passers-by (employees passing by) can also sit, listen, and even participate in discussions for a while.

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