

PLEA 2017 EDINBURGH

Design to Thrive

Exploring the influence of contemporary facade design on occupant satisfaction: a preliminary study in office buildings

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Abstract:

This paper describes the preliminary findings of a post-occupancy evaluation campaign conducted on contemporary and energy-efficient office buildings with different façades treatments. The aim is to investigate occupants' comfort and perceived productivity and to observe to what extent the space appearance and the façade design play a role in the ultimate user's satisfaction and overall comfort.

Two Swiss office buildings with different vertical enclosures are considered for this preliminary study: one has regular-shaped windows and regular blinds while the other presents a double-skin façade with a coloured silk-printed pattern partially covering the external pane and semi-transparent internal roller blinds. The results reported in this paper relate to an on-line extensive survey distributed among the buildings occupants to provide a global estimation of the comfort and perception they experience in their office.

Findings suggest that in case of high dissatisfaction with some environmental factors, these influence strongly people's overall comfort evaluation but not the self-rated productivity. However, when comfort ratings are less critical –though not optimal-, overall comfort as well as perceived productivity are more strongly correlated to the pleasantness of the space than to the environmental factors. Nevertheless, in the case of patterned glazing, the façade design has a low influence on comfort perception.

The study suggests that further research should be conducted, especially to look at façade designs that play a greater role in determining the appearance and/or a certain level of personal environmental control in a workspace.

Keywords: Façade design, Post-Occupancy Evaluation, Energy, Comfort, Perception

Introduction

In the last 20 years, comfort research in field studies has called the attention to the necessity to study human satisfaction in real contexts (Boardass, 2003) and to broaden the comfort debate from physiological to also psychological and behavioral aspects (Cole, 2008).

According to Meir et al. (2009), post-occupancy evaluation (POE) can play a role in determining “an acceptable balance between creativity and utility” in the building procurement process, by assessing if and how the design elements interact with elements of user satisfaction (including comfort). In the contemporary architectural context, this question is particular relevant if we think about the rapid advancement of façade design technologies in providing architects and engineers additional potential for the achievement of both high energy and aesthetic performance.

To our knowledge, the way comfort studies have looked at user satisfaction and behaviour under different façade systems has been indeed rather limited, and restricted to the consideration of single “conventional” façade components (regular-shaped windows

and common shading systems), being the factors explored in relation to indoor comfort normally the window dimension, the preferred configuration for window shading (generally venetian blinds, louvers or roller blinds), and the occupant behaviour in operating both windows and blinds. Very little is known about the possible implications that the aesthetics of a façade can have on the overall acceptability of an indoor space. This holds particularly true for unconventional work space façade solutions such as silk-screen printed glazing or patterned shading devices.

This paper shows the preliminary results of a POE campaign that is currently being conducted on different office buildings located in Switzerland. The objective of this POE is to explore whether there exists a correlation between people overall comfort or self-rated productivity and their rating of the space appearance, workspace adjustability and design factors in those buildings where the façade plays a prominent role in determining the aesthetics of the workspace and the personal control of the environment.

Methodology

Case studies description

The POE campaign was carried out in two Swiss office buildings. The criteria for the selection of the two case studies required them to be comparable in dimension, age of construction, occupation and function and to be designed according to energy-efficient principles. From an architectural point of view, although workspaces of the two buildings are comparable in terms of size, layout and furniture, they distinctly differ for the façade treatments: one (B1) has regular-shaped windows and typical horizontal metal venetian blinds (grey colour) while the other (B2) presents a double-skin façade with a coloured silk-printed pattern on the external pane and semi-transparent internal roller blinds (Figures 1 and 2). The buildings were both conceived to have fixed, non-openable windows. Following employees' pressing requests for thermal conditions improvement, operable windows were installed in B1. Occupants were however advised against opening them.

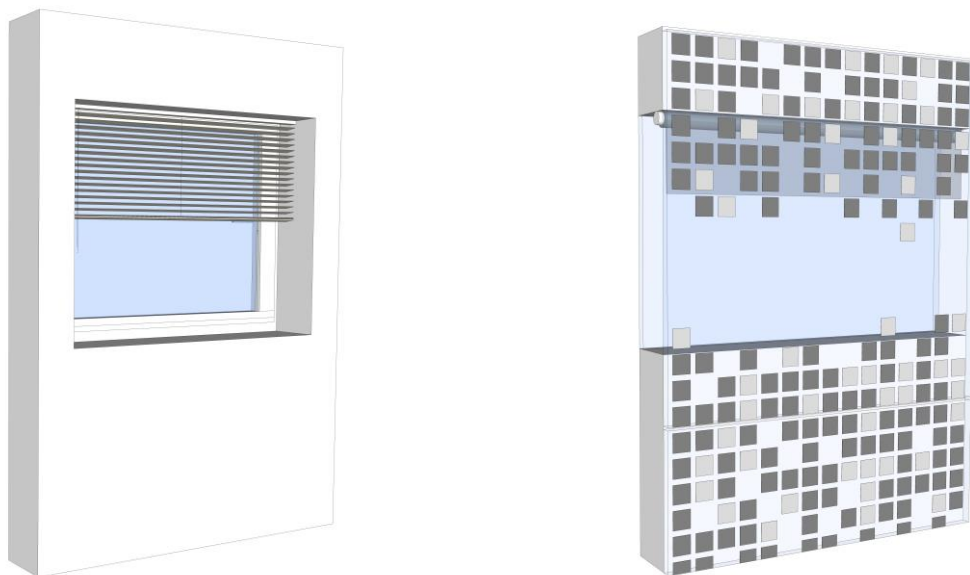


Figure 1. Schematic representation of the façade types used in the case studies: B1 (on the left) and B2 (on the right)

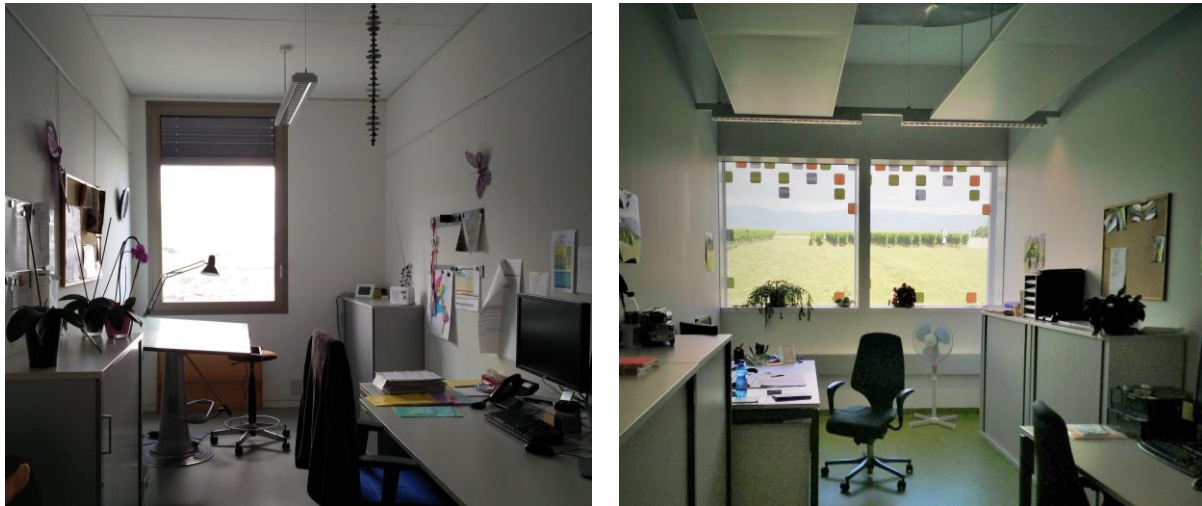


Figure 2. Examples of offices monitored during the POE in B1 (on the left) and in B2 (on the right) where the different façade treatments can also be noticed

Both buildings obtained the Minergie-P certification, a label attesting the high energy efficiency of new and refurbished buildings in Switzerland. This certification system relates primarily to the annual energy used by the building for heating, hot water and electrical ventilation, requiring air-tight building envelopes and the use of energy-efficient ventilation system. Particular attention is also paid to thermal comfort, especially to avoid the risk of overheating in summer. One of the two buildings obtained the additional “Eco” label, which resulted in further comfort criteria to be addressed with respect to light, air quality and protection against noise.

POE protocol

The post-occupancy monitoring was conducted along two weeks at the end of winter 2017. The POE protocol consisted of:

- A two-week environmental monitoring campaign: temperature and relative humidity data loggers as well as illuminance-meters were installed in some work spaces.
- Point-in-time environmental monitoring episodes: two point-in-time measurement campaigns per building were also performed for instantaneous recording of temperature, relative humidity, illuminance, luminance distribution and air quality.
- An on-line extensive survey: a questionnaire was sent to the buildings’ occupants to investigate the level of satisfaction they had experienced in the last 6 months (autumn-winter). The survey included 40 questions about the overall comfort and the indoor environmental quality (IEQ) factors (temperature, light, air quality and noise), the view to the outside, the perceived productivity and the personal environmental control (PEC) level. In addition, several non-environmental questions connected to design aspects and perception of the space were included in the survey. Responses were registered through a 7-point Likert scale. Additional open questions allowed the participants to add their own comments.
- Point-in-time surveys: along with the point-in-time measurements, occupants were also requested to give feedback about their instantaneous comfort within a short survey.

Table 1. Distribution of participants for the two buildings and the two surveys

Occupant responses	B1	B2	Total
Long-term survey	28	23	51
<i>Female</i>	11	14	25
<i>Male</i>	17	9	26
Point-in-time survey	40	32	72
Total	68	55	123

As shown in table 1, the groups of responses were comparable in terms of distribution of size and gender. The same protocol will be repeated during the spring-summer season in order to enable a full year evaluation.

In this paper only the responses of the long-term survey are analysed and commented.

Results from long-term surveys

Comfort factors

Figure 3 shows the distribution of occupants' satisfaction with the IEQ factors and overall comfort. With regard to the perceived overall comfort, in both buildings the portion of dissatisfied people was less than 50%. However, while in B2 64% of the occupants reported a satisfying opinion, this percentage is only 32% in B1 (more neutral answers than in B2).

Lighting was the only IEQ factor with a positive vote assigned by more than 50% of the respondents (68% in B1 and 55% in B2). Conversely, temperature and air quality were found to be the most critical factors in both buildings: despite the introduction of operable windows, 75% of people in B1 were dissatisfied with both temperature and air quality against the 41% and 50%, respectively, of occupants in B2. The main causes of dissatisfaction for thermal comfort reported in B1 were: not adequate temperatures (too hot or too cold) and not adequate air movements (too high or too low, air drafts vents). The most cited reason of dissatisfaction in B2 were: absence of personal control and not adequate temperatures. In both buildings the occupants referred to dry, stiff and smelly air when describing the main causes of dissatisfaction with air quality. Among the people dissatisfied with the acoustics (39% of people in B1 and 45% in B2), a significant majority attributed as reasons of discomfort the noise coming from the building systems and the presence of other people in the building. In addition, sound reverberation issues were also reported in B1.

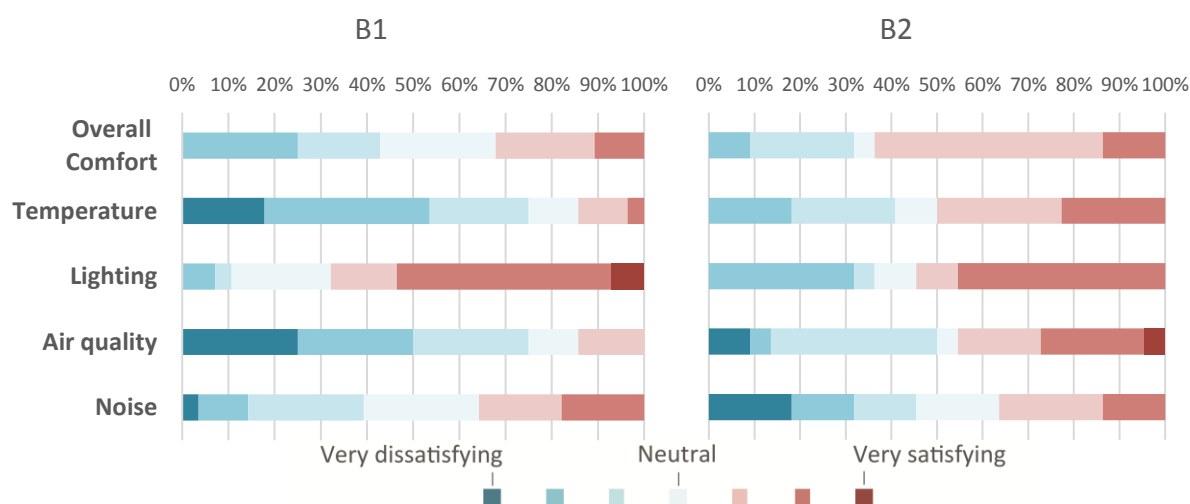


Figure 3. Occupants' ratings of IEQ factors and overall comfort in the two buildings

Design factors

Participants were also asked to give their opinion about the appreciation of some design aspects such as the layout of the office (e.g. space, furniture, storage...), the decoration and the building façade (Figure 4).

It resulted that around 40-60% of occupants appreciate in a certain measure the layout and/or the decoration of the work spaces in both buildings. Conversely, the façade rating was very different between the two group samples: 64% of respondents reported a positive vote in the building with the patterned façade, as opposed to the 7% only of the building with the conventional façade.

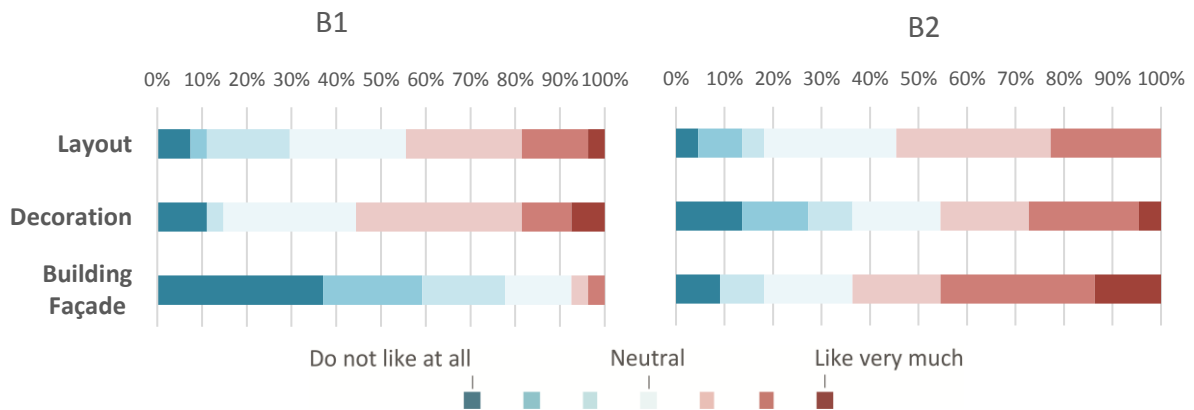


Figure 4. Occupants' ratings of design aspects in the two buildings

Participants were also asked about the general pleasantness of the space. To that question, respondents in B1 gave 57% of positive votes and 25% of neutral answers. In B2 11% more positive answers were counted (68% of satisfied) with 14% of neutral opinions.

Other factors

Figure 5 shows the distribution of votes with regard to other non-environmental factors such as the privacy level, the quantity and quality of the view to the outside and the personal control of the environment. Around half of respondents of the two case studies were satisfied with the privacy in their office. This percentage decreased when they were asked about the view to the outside (32% for B1 and 41% for B2) and dropped to just 14% and 5% when it came to the level of PEC. In particular, over 90% of the people in both buildings reported no or limited control on noise, temperature and ventilation, which is consistent with the related comfort rating.

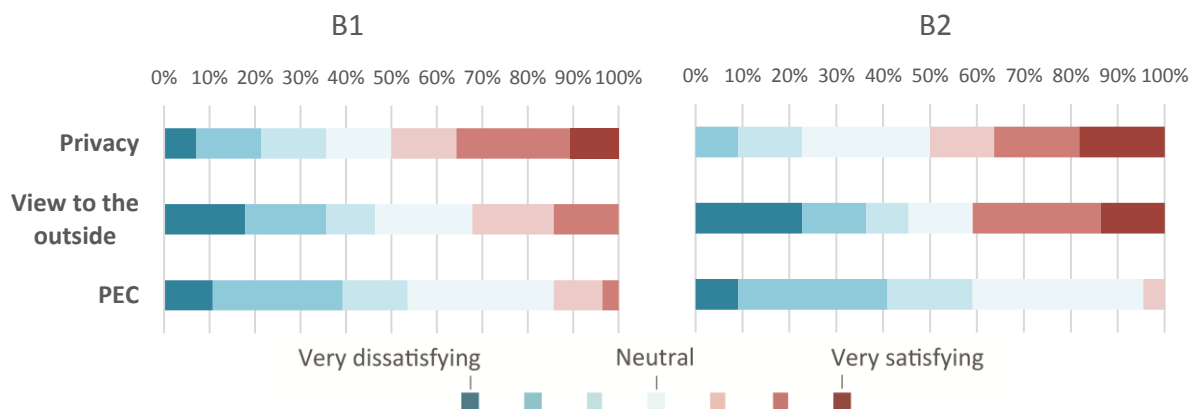


Figure 5. Occupants' rating of privacy, view to the outside and personal environmental control in the two buildings

Influence of variables on overall comfort and on self-rated productivity

A Spearman correlation was run to determine a possible relationship between overall comfort or the self-rated productivity and the other rated environmental and non-environmental factors. Spearman's r coefficient (r_s) is a measure for calculating the correlation between the two variables. The closer the r_s is to 1 the stronger the association, the more likely the effect of the given variable on the overall comfort or perceived productivity. In interpreting the outcomes, benchmarks were used to indicate low ($0.30 \leq r_s < 0.49$), moderate ($0.50 \leq r_s < 0.69$) and high ($0.70 \leq r_s \leq 0.89$) correlation (Asuero et al., 2009). Values of $r_s < 0.30$ were considered negligible, therefore excluding the variable to have any relevant effect. P-value was also calculated to assess whether the results were statistically significant, i.e. if the null hypothesis (no correlation between the factors; $r_s=0$), could be rejected. For this type of analysis a significance level = 0.05 is generally used, meaning that the null hypothesis is rejected when $p < 0.05$ and not rejected when $p > 0.05$.

As it can be observed in table 2, in B1 air quality is the only variable that is found to have a high correlation with overall comfort. Moderate correlations are found with decoration, PEC, layout, temperature and privacy, while low correlation emerged with the pleasantness of the space. These results reveal a strong influence on the overall comfort of the environmental factors perceived as the most critical and, conversely, of the design factors perceived as the most positive. The same factors don't seem to have any correlation with the self-rated productivity, except for a moderate influence of the pleasant space perception. Noise is also found to have a low influence on the productivity but not on the overall comfort.

In B2, where the comfort votes were more homogenous and less critical than in the other building, the pleasantness of the space appears as the most influential factor (high correlation) on the overall comfort but not on the perceived productivity. The office layout, PEC and noise have a moderate effect.

Despite the effect provided by the pleasantness of the space, the façade design seems to have no effect in the building with a conventional window design and a low effect in the offices with the partially patterned windows.

Table 2. Variables influence on overall comfort and self-rated productivity ratings for the two buildings. Spearman's r_s and p-value are shown (significance level $\alpha = 0.05$)

	Overall comfort				Self-rated productivity			
	B1		B2		B1		B2	
	r_s	p-value	r_s	p-value	r_s	p-value	r_s	p-value
Temperature	0.53**	0.004	0.38	0.082	0.22	0.246	0.32	0.151
Air quality	0.72***	0.000	0.03	0.869	0.07	0.731	-0.02	0.916
Light	0.25	0.205	0.46*	0.034	0.23	0.246	0.21	0.356
Noise	0.33	0.083	0.67**	0.001	0.38*	0.048	0.26	0.236
Pleasantness space	0.43*	0.022	0.74***	0.000	0.55**	0.003	0.34	0.119
Façade	0.020	0.918	0.41*	0.057	0.07	0.727	0.13	0.565
Layout	0.54**	0.003	0.52**	0.014	0.28	0.148	0.20	0.361
Decoration	0.57**	0.001	0.41*	0.058	0.30	0.122	0.33	0.133
View to the outside	0.13	0.497	0.356	0.105	0.00	0.980	0.34	0.124
PEC	0.54**	0.004	0.58**	0.006	0.28	0.115	0.28	0.207
Privacy	0.50**	0.007	0.087	0.699	0.01	0.939	0.32	0.151
Self-rated productivity	0.30*	0.041	0.53**	0.013				

* low correlation, ** moderate correlation, ***high correlation

A linear regression analysis (Figure 6) indicates the relationship between the pleasantness of the space on the overall comfort in the two buildings, although the boundary conditions for the application of this statistical model have not been verified yet.

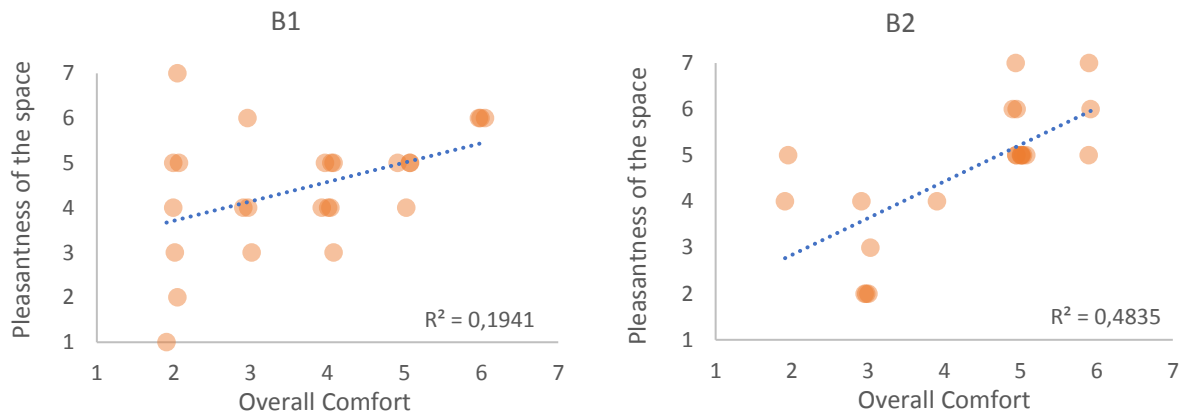


Figure 6. Linear regression model showing the relationship between overall comfort and pleasantness of the space

Conclusions

The study described in this paper is part of a broader POE campaign aimed at exploring building users' satisfaction in contemporary Swiss offices, with a particular focus on buildings where the façade can play a major role in determining the appearance and/or a certain level of personal environmental control. One of the premises for the buildings comparison is that they should respect some common high-energy design standards.

In this paper, the preliminary outcomes of an extensive comfort and perception survey distributed to people working in offices with a conventional façade system are analysed and compared with those of people working in a building with an unconventional façade system.

The first evidence that resulted from this study is that, despite the high energy design requirements, both the buildings seem to perform poorly in meeting users' expectation with comfort. Except for lighting, all the investigated IEQ factors obtained a satisfying score from less or equal 50% of respondents, with thermal comfort and air quality appearing as the main criticalities. This is particularly evident in B1, despite the adjustments provided to the windows to enable an increased personal control on temperature and ventilation.

Limitations in façade-dependant workspace adjustments, i.e. solar and natural ventilation control, are perceived by the majority of respondents as a factor of dissatisfaction, which is consistent with several comfort studies on green buildings (Wagner et al. 2007, Healey 2013) as a consequence of air-tight and mechanically ventilated sustainable design concept. This results also in a moderate correlation, in both cases, of PEC with the overall comfort but not to the self-rated productivity.

In line with previous studies about comfort, it was found that when users are particularly dissatisfied with some IEQ factors, these last play the main role in people's overall comfort.

However, the research showed that when comfort ratings are less critical, users appear to be happier with the overall comfort mainly when the space where their work

looks pleasant. Among the explored design factors, the layout of the space resulted as the one with the major influence, in line with existing studies (Schiavon & Altomonte, 2014; Leaman & Bordass, 2001; Baird et al., 2012; Frontczak et al., 2012; Kamaruzzaman et al., 2015). In the case of the patterned glazing, the façade design seems to barely affect people comfort perception, thus not providing any significant evidence about the influence of façade design on building occupants satisfaction.

Nevertheless, these first findings suggest the need for further research in this direction and confirm the necessity to account for a “re-contextualized notion of comfort” (Cole et al. 2008), as a state of mind where both environmental and non-environmental factors -including aesthetics- can have a key role for people’s satisfaction at work. In particular, these results encourage to explore situations where more “extremes” façade design configurations can be adopted. This would serve to assess to what extent an increased aesthetic presence can affect the users’ satisfaction with the workplace and to gain, as a consequence, a deeper and more comprehensive understanding to move towards optimal design.

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