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Elements of design in workplace environment
Pre and post studies

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Abstract
The aim of this paper is to investigate the impact of various design elements and spatial configurations on workplace environments using results from pre and post occupancy evaluations from different organisations studied in practice. The research contributes to the existing knowledge and studies in the field of architecture and interior design and proposes an evidence-based framework of design elements to be considered during the design stages of commercial buildings. The paper investigates how communication and collaboration in office environments are influenced by the shape and arrangement of furniture, workplace density, form of the floor plate, number of floors and elements of connection. These elements have a great impact on employees’ interaction and behaviour. Different organisations, studied in the past year, are investigated applying evidence-based design methodology. Pre and post occupancy data from direct observations of activities is used to understand behaviours. Spatial analysis using Visibility Graph Analysis (VGA) is applied to analyse the layout configuration. Results illustrate how the selected architectural elements could change behaviours and that different spatial parameters should be tested when designing an office layout.

Keywords
Workplace, evidence-based design, elements of design.
1. Introduction and Research Questions

Changes in the working culture have occurred in recent years and people are more likely to work remotely now in comparison to the past. However, having a physical space for employee encounters and interactions still remains valuable (Sailer, 2014). The physical office still plays an important role as a social space in bringing people together. Due to global market competition, organisations are investing in solutions to become more spatially efficient and looking into the physical facilities and individual tasks in order to generate an optimised social fabric and blueprint of opportunities for encounters within the office space (Wineman, 2007).

Occupancy and usage patterns in offices have been through a process of rapid evolution, driven partially by the advance in technology and by changing lifestyles and aspirations of the workforce (Penn et al., 1997). As a result, the work environment is being thought of as a place to support an organisation’s specific needs and spaces are being configured in diverse ways to boost productivity and collaboration.

Researchers and professionals from the space syntax community have shown that layout configuration has a great impact on structuring the patterns of global and local movement as well as employee encounter and interaction thus shaping the organisational culture (Penn et al., 1997; Sailer, 2009; Koch, 2012; Steen, 2009). According to Wineman (2013), metric distance was found to have a positive impact on organisation’s innovation; long metric distances facilitated serendipitous encounter, while short metric distance helped move production knowledge forward. Steen (2009) found that higher correlation with movement occurred on a global level, while locally, more interaction was happening with people sitting in more visible positions. Steen’s investigation on office buildings suggested that people located in the most visible positions were more likely to interact, thus interaction distribution was related to visual accessibility. These findings can be directly associated with the conclusion that “individuals, who are seen more often than others, are experienced as useful, and therefore, more recruited to interaction” (Penn et al., 1999).

In the light of these evidences, the aim of the paper is to investigate the impact of various selected design elements on movement and interaction in workplace environments using results from pre and post occupancy evaluations from two cases studied in practice. Of interest is whether furniture shape and arrangement, workplace density, form of the floor plate, number of floors and elements of connection could affect behaviours. This research will contribute to the existing knowledge and studies in the field of architecture and interior design with an evidence-based framework of design components to be considered during the design stages of commercial buildings.

2. Literature Review

“Architecture is a profession trained to put things together, not to take them apart. But no architect in their right mind would dare to write today an ‘Element of Architecture’ that intended to describe both what the components of architecture are and how they should be put together. (...) The fact that elements change independently, according to different cycles and economies, and for different reasons, turns each smoothness and bricolage – a complexity revealed in its full extent only by looking under a microscope at its constituent parts – the elements." (Koolhaas, 2014)

Intrigued by the 14th International Architecture Exhibition – Fundamentals - in the Venice Biennale (2014), when Rem Koolhaas stated the importance of design elements for the composition of occupied spaces and taking into consideration that spatial properties of the built environment drive people’s behaviour (Hillier,1996), the proposed framework focuses on how the following design elements influence workplace environment.

Furniture shape and arrangement are elements of design that compose workplace environment. Bafna’s (2007) investigation on workstation typologies found that a square-shaped workstation produces higher
integration than polygonal or hexagonal shapes; most importantly, “decisions that affect localized, but typical, repeated conditions in the plans can have predictable effect on the syntactical structure of the layout.”

Workspace density, or number of desks per floor, is influenced by the typology of furniture shape adopted. Increasing occupational density, utilisation, movement and exchange of ideas are key to designing dynamic spaces that allow a building to support more people in the same amount of space. In this sense, spatial efficiency, dynamism, high density, collaboration and productivity seem demand driven (BCO 2013). For instance by looking to Bafna (2007) research, according to the design arrangements generated, the hexagonal-type desk produced a layout with greater number of desks and less area, 8% less than the number of the square or polygonal type used in the comparisons developed.

The form of the floor plate, which presents the geometrical potential of the spatial structure of the layout, relates directly to the pattern of space utilised: movement, encounters, static activities, people’s interaction and relationship interfaces among different groups and hierarchies within an organization (Hillier, 1996; Shpuza and Peponis, 2007).

Element of connection – staircases – are infrastructural components that connect the various elements of a building. Going beyond this functionality, staircases are means for vertical conveyance (Koolhaas, 2014) and influence the social nature of human behaviour. ‘Sociality is about itineraries and trajectories of bodies meeting in space, from the studio to the office, from the exhibition up the staircase’ (Psarra, 2014). The existence and position of those elements have a great influence on people’s movement patterns. When there is a need to move from one place to another vertically, the staircase become an attractor as it drives the movement from any point of the floor to a specific location.

Number of floors in which an organisation occupies is another parameter to be taken into consideration as a factor of influencing employee interaction and occupancy, specifically, whether the organisation is divided across different floors or distributed throughout a single floor plate. One of Sailer’s (2010) studies about different organisations relocating to new building space highlight the impact of changing from four separated floors into a compact one. According to the pre-post evidence-based analysis, the overall density of desk occupancy increased (Pre: 38%, Post: 51%) and there was a slight improvement on the level of movement in the new office space. However, intensity of co-presence and interactivity decreased (Pre: 27%, Post: 12%) perhaps due to the distribution of activities within the large building and away from immediate desk areas.

3. Case Studies

Results from pre and post occupancy evaluation studies in two organisations were compared. The cases were selected because major configurational design changes took place in both companies.

Case study 1 is a PR agency which occupied a 5-floor building in central London. Lifts and a fire staircase connected the floors physically. The agency moved to a 2-floor building by cutting the number of desks by 20% from 337 to 268 and adopting agile working or hotdesking. The two floors were connected physically via an interior staircase located along the periphery of the building and visually via an atrium. The post occupancy study was conducted 12 months after the move. The main objective of the project was to create a more efficient and flexible space that would accommodate new ways of working, increase desk utilisation and improve communication amongst staff as well as increase movement.

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1 Agile working or hotdesking stands for working flexibly in terms of a place in the office. A definition of agile working was aired at the CoreNet Global Conference in Brussels in 2009: ‘Agile working is about bringing people, processes, connectivity and technology, time and place together to find the most appropriate and effective way of working to carry out a particular task.’
Case study 2 is a charity organisation which occupied 2 floors of a building connected via an atria space and an internal staircase. The office was refurbished and several major changes took place. The number of desks increased by 17% from 149 to 180 and 50 people were relocated from another building. The desk type and configuration were changed and new informal meeting spaces and tea points were accommodated. The client requested the removal of the internal staircase as it was spiral within an open atria and staff were not comfortable using it. However, the visual link created via the atrium was kept. Previously, the company held meetings either in the two meeting rooms located on each floor or outside of the building. During the refurbishment, the lower ground floor, which had been used as storage, was converted into a meeting room suite that connected to the other two floors via lifts and a fire staircase. The post occupancy evaluation was conducted 6 months after the refurbishment.

In summary, the number of floors in case study 1 was reduced and an interior staircase was accommodated making the environment physically and visually more connected. In contrast, an additional floor was introduced in case study 2 and the existing staircase was removed, creating a less physically connected workspace.

4. Methodology and metrics used

An evidence-based design\(^2\) approach was applied to understand the spatial and social phenomena occurring in the two organisations. Space syntax\(^1\) methodologies (Hillier and Hanson, 1984; Hillier, 1996) were applied to analyse the configurations of the buildings and direct observations of space use were used to study human behaviour.

Different space syntax measures such as integration (Sailer, 2009; Steen, 2009), mean depth (Sailer, 2010), metric distance (Wineman, 2013) or isovist and axial maps (Beck, 2013) were used to study floor plans of office buildings. In this study, the spatial metrics terminology used to analyse the configurational changes were ‘accessibility’, ‘visibility’ and ‘visual field’ and these were measured using mean depth\(^4\) and connectivity\(^5\). Accessibility, meaning the ease to approach or be approached, was defined by calculating the mean depth value of a building in depthmap\(^X\) (Varoudis, 2012) including every obstacle which would stop a person from going through the space e.g. interior walls, partitions and furniture. Visibility, defined as the ease to see or be seen, was calculated from a standing viewpoint, again using the mean depth values but analysing the floor plans without furniture. Visual field\(^6\) is a metric, which calculates the maximum visual field for a given area in percentage, which one could see in 360 degrees. It is calculated per floor plate based on connectivity. This is a proxy metric to compare floor shapes and will be elaborated upon in the discussion section.

Pre and post observations of activities were conducted for three working days in case study 1 and for five working days in case study 2 from 9:00 until 18:00. For each day of the data collection period, snapshots were completed at eight different times of the day and the following activities were distinguished: sitting, standing, moving, talking on the phone and interacting. Movement behaviours were observed for

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\(^2\) For a detailed discussion of evidence-based design see: Sailer (2008).

\(^3\) Space syntax is a method and theory to study how elements of a city or a building are interconnected in a system and how this reflects on social life. For example, the way in which rooms and corridors are connected influences people’s encounter and the relations they develop. Space syntax is a quantitative method based on graph theory. For more information see Hillier and Hanson (1984) and Hillier (1996).

\(^4\) Mean depth is a term used by the space syntax community and in general terms indicates how deep or shallow a node is in relation to the rest of the graph. For the calculation of mean depth (MD), the total depth (TD) of an element is identified through the number of steps that are needed to reach every other element in the spatial system. Then mean depth is calculated as \(MD = TD(n-1)\) where \(n\) is the number of nodes.

\(^5\) Connectivity measures the number of immediate nodes that are directly connected to a given node.

\(^6\) The visual field of a floor plate was calculated by taking the maximum connectivity value and dividing it by the total number of nodes.
case study 2 only. Two designated areas around the staircase on each floor were observed for an exact time period of five minute rounds and movement traces of people entering and exiting the areas were mapped. From the observations, data movement and interaction levels were calculated.

5. Analysis

*Case Study 1*

Looking at the spatial properties of the office (Figure 1), the change of five separate floors comprised into two larger floor areas facilitated the accessibility throughout by 27% (Table 1). The new place allowed people to be closer to each other, which improved their sense of awareness. Visibility was also enhanced and spaces were more visible by 25%. Similarly, the visual field increased by 3% meaning that the maximum floor area one can see from the highest visual node increased.

As a result of the substantial change of relocating to a new building, the dynamic of people’s behaviour shifted, creating new patterns of flow and activities. Movement levels and occupancy of communal spaces increased significantly (Table 2). The observed movement levels rose by 13% and occupancy of shared facilities by 14%. Additionally, within the workspace area, agile working implementation allowed an increase in desks utilisation of 12% on average. The organisational synergy was improved overall with 8% increase in levels of interaction. Communication among staff shifted from taking place mainly locally at their desks (reduction of 4% in post study) to around informal shared spaces (increase of 8% in post study). It is suggested that people now, not having ownership of desks, tend to use the provided shared spaces for collaboration rather than communicating locally at their desks as had occurred previously.

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average mean depth</td>
<td>6.3</td>
<td>4.6</td>
</tr>
<tr>
<td>Visibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average mean depth</td>
<td>5.52</td>
<td>4.13</td>
</tr>
<tr>
<td>Visual field</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connectivity of a single floor plate without partitions</td>
<td>77%</td>
<td>80%</td>
</tr>
</tbody>
</table>

*Table 1:* Pre and post values of spatial metrics for case study 1

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>NET area [sqm]</td>
<td>3,400</td>
<td>2,500</td>
</tr>
<tr>
<td>Number of desks</td>
<td>337</td>
<td>268</td>
</tr>
<tr>
<td>Workplace density [sqm]</td>
<td>10.1</td>
<td>9.3</td>
</tr>
<tr>
<td>Average desk occupancy</td>
<td>44%</td>
<td>56%</td>
</tr>
<tr>
<td>Average shared facilities occupancy</td>
<td>30%</td>
<td>44%</td>
</tr>
<tr>
<td>Movement levels</td>
<td>5%</td>
<td>18%</td>
</tr>
<tr>
<td>Interaction levels</td>
<td>34%</td>
<td>42%</td>
</tr>
<tr>
<td>Interaction at desks</td>
<td>18%</td>
<td>14%</td>
</tr>
<tr>
<td>Interaction informal spaces (informal meeting room, tea point, communal area)</td>
<td>6%</td>
<td>14%</td>
</tr>
<tr>
<td>Interaction formal meeting room</td>
<td>10%</td>
<td>14%</td>
</tr>
</tbody>
</table>

*Table 2:* Pre and post values of observational metrics for case study 1
Elements of design in workplace environment: Pre and post studies

Figure 1: Pre visibility (left) and accessibility (right)
Elements of design in workplace environment: Pre and post studies

**Case Study 2**

The inclusion of the lower ground floor and removal of the interior staircase added an extra level of depth to the overall environment (Figure 4) and decreased both accessibility and visibility levels by 38% and 50% respectively (Table 3). The visual field stayed the same since the floor plate of the building was unchanged.

After the refurbishment, the office occupancy increased by 11% for workplace areas and by 5% for communal spaces (Table 4). The new look and feel of the place as well as the additional shared facilities, created an office environment which better suited staff needs. The observed movement levels decreased by 2%, which is considered to be as a result of removing the interior staircase. Interaction levels rose by 14%, mainly because of the additional meeting room suite on the lower ground floor which raised communication by 10%. Interaction in shared facilities increased by 4% largely due to the new tea points (increase by 2%) and informal meeting spaces (increase by 1%). Interaction in workspace areas also increased, though only by 1%. In comparison to case study 1 where desk conversation was shifted to informal meeting spaces, a different phenomenon can be observed here. This is attributable largely to the improved layout, which, compared to the previous less structured and confusing desk configuration, is clean and structured.

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accessibility</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average mean depth</td>
<td>4.7</td>
<td>7.6</td>
</tr>
<tr>
<td><strong>Visibility</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average mean depth</td>
<td>3.4</td>
<td>6.8</td>
</tr>
<tr>
<td><strong>Visual field</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connectivity of a single floor plate without partitions</td>
<td>87%</td>
<td>87%</td>
</tr>
</tbody>
</table>

**Table 3**: Pre and post values of spatial metrics for case study 2
Elements of design in workplace environment: Pre and post studies

Table 4: Pre and post values of observational metrics for case study 2

<table>
<thead>
<tr>
<th>Metric</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>NET area [sqm]</td>
<td>1220</td>
<td>1500</td>
</tr>
<tr>
<td>Number of desks</td>
<td>149</td>
<td>180</td>
</tr>
<tr>
<td>Workplace density [sqm]</td>
<td>8.2</td>
<td>6.7</td>
</tr>
<tr>
<td>Average desk occupancy</td>
<td>37%</td>
<td>48%</td>
</tr>
<tr>
<td>Average shared facilities occupancy</td>
<td>29%</td>
<td>34%</td>
</tr>
<tr>
<td>Movement levels</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>Interaction levels</td>
<td>25%</td>
<td>39%</td>
</tr>
<tr>
<td>Interaction at desks</td>
<td>21%</td>
<td>22%</td>
</tr>
<tr>
<td>Interaction informal spaces (informal meeting room, tea point, communal area)</td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>Interaction formal meeting room</td>
<td>3%</td>
<td>13%</td>
</tr>
</tbody>
</table>

Figure 3: Pre visibility (left) and accessibility (right)
Elements of design in workplace environment: Pre and post studies

Figure 4: Post visibility (left) and accessibility (right)
6. Discussion

Referring back to the initial questions of how the elements of design and the configuration of the space itself affect behavioural user’s patterns, combined with what was observed in the different case studies, it can be suggested that:

Furniture shape and arrangement in case study 2, where the layout of space occupied before the intervention was composed by different furniture typologies, which resulted in a less structured environment. In the new space, one type of rectangular shaped furniture was adopted, which allowed a more structured and intelligible arrangement. It is argued that for this particular case the shape adopted not only enhanced employees’ perception, but also it allowed a higher number of units. This new arrangement permitted an increase of 9% in accessibility as well as 17% more desks, hence the new design allows higher efficiency.

By testing several layout options with distinct furniture shapes – long bench, singular rectangular, chamfered - distributed across same generic floor plate (Figure 5), it was possible to confirm the impact these objects had on density and accessibility. Taking this exercise into consideration case study 2 had a different configuration. The hexagonal option (MD: 2.36) in case study 2 allows higher accessibility with lower desk number (45 desks) than the rectangular one (MD: 2.57 / 50 desks). It can be argued that spatial efficiency depends on both the object typology and the form of the floor plate available; therefore, it varies case by case.

Workspace density decreased in both case studies presented, meaning there was less area available per employee in comparison to the pre occupancy ones. The rise in the number of desks was possibly due to the following factors: first, pre occupancy figures for both organisations indicated that less than 50% of the people were present in the office at the same time. Second, agile working was adopted in case study 1, which provided shared desks to staff; and lastly, there was a change in furniture shape, hence, number of units for case study 2. From an economic perspective, this approach resulted in beneficial cost-savings.

The form of the floor plate itself was assessed by the visual field and visibility metric which are both useful tools to address how the outline of the building impacts people’s visibility. In both cases, a different layout shape affects the percentage of what one can see.
Comparing the different building footprints (Figure 6), floor plate 3 in case study 2 has a higher percentage of visual field (87%) and lower visibility (MD: 1.31) than floor plate 1 and 2 in case study 1.

The organisation in case study 1 benefited from moving to a more visible floor plate compared to the building they were previously occupying. In case study 2, the impact on visibility was due to the location of internal partitions rather than the outline of the building as the organisation was kept in the same place.

![Floorplate 1](image1)
![Floorplate 2](image2)
![Floorplate 3](image3)

**Figure 6: Visibility of floor plates**

<table>
<thead>
<tr>
<th>Floor plate 1</th>
<th>Floor plate 2</th>
<th>Floor plate 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual field = 77%</td>
<td>Visual field = 80%</td>
<td>Visual field = 87%</td>
</tr>
<tr>
<td>MD = 1.53</td>
<td>MD = 1.41</td>
<td>MD = 1.31</td>
</tr>
</tbody>
</table>

Number of floors; Case study 1 reveals the effect of splitting the organisation into spaces across levels. Individuals moved from occupying five different floors to occupying two floors. This redistribution resulted in the accessibility, which is reflected by the increase of mean depth (Table 1), as well as visibility and accessibility (Figure 1 and 2). This spatial change allows greater proximity; people, in this case, became closer to each other, affecting the global communication of the organisation. Thus, higher levels of interaction were recorded overall in various spaces.

Element of connection presented in case study 2 was shown to play an important role on driving the pattern of movement on the floors, and consequently the levels of unplanned encounters. The implication of taking out the staircase, which was the core element of connection across floors, resulted in a reduction of movement levels overall. If the internal staircase was kept or perhaps relocated to a more central point on the plan, people’s flow may have increased, and hence, probabilistic co-presence and encounter as well as desk interaction.

7. Conclusion

This paper aimed to analyse the impact of various design elements on behaviour in workplace environments. From the evidence-based investigations, it was found that five architectural parameters were directly associated with specific outcomes:

1) Furniture shape and arrangement impacted the spatial efficiency of an office environment;
2) Strategic workplace density resulted in beneficial saving costs;
3) The form of the floor plate had an effect on user’s visibility;
4) The number of floors affected accessibility and communication across organisation;
5) In relation to the previous parameter, the elements of connection (staircases) increased movement levels overall and interaction.
This research sets out being a valuable contribution to designers, and architects who work in the field of workplace design, where various architectural details play a role in the user’s behaviour.

Taking all into consideration, different spatial parameters should be tested when designing an office layout. A ‘one size fits all’ approach is not applicable. Designing a workplace environment requires a bespoke and robust methodology to support more efficiently the organisation’s needs.

Further lines of enquiry are needed due to the limited number of cases assessed. Owing to the lack of references, future studies could delve more deeply into the effect of furniture shape and layout arrangement as well as floor shape of office buildings.

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