

**Promotion of Researchers' Creativity and Innovation in an Architecture
and Urban Design Research Center with Effective Spatial Aspects of
Offices**

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Abstract

Creativity and innovation are major drivers for developments of societies and nations. In this way, research activities have an extremely significant role whose promotion is strongly dependent on the creativity and innovation. There are several factors such as the built environment, which affect the creativity and innovation. This paper extracts a set of design rules for researchers' offices in an "architecture and urban design research center", which lead to the growth of researchers' creativity and innovation. The type of plan, namely open or closed plans, and spatial aspects of researchers' offices are investigated from the perspective of factors influencing the creativity and innovation. The spatial aspects, chosen based on the available literature, are privacy, beauty, spatial diversity/flexibility, and proximity/visibility. Additionally, four factors affecting the creativity and innovation consist of tranquility/physical comfort, motivation, creative thinking, and communication. The survey methodology, with a 26-question four-choice questionnaire, was adopted here for the sake of numerical studies. The sample group covered 91 faculty members and Ph.D. students associated with Architecture and Urban Design Departments of several universities in Tehran. The collected data has been analyzed through a statistical method, named repeated measure analysis of variance (RM-ANOVA), and the most affected creativity and innovation factors by spatial aspects are specified.

Key words: Creativity and innovation, spatial aspects, offices, architecture and urban design research center.

1. Introduction

In recent decades, the policy makers of countries have shown an increasing interest in the expansion of knowledge-based innovation and creativity decisions, which are driving forces for the development of countries. In addition, the main activities of governments and international organizations have been making policies toward expanding the social and economic efforts [1-8]. Creativity and innovation are happening in contexts such as universities and research centers. In a research center, there are lots of factors, such as the built environment, influencing the quality and quantity of creative and innovative outputs of researchers. Studying the organizational behaviors verifies the effect of physical

environment on the employees' satisfaction, efficiency, and motivation [9-11]. Research centers could be assumed as workplaces whose outputs are creativity and innovation and whose main resource is expert employees [12, 13]. Accordingly, it could be a feasible alternative to identify the set of appropriate attributes for a research center and consequently to design a physical environment with the objective of increasing the researchers' creativity and innovation.

So far, no comprehensive study has appeared in the literature about the architectural aspects of research centers and the creativity and innovation in these centers. To the best knowledge of the authors, the research conducted by Toker [14, 15] is the sole work focusing on the innovation in research centers. Toker concentrated on spatial configurations of research centers and emphasized on the face to face communication, as one of the essential factors in growth of the researchers' innovation. Toker utilized the space syntax and demonstrated the best layout among three various spatial configurations. This research, however, did not account for the researchers' satisfaction. Moreover, among various factors influencing the innovation, only the face to face communication was investigated.

This paper intends to determine the effective spatial aspects of offices with the objective of increasing the researchers' creativity and innovation. Among two classes of areas in a research center, namely private and public areas, private area, which mostly includes the working offices, is considered in this study. First, important factors affecting the creativity and innovation are identified. These factors are tranquility/physical comfort, motivation, creative thinking, and communication. In addition, spatial aspects considered here include privacy, beauty, spatial diversity/flexibility, and proximity/visibility. Then, based on data collected with the survey method, the important spatial aspects in increasing creativity and innovation are extracted. Additionally, the researchers' preference about the open or closed plans is reported. Various statistical metrics are presented and the obtained results are thoroughly discusses.

2. Creativity and innovation

Some researchers believe that creativity is a process leading to novel and useful ideas [16] and innovation is the successful implementation of those creative ideas [17, 18]. Evidently, knowing this process can develop and ease the creativity and innovation. Graham Wallas has presented one of the first models associated with the creativity process [19] which has the following four stages:

- 1- *Preparation*: stand preliminary tasks on the problem which concentrates the researcher's mind on the problem and exploring its miscellaneous dimensions.
- 2- *Incubation*: denotes when the problem is internalized into the unconscious mind and externally it seems that nothing is happening.
- 3- *Illumination or insight*: implies when the creative idea comes from unconscious mind to conscious mind.
- 4- *Verification*: is referred to when the idea is intentionally verified and then applied.

Some other researchers [20] believe that another stage called "implementation" could be added after the verification. Implementation means realizing the new idea and creating novel things. By this evolution, the creativity is converted to innovation.

As mentioned before, creativity and innovation are the results of a process. Accordingly, in order to raise individuals' creativity and innovation, the factors affecting this process could be boosted. Various and different factors influence each stage of the creativity and innovation process. For instance, in the stage of preparation, communication and creative thinking could have significant effects. Communication is one way of information flow and transferring knowledge [21-23], and creative thinking (or divergent thinking) is the capability of distinguishing differences between various data and exploring the best solution among all available [20]. Motivation is an underlying requirement in all stages of creativity and innovation process, particularly in the incubation stage [24, 25]. In the incubation stage, although individuals may be disappointed because nothing appears externally under happening, motivation helps them to not give up endeavor and to concentrate more on the subject. The most effective factor in illumination stage is the tranquility. Transferring an idea from the unconscious mind toward the conscious mind can be done easier if individuals have physical comfort and tranquility. In the verification stage, creative thinking becomes highlighted again since individuals are trying to introduce their idea, achieved in illumination stage, and make it easy to

comprehend. The last stage for innovation, namely implementation stage, necessitates group working and communication with other experts to convert the idea to product [26, 27].

As discussed above, several factors influence the creativity and innovation process consisting of creative thinking, motivation, tranquility/physical comfort, and communication. In this paper, these factors are considered as effective factors in creativity and innovation process; thus, the influence of each spatial aspect on these factors is going to be studied.

3. Open plan and closed plan offices

Offices in a workplace can be categorized into two classes: open plan and closed plan. Open plan offices are large rooms in which the employees work. Sometimes, the space of this type of offices is divided by some partitions; however, they still are one hall where employees work together. Closed plan offices are completely enclosed with dry walls and a door. A large body of research activities in the field of open plan offices has been conducted to their pros and also cons have been widely investigated.

Many studies have implied the benefits of open plan offices [11, 28-31]. The main claim of designers of open plan offices is to create a flexible space which can be diversely furnished by changes in size or organizational structure. Furthermore, these kinds of offices can reduce the cost [32]. In open plan offices, eliminating the obstacles increases employees' communication; as a result, their productivity increases as well [33-35]. Based on the new work patterns, which emphasize group working, low- hierarchical organizations, and increased communication [12, 36, 37], open plan offices seem to be appropriate choices in new workplaces.

On the contrary, open plan offices have disadvantages too which have been speculated in some studies. Among these points are the low level visual and acoustic privacy as well as more distractions and interruptions [11, 29, 30, 38-43]. Moreover, reducing employees' efficiencies [10, 31], job satisfaction, motivation, and privacy are other disadvantages of open plan offices [26, 31, 44, 45]. Other studies based on subjective reports of employees in open plan offices have illustrated that the irrelevant speeches result in lower productivity, more stress, and dissatisfaction of employees [10, 45-

49]. Nowadays, one of the main challenges of work system designers is to have a workplace in which the satisfaction of employees is guaranteed [50].

A number of solutions, such as implementing standing partitions, for the problems of open plan offices have been suggested in other works [11, 29, 51]. Partitions in open plan offices decrease distraction and increase privacy; however, they cannot remove all unwanted stimulations [11, 51-54].

Recently, open plan offices have been broadly used mainly due to their lower cost and other benefits. Felstead, Jewson, and Waters (2003) have reported an observation in the growth of development of open plan offices in Britannia, in a three year period. They also predicted that no decrease in this layout of workplace would happen [55]. However, the reality is against this prediction and the tendency is now turning to closed plan offices [56]. Cain believes that open plan offices decline employees' creativity and productivity because of low privacy. He declares that the best way of communication is what takes place in the midst of solitude such as the communication through the internet.

Based on aforementioned discussions, these questions arise: *Whether for all organizational tasks a unique type of office is appropriate or does it depend on the task? Do the cultural aspects affect the preference?* Answers to these questions need comprehensive and further studies. This paper intends to find an answer for a more limited question: *Which kinds of offices are preferred for Iranian researchers in an architecture and urban design research center?*

4. The impact of built environment on human being

Until 1960s, psychologists were mostly ignoring the effects of physical environment on human behavior. Since then, a significantly growing body of literature has appeared in the field of environmental psychology, confessing the relationships between human beings and their built environments [57, 58]. Nowadays, the fact that human behavior is influenced by physical environment is very obvious and widely accepted [58]. Consequently, a suitable context for a specific behavior could be provided by designing built environment with especial aspects.

As discussed in the literature review, there are lots of spatial aspects affecting those factors important in the creativity and innovation process such as privacy, beauty, spatial diversity/flexibility, and proximity/visibility. In the following, the effects of each special aspect on important factors in creative and innovative process are briefly reviewed:

- “Privacy” provides individuals’ tranquility and physical comfort. Also, it eases the concentration which can lead to the creative thinking [26, 59, 60].
- “Beauty” of a place promotes the tranquility and could lead to more physical comfort as well [61]. Beauty can increase individuals’ motivation to stay longer in the place [59].
- “Spatial diversity/flexibility” can afford various contexts for creative thinking [26]. Furthermore, owing to differences among individuals, such a place can provide more people with satisfaction and each individual can reconfigure the furniture. Additionally, the spatial diversity can increase individuals’ motivation to stay longer in the office according to answer larger domain of their needs.
- “proximity/visibility”¹ of people is the best way to increase their communication [59, 61, 63]. Accordingly, consideration of this spatial aspect can be effective in the creativity and innovation process. Moreover, the researchers’ motivation may increase by being informed of another’s condition.

5. An appropriate office for increasing the creativity and innovation in architecture and urban design research centers

Based on preceding discussions, it is assumed that spatial aspects of an office can influence the researcher’s behavior working there. This paper is going to find answers to below questions:

- 1- Which types of offices (open plan or closed plan) are preferred by Iranian architecture and urban design researchers?

¹ - In this paper “proximity” means physically being next to each other. For instance, researchers’ offices locate next to each other or they work in open plan offices. “Visibility” means that it is possible to see other researchers during the work. For example, imagine a window on the door of the closed plan office through which other researchers coming and going can see inside the office; or the layout of researchers’ desks in an open plan office are in an order let workers see each other during the work.

- 2- Whether or not and in what order the effective factors in the creativity and innovation process (tranquility/physical comfort, motivation, creative thinking, and communication) are influenced by each of spatial aspects (privacy, beauty, spatial diversity/flexibility, and visibility/ flexibility)?

5.1. Research method

The questionnaire-based survey method is adopted in this paper to collect the researchers' viewpoints about the type of office plan and the importance of spatial aspects. The statistical population in this research is architecture and urban design researchers. The sample group is 91 faculty members and PhD students of Architecture and Urban Design Departments of several governmental universities in Tehran. The questionnaire was designed in the four-point Likert scale¹ and has two parts: first part includes one question asking the researchers' preference about open plan offices or closed plan offices; and second part has 25 questions around the impacts of spatial aspects on effective factors in creativity and innovation process. For analysis of the data, the statistical method called RM-ANOVA² is employed. RM-ANOVA is a version similar to ANOVA; however in RM-ANOVA, the same group of people is questioned in different situations [64]. As in this study all questions have been answered by just one group; the RM-ANOVA method in the SPSS environment was employed.

5.2. Data Analysis and Discussion

The first question is about the researchers' preference of open plan offices; their answers have a mean equal to 2.13 with the standard deviation (SD) of .90. The mean value shows the researchers' disagreement with the open plan offices. However, the rather large SD, .9, declares the variety of researchers' opinions. Consequently, architecture and urban design researchers prefer closed plan offices against open plan ones.

¹- In four-point Likert scale, strongly disagree is scored 1, disagree is scored 2, agree is scored 3, and strongly agree is scored 4.

²-Repeated Measures Analysis of Variance: RM-ANOVA

In order to study the impact of spatial aspects on effective factors in creativity and innovation process, four sets of analyses are fulfilled in the following. These analyses are based on multivariate test and significant differences; a summary of software outcomes are outlined as well. The P-value under null hypothesis¹ is supposed .05. The null hypothesis is defined here as “there is no significant difference between the impact of spatial aspects of offices on different effective factors in the creativity and innovation process.” Hereafter, the factors affecting the creative and innovative process are called *effective factors* for short.

- 1- *The influences of “privacy” on effective factors*: The results of SPSS software shows that effective factors is impacted significantly differently by the spatial aspect of privacy because $F(2.28, 207.70) = 6.61, p = .001, \text{ and } \eta_p^2 = .068.$

Based on the numerical results given in tables “Descriptive Statistics” (table 1) and “Pairwise Comparisons”² (table 2), researchers believe that the impact of “privacy” is significantly more on the tranquility/physical comfort (mean=3.31, SD=.39) compared with motivation at $p < .001$ but not compared with the communication (mean=3.29, SD=.66). In the comparison of the tranquility/physical comfort with the creative thinking, a tricky point exists due to $p = .056$. This value is so close to the assumption of .05. Thus, it is decided to account for it as a moderate factor leading to a moderately higher impact of “privacy” on tranquility/physical comfort compared with creative thinking. Therefore, the creative thinking (mean=3.47, SD=.54) and the motivation (mean=3.08, SD=.85) are affected most and least by “privacy”, respectively.

- 2- *The influences of “beauty” on effective factors*: According to $F(2.37, 216.01) = 54.47, p < .001, \eta_p^2 = .37,$ “beauty” affects significantly differently the effective factors.

Referring to table 3, “Descriptive Statistics of the influence of beauty on effective factors”, and table 4, “Pairwise Comparisons of the influence of beauty on effective factors”, researchers believe that the impact of “beauty” is significantly higher on the

¹ The null hypothesis is in the opposite of research hypothesis. If the null hypothesis fails to approve, it means that the research hypothesis is confirmed.

² “Descriptive Statistics” and “Pairwise Comparisons” tables are from outputs of SPSS software. In all Pairwise Comparisons tables mean differences are significant in .05 and sig. shows P value. In addition, the “Bonferroni correction” is considered the adjustment for multiple comparisons.

tranquility/physical comfort (mean=3.70, SD=.47) compared with the motivation, creative thinking, and communication (all p s<.001). In addition, the effect of “beauty” is significantly lower on the communication (mean=2.62, SD=.74) compared with all tranquility/physical comfort, motivation, and creative thinking (all p s <.001). However, “beauty” does not have significantly different effects on the motivation (mean=3.33, SD=.57) and creative thinking (mean=3.29, SD=.81).

- 3- *The influences of “spatial diversity/flexibility” on effective factors:* According to the result, “spatial diversity/flexibility” affects significantly differently the effective factors, as $F(2.64, 240.49) = 27.03$, $p < .001$, $\eta_p^2 = .23$.

The tables 5, “Descriptive Statistics of the influence of spatial diversity/flexibility on effective factors”, and table 6, “Pairwise Comparisons of the influence of spatial diversity/flexibility on effective factors”, show, in researchers’ viewpoints, “spatial diversity/flexibility” has a significantly higher impact on the tranquility/physical comfort compared with all motivation ($p=.004$), creative thinking ($p=.016$), and communication ($p<.001$). Moreover, the importance of “spatial diversity/flexibility” is significantly lower in communication compared with motivation and creative thinking (both p s<.001). However, no significant difference is observed between the motivation (mean=2.69, SD=.91) and creative thinking (mean=2.83, SD=.65) at $p=.96$.

As a result, the researchers believe that the highest impact of “spatial diversity/flexibility” is on the tranquility/physical comfort (mean=3.08, SD=.66) and they almost disagree with the effect of this spatial aspect on communication, according to its mean.

- 4- *The influences of “proximity/visibility” on effective factors:* The ANOVA results in $F(3,273) = 48.87$, $p < .001$ and $\eta_p^2 = .35$ which means that there are significant differences between the impacts of “proximity/visibility” on effective factors.

Referring to table 7, “Descriptive Statistics of the influence of proximity/visibility on effective factors”, and, table 8, “Pairwise Comparisons of the influence of proximity/visibility on effective factors”, in researchers’ opinions, “proximity/visibility” has more effects on motivation (mean=2.72, SD=.91) compared with tranquility/physical comfort, creative

thinking (both $p < .001$), and communication ($p = .05$). Also, the importance of “proximity/visibility” was significantly higher in communication compared with the tranquility/physical comfort and the creative thinking (both $p < .001$). However, there are no significant differences between tranquility/physical comfort and communication ($p = 1.00$).

In this case, based on the researchers’ beliefs, the most significant impacts of “proximity/visibility” are on communication (mean=2.96, SD=.53) which was significantly higher than the other effective factors. The least significant impacts of this spatial factor was on tranquility/physical comfort and creative thinking which are not significantly different ($p = 1.00$). In fact, according to the means of tranquility/physical comfort (mean=2.13, SD=.88) and creative thinking (mean=2.03, SD=.76), the researchers disagree with the effect of “proximity/visibility” on creative thinking and roughly on the tranquility/physical comfort.

6. Conclusion

This paper exposed the impressive spatial aspects on researchers’ creativity and innovation through the viewpoints of architecture and urban design researchers. According to the result, researchers prefer closed plan offices for research, whereas open plan offices might be more effective in increasing the communication and interaction. As outlined in table 9, each spatial aspect, namely privacy, beauty, spatial diversity/flexibility, and proximity/visibility, mostly influences one of the effective factors in creative and innovative process, i.e., tranquility/physical comfort, motivation, creative thinking, and communication.

All things considered, “privacy” has the most effect on creative thinking in researchers’ opinion. This conclusion is consistent with the literature review outcome where the privacy was recognized as an essential requirement for the concentration which was, in turn, an important matter in creative thinking. Closed plan offices offer more privacy. In these kinds of offices, a built environment defines territories belonging to each researcher. The researchers can avoid unwanted interaction and conversation by closing the door of the office. In addition to social privacy, visual and acoustic privacy is important too. The offices should be acoustic to eliminate disturbing noises. Moreover, it is

pleasure if the office window has a view of nature and green space instead of crowded streets or parking lots.

The “beauty” of offices has the most impact on increasing the researchers’ tranquility/physical comfort. The mean of researchers’ score is the highest value among all outputs while its associated SD is relatively low. These results reveal the researchers’ complete agreement on the issue of beauty impacts on the tranquility/physical comfort. The beauty of an office can be obtained by suitable layout of furniture, selecting desired light colors, and personalizing the environment. Meanwhile, a window toward nature can increase the beauty of the office; even a picture of nature and green space can do the same.

Likewise beauty, “spatial diversity/flexibility” of offices has the most impact on escalating researchers’ tranquility/physical comfort. In other words, researchers feel tranquil and comfortable in a working office which has been designed with diversity and flexibility. Indeed, this spatial aspect is provided when the office could be rearranged according to researcher’s (user) taste and variety in different parts of the office is seen. For example, imagine an office where a desk, a chair, and a wardrobe are in a corner and a sofa, a coffee table, a green plant, and a bookcase are on the other side. Lighting is various there (variety). Moreover, furniture can be moved and arranged easily and the inside light can be increased or decreased by user (flexibility). This is a kind of diverse and flexible office. In contrast, imagine an office where a desk, a chair, a bookcase, and a wardrobe are laid out in a way to fill the rooms as little as possible, without any specific order. It is obvious that in the first office, researchers will have more tranquility and physical comfort. Diversity and flexibility of a place let researchers supply their various needs during the day ranging from sitting behind the desk and concentrating on the research to relaxing on the sofa.

"Proximity/visibility" of researchers’ offices has the most effect on communication. With attention to researchers’ preference for closed plan offices, the proximity/visibility should be afforded by designing the offices next to each other. In this way, researchers can see their colleagues by passing in front of their rooms, without distracting their privacy.

Accordingly, depending on various occasions, spatial aspects of researchers' offices in architecture and urban design research centers should be intentionally used as a set of means to elevate their creativity and innovation.

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Table 1. Descriptive Statistics of the influence of privacy on effective factors

Factor	Mean	Std. Deviation	N
Tranquility/physical comfort	3.3098	.39113	91
Motivation	3.0761	.85464	91
Creative thinking	3.4674	.54372	91
Communication	3.2935	.65529	91

Table 2. Pairwise Comparisons of the influence of privacy on effective factors

Objective (I)	Objective (J)	Mean Difference (I-J)	Std. Error	Sig.
Tranquility/physical comfort	motivation	.234	.086	.047
	Creative thinking	-.158	.059	.056
	Communication	.016	.083	1.000
motivation	Tranquility/physical comfort	-.234	.086	.047
	Creative thinking	-.391	.089	.000
	Communication	-.217	.118	.406
Creative thinking	Tranquility/physical comfort	.158	.059	.056
	motivation	.391	.089	.000
	Communication	.174	.087	.290
Communication	Tranquility/physical comfort	-.016	.083	1.000
	motivation	.217	.118	.406
	Creative thinking	-.174	.087	.290

Table 3. Descriptive Statistics of the influence of beauty on effective factors

Factor	Mean	Std. Deviation	N
Tranquility/physical comfort	3.7011	.46916	91
Motivation	3.3261	.56663	91
Creative thinking	3.2935	.80572	91
Communication	2.6196	.73891	91

Table 4. Pairwise Comparisons of the influence of beauty on effective factors

Objective (I)	Objective (J)	Mean Difference (I-J)	Std. Error	Sig.
Tranquility/physical comfort	motivation	.375	.060	.000
	Creative thinking	.408	.075	.000
	Communication	1.082	.088	.000
motivation	Tranquility/physical comfort	-.375	.060	.000
	Creative thinking	.033	.089	1.000
	Communication	.707	.087	.000
Creative thinking	Tranquility/physical comfort	-.408	.075	.000
	motivation	-.033	.089	1.000
	Communication	.674	.110	.000
Communication	Tranquility/physical comfort	-1.082	.088	.000
	motivation	-.707	.087	.000
	Creative thinking	-.674	.110	.000

Table 5. Descriptive Statistics of the influence of spatial diversity/flexibility on effective factors

Factor	Mean	Std. Deviation	N
Tranquility/physical comfort	3.0815	.65999	91
Motivation	2.6848	.91302	91
Creative thinking	2.8297	.64714	91
Communication	2.1304	.90441	91

Table 6. Pairwise Comparisons of the influence of spatial diversity/flexibility on effective factors

Objective (I)	Objective (J)	Mean Difference (I-J)	Std. Error	Sig.
Tranquility/physical comfort	motivation	.397	.113	.004
	Creative thinking	.252	.082	.016
	Communication	.951	.113	.000
motivation	Tranquility/physical comfort	-.397	.113	.004
	Creative thinking	-.145	.102	.963
	Communication	.554	.131	.000
Creative thinking	Tranquility/physical comfort	-.252	.082	.016
	motivation	.145	.102	.963
	Communication	.699	.110	.000
Communication	Tranquility/physical comfort	-.951	.113	.000
	motivation	-.554	.131	.000
	Creative thinking	-.699	.110	.000

Table 7. Descriptive Statistics of the influence of proximity/visibility on effective factors

Factor	Mean	Std. Deviation	N
Tranquility/physical comfort	2.1304	.87978	91
Motivation	2.7174	.90573	91
Creative thinking	2.0326	.76246	91
Communication	2.9601	.53416	91

Table 8. Pairwise Comparisons of the influence of proximity/visibility on effective factors

Objective (I)	Objective (J)	Mean Difference (I-J)	Std. Error	Sig.
Tranquility/physical comfort	motivation	-.587	.090	.000
	Creative thinking	.098	.095	1.000
	Communication	-.830	.095	.000
motivation	Tranquility/physical comfort	.587	.090	.000
	Creative thinking	.685	.098	.000
	Communication	-.243	.090	.051
Creative thinking	Tranquility/physical comfort	-.098	.095	1.000
	motivation	-.685	.098	.000
	Communication	-.928	.076	.000
Communication	Tranquility/physical comfort	.830	.095	.000
	motivation	.243	.090	.051
	Creative thinking	.928	.076	.000

Table 9. The most important factors in creative and innovative process through spatial aspects

Public areas spatial aspects	The most influenced effective factors in creative and innovative process
Privacy	Creative thinking
Beauty	Tranquility/Physical comfort
Spatial diversity/flexibility	Tranquility/Physical comfort
Proximity/visibility	Communication