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ABSTRACT

Increasing productivity, stimulating knowledge sharing and satisfying employees. Three objectives which are heard quite often during the design phase of an office. Both latter objectives are often perceived as ways to increasing productivity as well. The Center for People and Buildings (CfPB) in Delft, The Netherlands, has conducted a number of case studies into employee satisfaction with the working environment and perceived productivity – i.e. the extent to which employees appraise the physical environment of the office as supporting their productivity.. This paper focuses on physical characteristics of the office that might influence the perceived productivity. According to our data (over 10.000 respondents from 71 case studies), the ability to concentrate has a substantial influence on the perceived productivity in general, as well as of the individual, the team and the organisation. Respondents that are more satisfied with the ability to concentrate are also more likely to experience the workplace as supportive for their productivity. The possibility to communicate only has impact on the perceived team and organisational productivity. According to the results, employees rate the general productivity primarily on the basis of their individual productivity, rather than team productivity or organisational productivity. In connection to work processes it appeared that for particular work processes employees judge the functionality and comfort of the workplace as most important in affecting their perceived productivity. These research findings may help facility managers in dealing with workplace design and workplace management. It gives the facility manager a solid input to decision making about the best possible office concept by taking into account the preferences of employees.

Keywords

Productivity, employee satisfaction, work environment, work processes.

The influence of the workplace on perceived productivity

1. INTRODUCTION

Productivity is an important factor in every organisation. Profit and loss depend to a large extent on labour productivity, i.e. how productively employees work. Although public organisations are not about profit and loss, costs are undoubtedly important in this sector. In the Netherlands, the government needs to cut down costs drastically by making the own organisation more efficient. The physical environment is one tool which can be used to exert a positive influence in that respect. Various studies have found that aspects such as openness, noise, lighting and temperature can affect productivity.

For instance, a number of publications (e.g. Lan et al., 2010; Niemela et al., 2002) have revealed that temperature has an effect as long as the task concerned lasts at least 60 minutes (Lorsch and Ossama (1994) in Lan et al., 2009). In one experiment, Lan et al. (2010) investigated the impact of three different indoor temperatures (17°C, 21°C and 28°C) on productivity. They found that employees felt slightly uncomfortable in both the coolest and warmest of these climates, that they were less motivated and that they experienced their workload as more onerous, with a consequent decline in productivity. These results tie in with those from a study by Niemela et al. (2002), which found that a temperature higher than 25°C adversely affects productivity.

A study by Barber (2001) attempted to ascertain what employees consider to be the most significant aspects affecting their own productivity. This survey found that aspects regarding technology, storage space, quiet space, climate control, personalising the workspace and its visual appeal were the most important factors. A study by Hameed and Amjad (2009) on “office design factors” such as furniture, noise, lighting, temperature and spatial arrangements revealed lighting as having the greatest impact on staff productivity, followed by spatial arrangements.

Block and Stokes (1989) also found that the layout of an office influences productivity, with the extent of influence depending on the kind of work being undertaken. People carrying out difficult tasks are happier in private offices, and also perform better, than in non-private offices. Conversely, employees performing simple tasks perform better in non-private settings. Working in an open-plan office can, however, lead to distraction and disruption, which have a negative effect on performance (Hedge, 1982).

According to Penn et al. (1999), office layout directly affects the frequency of interaction with coworkers. People seated in the immediate vicinity of one another have more face-to-face contact (Keller and Holland, 1983). Backhouse and Drew (1992) discovered that 80 per cent of meetings between colleagues occur spontaneously – when, for example, they encounter each other by chance in a corridor or the staff canteen. Although communication is not the same as productivity, organisations often assume that the former promotes the latter. Collaborative learning can have a more positive effect than individual learning on deep learning of complex cognitive tasks (Kirschner et al., 2009), and according to Strubler and York (2007) collaboration can lead to an enhancement of productivity.

Brill and Weideman (2001) found that spatial arrangements favouring spontaneous interaction are extremely important to productivity. Another factor they highlight as significant is the ability to work individually, without distractions. Meanwhile, Haynes (2007) states that interaction and distraction are the behavioural aspects of the work environment with the greatest impact upon self-assessed productivity. Another study by Haynes (2008) looked at the extent to which the work processes of employees play a part in their productivity. Having defined four work patterns in terms of autonomy and interaction, this examined how the environmental factors of comfort, office layout, interaction and distraction affected perceived productivity, either positively or negatively. Interaction was considered by all groups as having the most positive effect, but especially so by the “transactional knowledge” workers. All groups regarded distraction as adverse to productivity.

Knowing which aspects of the office environment are most conducive to productivity can help architects and facility managers to design workplaces accordingly. Although various studies

have examined how particular environmental factors influence employee productivity, there is still little understanding of how much their effects are interrelated. Whilst it seems that opportunities for communication and concentration are especially important, there are also indications that other factors – such as indoor climate and workplace layout – play a significant role as well. Moreover, so far there has been little research looking specifically at factors influencing the extent to which various aspects of the *work environment* are thought to encourage productivity. This research will seek to identify whether satisfaction with aspects of the work environment can predict the extent to which the work environment supports the perceived labour productivity, which in this paper is referred to as productivity.

We expect satisfactory opportunities for communication and concentration to be key predictors of support for productivity. Furthermore, we also expect that employee work processes will be significant in determining how their satisfaction with environmental factors affects that perception. For this reason, we shall be investigating the influence exerted by work processes.

Before testing these two hypotheses, however, we look first at which form of specific productivity – individual, team or organisational – plays the biggest part in determining how much a work environment supports overall productivity. This we expect to be predicted primarily by individual productivity and to a lesser extent by that of the team or organisation.

2 METHOD

This study uses a dataset collected by the Center for People and Buildings (CfPB) in the Netherlands by means of its Work Environment Diagnosis Instrument (WODI; Maarleveld et al., 2009), a standardised tool developed to measure employee satisfaction with the work environment. The complete set consists of information gathered from 10,192 respondents from 71 different surveys at 21 organisations (Table 1). Our analysis is based on data obtained from 2007 to 2010 using the short version of the questionnaire. This version is known as WODI Light, and contains 39 questions.

Table 1. Respondents by gender, age, education and sector

		Percentage of whole sample (<i>n</i> = 10.192)
Gender	Male	62%
	Female	38%
Age	<31 years	12,4%
	31-40 years	24,8%
	41-50 years	33,3%
	51-60 years	26,9%
	> 60 years	2,5%
Education	Secondary	10,1%
	Vocational secondary	21,1%
	Undergraduate	33,5%
	Postgraduate	33,5%
Sector	Other	1,8%
	Public sector	83,8%
	Higher education Commercial	13,2% 3,0%

Four questions measure the extent to which the work environment supports productivity. One of these is a direct request to assess the level of support on a ten-point scale, with “1” being the most negative score and “10” the most positive. The other three use a five-point scale to

gauge how well the work environment supports personal, team and organisational productivity respectively. Another 21 questions cover satisfaction with the organisation, the job, the building as a whole, the immediate working environment, privacy, the workspace, concentration, communication, archive facilities, ICT, the indoor climate and facilities. All are answered using a five-point Likert scale, ranging from very dissatisfied (1) to very satisfied (5).

Yet another question is designed to reveal the activity patterns of respondents: they are asked to state the percentage of their working time they devote to each of nine activity categories. These answers have been subjected to a two-step cluster analysis in order to generate four activity clusters (Table 2).

Table 2. Mean percentage of time that is spend on the mentioned activities per cluster

Activity clusters	Cluster 1 (meetings)	Cluster 2 (desk work concentration, reading)	Cluster 3 (desk work interaction, telephone)	Cluster 4 (general desk work)
<i>n</i>	1649	945	602	1571
% general desk work	18,87	14,93	19,81	57,67
% desk work concentration	12,21	30,04	7,69	6,07
% desk work interaction	14,61	10,91	23,43	9,99
% planned meetings	21,71	8,28	6,18	6,74
% unplanned meetings	12,44	5,21	4,15	3,90
% telephone use	6,96	5,60	18,20	5,42
% reading	5,53	12,41	3,04	3,09
% document management	3,99	8,72	4,22	3,76
% other	3,68	3,91	13,28	3,38

Meetings, both planned and unplanned, are a relatively prominent component in the first of these clusters when compared with the others. The second features a relatively high proportion of desk work which requires concentration and reading. The third is characterised by desk work involving interaction, use of the telephone and other activities. Predominant in the fourth cluster is general desk work.

A multiple regression analysis was performed to see whether the overall rating of productivity support (the direct question answered on a ten-point scale) is predicted primarily by support of individual, team or organisational productivity. In this case the overall rating is the dependent variable and the answers to the other three questions are the independent variables.

Further multiple regression analyses were carried out in order to establish how much satisfaction with aspects of the work environment predicts support of overall productivity and of individual, team and organisational productivity respectively.

To find out whether the results vary according to employee activity patterns, each individual activity cluster also underwent the same set of analyses.

Finally, all multiple regression analyses were subjected to tests for collinearity (tolerance and variance inflation factor, VIF) so as to gain an insight into the correlation between the independent variables. Because the respondents were not obliged to answer all questions, their absolute number may vary in each case.

3 RESULTS

3.1 Individual, team and organisational productivity as predictors of general productivity

The support ratings for individual, team and organisational productivity are all significant predictors of those for overall productivity. The adjusted R square is 0.570 (Table 3). The predictor variable with the greatest impact upon the overall rating is individual productivity (B = 0.897).

Table 3. Types of productivity as predictors of overall productivity

	Support of productivity
<i>n</i>	7394
Support of individual productivity	0,897
Support of team productivity	0,303
Support of organizational productivity	0,375
Adjusted R Square	0,570

The table shows the B-values which are significant ($p \leq 0,05$)

The regression analysis produces a significant model ($F_{3,7390} = 3262.028$, $p = 0.000$). In this analysis, the tolerance level is never less than 0.320 and the maximum VIF value is 3.120. It can therefore be assumed that there is not a high degree of multicollinearity.

3.2 Aspects of the work environment as predictors of productivity

The extent to which aspects of the work environment determine its support of overall productivity is approximately 56 per cent (R square = 0.561; adjusted R square = 0.557). Moreover, the declared variance in that environment's support of *individual* productivity is also fairly high (adjusted R square = 0.474). The declared variance is lower in the responses to questions concerning support for *team* (adjusted R square = 0.371) and *organisational* (adjusted R square = 0.361) productivity (Table 4).

Levels of satisfaction with opportunities to concentrate (B = 0.300) and the functionality and comfort of the workplace (B = 0.284) are the predictor variables with the greatest impact upon how much the work environment is supporting overall productivity. These are followed by number, variety and functionality of workspaces (B = 0.198) in third place, and by privacy (B = 0.190) in fourth (Table 4).

Opportunities to concentrate (B = 0.234) and workplace functionality and comfort (B = 0.137) are also the most influential predictor variables in the case of *individual* productivity. When it comes to support for *team* productivity, the leading variable is opportunities for communication and social interaction (B = 0.102). And for *organisational* productivity, satisfaction with the organisation itself has the most impact (B = 0.101) (Table 4).

Table 4. Aspects of the work environment as predictors of productivity.

	Support of productivity	Support of individual productivity	Support of team productivity	Support of organisational productivity
<i>n</i>	2402	2415	2359	2366
Organisation	0,140	0,045	0,086	0,101
Content and complexity of work tasks				
Sharing own ideas about working environment	0,142	0,087	0,071	0,075
Accessibility of the building			-0,051	-0,032
Architecture and appearance of the building				0,037
Subdivision of the whole building	0,108			
Number, diversity, and functionality of spaces	0,198		0,081	0,054
Adjacency and locality of the spaces			0,047	
Openness and transparency of environment	0,080	0,047	0,047	0,054
Functionality and comfort of the workspaces	0,284	0,137	0,071	0,049
Interior design appearance and ambiance		0,069	0,061	
Privacy	0,190	0,063	0,070	0,036
Opportunities to concentrate	0,300	0,234	0,087	0,075
Opportunities to communicate			0,102	0,066
Archive and storage facilities		0,060	0,047	0,062
ICT and ICT supporting services				
Facilities and facilities management				
Indoor climate	0,091			
Lighting				
Acoustics	0,137	0,067	0,055	0,080
Opportunities for remote working				
Adjusted R Square	0,557	0,474	0,371	0,361

The table shows the B-values which are significant ($p \leq 0,05$)

The four regression models are significant (score for support of overall productivity: $F_{21,2380} = 145.034$, $p = 0.000$; for support of individual productivity: $F_{21,2393} = 104.489$, $p = 0.000$; for support of team productivity: $F_{21,2337} = 67.293$, $p = 0.000$; for support of organisational productivity: $F_{21,2344} = 64.649$, $p = 0.000$).

In the four regression analyses, no tolerance levels lower than 0.421 and no VIF values higher than 2.377 were found. From this we can assume that there is no problem of multicollinearity.

3.3 Work processes

In each activity cluster, approximately half of the extent to which the work environment influences overall productivity is predicted by satisfaction with aspects of that environment

Table 5. Influence exerted by work processes over environmental factors predictive of productivity

	General support of productivity				Support of individual productivity				Support of team productivity				Support of organisational productivity			
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 1	Cluster 2	Cluster 3	Cluster 4
<i>n</i>	669	443	193	626	677	444	193	626	670	430	186	608	667	436	189	612
Organisation	0,14	0,17	0,35	0,28	0,09	0,09				0,10	0,19	0,14	0,11		0,17	0,15
Content and complexity of work tasks			-0,2												-0,15	
Sharing own ideas about working environment	0,12	0,17	0,22	0,15	0,07	0,10		0,14		0,10		0,1	0,07	0,09	0,10	0,09
Accessibility of the building	0,13															
Architecture and appearance of the building						-0,10	0,15									0,09
Subdivision of the whole building				0,16												
Number, diversity, and functionality of spaces	0,28		0,32						0,09	0,17			0,10		0,22	
Adjacency and locality of the spaces												0,11				0,11
Openness and transparency of environment	0,17															
Functionality and comfort of the workspaces	0,17	0,41	0,38	0,2	0,16	0,14	0,21		0,04	0,09	0,17		0,07			
Interior design appearance and ambiance						0,12		0,12	0,08							
Privacy	0,18	0,26		0,18						0,12		0,10		0,11		
Opportunities to concentrate	0,26	0,34		0,29	0,30	0,27		0,19	0,12	0,11		0,08	0,08			0,08
Opportunities to communicate									0,12			0,14			0,16	
Archive and storage facilities																0,07
ICT and ICT supporting services																
Facilities and facilities management																
Indoor climate	0,15															
Lighting															-0,09	
Acoustics	0,15	0,18		0,15	0,09			0,09		0,09			0,07	0,17		
Opportunities for remote working																
Adjusted R Square	0,602	0,592	0,495	0,560	0,546	0,553	0,460	0,410	0,379	0,456	0,423	0,366	0,403	0,406	0,499	0,352

The table shows the B-values which are significant ($p \leq 0,05$)

(adjusted R square ≥ 0.495 , ≤ 0.602 ; Table 5). Which aspects are most significant varies by cluster, as does the extent of their impact.

In the first cluster, with a relatively high proportion of meetings, the leading predictors are the number, variety and functionality of workspaces ($B = 0.283$) followed by opportunities to concentrate ($B = 0.260$). In the second, dominated by work requiring concentration and reading, the variables with the greatest impact are workplace functionality and comfort ($B = 0.414$) and opportunities to concentrate ($B = 0.335$). In cluster three – interactive desk work, telephone use and other activities – workplace functionality and comfort ($B = 0.380$) again comes out on top, followed by the organisation ($B = 0.352$). And in the final cluster, characterised by general desk work, the main predictors of work environment support for productivity are opportunities to concentrate ($B = 0.289$) and the organisation ($B = 0.276$).

All the regression models are significant ($p \leq 0.05$). The tolerance levels in the regression analyses are never lower than 0.365 and the highest VIF value found is 2.737, from which it can be assumed that there is not a high degree of multicollinearity.

4 CONCLUSION

Satisfaction with aspects of the work environment is 56 per cent responsible for the perceived support of overall labour productivity of a specific environment. Of the various aspects addressed by this study, it appears that opportunities to concentrate and workplace functionality and comfort have the greatest impact in this respect. Then come the number, variety and functionality of workspaces, followed by privacy. Although a work environment that supports opportunities to communicate is widely cited as a design objective for office premises, satisfaction in this respect in fact seems to have no impact upon overall productivity when a variety of other aspects are taken into consideration. Communication opportunities are influential, though – indeed, they are the most important factor – in the case of support for team productivity. On the matter of organisational productivity, the aspect with the greatest impact is satisfaction with the organisation itself.

However, work environment support of team and organisational productivity makes relatively little contribution towards overall productivity. Employees rate that environment's impact upon productivity in general very much in terms of what it does to support their own individual productivity. And that in turn is determined more emphatically by satisfaction with aspects of the work environment than is the case with team and organisational productivity.

Nonetheless, focusing upon opportunities to concentrate and workplace functionality and comfort alone will not always optimise a work environment's contribution towards productivity. This is because employees' particular patterns of activity also play their part in that perception. For those who spend a relatively large proportion of their time deliberating with colleagues, the most important factor is the number, variety and functionality of workspaces. That is followed by opportunities to concentrate. For people whose work require relatively much concentration and reading, these factors are functionality and comfort of the workplace plus opportunities to concentrate. Employees who spend relatively more time on deskwork that involves interaction and telephone work, have workplace functionality and comfort and the organisation as the most important factors. For those who mainly perform general desk work the factors with most impact are opportunities to concentrate and the organisation. The aspects of the work environment to be addressed when seeking to enhance

its productivity support function should therefore vary according to the type of tasks performed within the organisation.

At the same time, a number of factors associated with every work process affect the degree to which its environment supports productivity. They are the functionality and comfort of the workplace, the organisation as a whole and the input of ideas about the work environment. Haynes (2008) shows that certain factors (interaction and distraction) play a part in productivity regardless of the process concerned, whilst the role of others is dependent upon the type of process.

One striking finding in our study is that satisfaction with opportunities for communication has no bearing on the extent to which any of the activity groups perceive the work environment as supporting overall productivity. Only in some of the clusters do such opportunities have any impact, and then only in respect of team and organisational productivity. This outcome is at odds with the results of other studies, such as those by Brill and Weideman (2001) and Haynes (2007), both of which recognise – as we do – the importance of being able to work undistracted but also highlight how vital interaction is. Moreover, workplace temperature has been found to be significant to productivity in some other studies (Lan et al., 2010; Niemela et al., 2002), whereas in ours the indoor climate factor (which includes temperature) seems to have only a minor effect upon how the work environment supports productivity.

This discrepancy can be explained by examining the context of the research. Whilst both Niemela and Lan specifically investigated how relatively extreme temperatures (17°C and 25°C or more) affect actual productivity, our study queried employee satisfaction with the indoor climate as it related to perceived productivity in normal office conditions. It is unlikely that our respondents were working in ambient temperatures lower than 17°C or higher than 25°C. Apparently, then, the indoor climate has an adverse effect upon actual productivity when the workplace is too hot or too cold, but at average office temperatures there are other factors which have a greater impact upon perceived productivity.

Whilst company directors and workplace managers prefer to emphasise opportunities for interaction, the facility manager must remain aware that such factors as workplace functionality and comfort, opportunities for concentration and the indoor climate are of huge importance in creating a work environment that is perceived as encouraging labour productivity. And although some of these are universally relevant, it is essential to consider the particular work processes within the organisation when determining which specific aspects to focus upon.

5 LIMITATIONS

For this study, employees themselves assessed how supportive they consider their work environments were to be of productivity. Moreover, the questions put did not ask directly about productivity but about how the environment is seen as contributing towards it. Consequently, our findings specifically concern only those factors significant to productivity support emanating from the work environment.

Finally, it should be noted that the great majority of our results (83.8 per cent) come from public-sector bodies. It may well be that the factors of significance are different in commercial organisations. On the other hand, the overall gender, age and educational profile

of our respondents seem to correspond with that of the average office worker in the Netherlands.

REFERENCES

- Backhouse A. & Drew, A. (1992), "The design implications of social-interaction in a workplace setting", *Environment and Planning B: Planning and design*, 19, 5, 573-584.
- Block, L. K. & Stokes, G. S. (1989), "Performance and satisfaction in private versus nonprivate work settings", *Environment and Behavior*, 21, 3, 277-297.
- Brill, M. & Weidemann, S. (2001), *Disaproving widespread myths about workplace design*, Jasper, USA: Kimball International.
- Hameed, A. & Amjad, S. (2009), "Impact of office design on employees' productivity: A case study of banking organizations of Abbottabad, Pakistan", *Journal of Public Affairs, Administration and Management*, 3, 1.
- Haynes, B. P. (2008), "Impact of workplace connectivity on office productivity", *Journal of Corporate Real Estate*, 10, 4, 286 – 302.
- Haynes, B. P. (2007), "Office productivity: a theoretical framework", *Journal of Corporate Real Estate*, 9, 2, 97-110.
- Hedge, A. (1982), "The open-plan office. A systematic investigation of employee reaction to their work environment.", *Environment and Behavior*, 14, 5, 519-542.
- Keller, R. T. & Holland, W. E. (1983), "Communicators and innovators in research and development organizations", *Academy of Management Journal*, 26, 4, 742-749.
- Kirschner, F., Paas, F. & Kirschner, P. (2009), "Individual and group-based learning from complex cognitive tasks: Effects on retention and transfer efficiency", *Computers in human behavior*, 25, 2, 306 – 314.
- Lan, L., Lian, Z., Pan, L. & Ye., Q. (2009), "Neurobehavioral approach for evaluation of office workers' productivity: The effects of room temperature", *Building and Environment*, 44, 8, 1578 – 1588.
- Lan, L., Lian, Z. & Pan, L. (2010), "The effects of air temperature on office workers' well-being, workload and productivity-evaluated with subjective ratings", *Applied ergonomics*, 42,1, 29-36
- Maarleveld, M., Volker, L. & van der Voordt, D.J.M. (2009), "Measuring employee satisfaction in new offices - The WODI toolkit", *Journal of Facilities Management*, 7, 3, 181-197.
- Niemela, R., Hannula, M., Rautio, S., Reijula, K. & Railio, J. (2002), "The effect of air temperature on labour productivity in call centres – a case study", *Energy and Buildings*, 34, 8, 759 – 764.

Penn, A., Desyllas, J. & Vaughan, L. (1999), "The space of innovation: interaction and communication in the work environment", *Environment and Planning B: Planning and Design*, 26, 2, 193-218.

Strubler, D. C., & York, K. M. (2007), "An exploratory study of the Team Characteristics Model using organizational teams", *Small Group Research*, 38, 6, 670-695.