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*The effects of interventions in an innovative office on satisfaction, perceived productivity and health complaints.*

### **ABSTRACT**

Sustainability becomes a more and more important goal in the Netherlands when it comes to designing and building new offices. The DCMR Environmental Protection Agency in the Netherlands moved into a new A+ labelled office building with thermal energy storage in January 2010. There are fewer desks than there are employees, so people share workplaces. People can choose several types of workplaces that are suitable for specific activities (e.g. communication, concentration). Nine months after moving into the new building an employee satisfaction survey was conducted to measure satisfaction with the office building and perceived support of productivity (377 respondents, 75% response rate). Although the results pointed out that people are in general satisfied with the office environment, several issues with the indoor climate, acoustics and IT were revealed. Following the results, the organisation has undertaken numerous interventions in the indoor climate, acoustics and IT to increase employee satisfaction. Exactly two years after the first measurement a second employee satisfaction survey was conducted to measure the effects of the interventions (389 respondents, 73% response rate). The results show improvement in most satisfaction scores. Furthermore, the results of the second measurement are compared with a benchmark which shows that the DCMR office environment performs very well compared to other organisations. The outcomes of this case study can lead to more insight into the appraisal of innovative offices with workplace sharing in general and specifically the effects of the interventions that were undertaken within the office environment on satisfaction and perceived productivity support.

Keywords: work environment, satisfaction, benchmark, post occupancy evaluation

## 1 INTRODUCTION

Considerable research has been conducted on the influence of office environments on well-being, employee satisfaction and productivity (De Croon et al., 2005; Bodin-Danielsson & Bodin, 2008). Such research is important, as satisfaction with the physical working environment appears to be directly related to job satisfaction and productivity (Carlopio, 1996; Veitch et al., 2003).

In the Netherlands there is a shift going on from more traditional cellular offices towards a more open and diverse office lay-out with shared use of spaces (Van Meel, 2000). The combi and flex offices have a much more open character and a great variety in workspaces. Nowadays, not only the more traditional individual and small shared room offices but also the innovative flexible offices are a very common office type in the Netherlands (Van Meel, 2000). Research on the influence of the office environment is extra important, since the impact of this innovative lay-out and way of working on satisfaction and productivity is not always clear.

One of the organisations that developed a new office building with a flexible office concept is the DCMR Environmental Protection Agency (DCMR). DCMR was founded in 1972 in order to improve environmental protection in the Rotterdam-Rijnmond region in The Netherlands. This region is a heavily industrialised area with refineries, waste incinerators, several waste dumping sites, many large chemical plants, metallurgy, food processing plants and about 19,500 smaller companies. The tasks of the DCMR include regulation of the industries, monitoring and assisting authorities on developing environmental policy. With a growing number of employees over the years, the organisation decided to develop and build a new office building.

Following the activities and responsibilities of the organisation, sustainability and efficiency were important goals for the new building. This resulted in the development of an A+ labelled building with thermal energy storage. To be able to use the office environment as efficient as possible, an office concept with desk sharing was introduced. Another goal was to develop an inspiring and attractive work environment. For the new office environment, different types of open and enclosed workspaces were designed (e.g. for concentration work, interaction, administrative work and meetings). There are less work desks than there are employees (0,9 desks per employee). This means that in the new work environment people would not have their own, assigned workplace anymore but that they have to share all the present workspaces in the building with each other.

In January 2010 the organisation moved into their new office building. To get insight in how the employees experience the work environment and whether the work environment supports the productivity of the employees, an evaluation research was conducted. In November 2010, nine months after moving into the new building, a first employee satisfaction survey was performed. The results of this evaluation were used by the organisation for improving and optimising the work environment. Exactly two years after the first evaluation a second employee satisfaction survey was conducted to measure the possible effects of the improvements and habituation to the new work environment and the flexible way of working.

The results of this case study are important for other organisations because it gives insight into the experience of this particular sustainable office building with flexible use of workspaces. It is useful not only to other Dutch organisations, but also organisations from other countries in Europe who are thinking about introducing new office concepts. Secondly, this paper gives insights into the possibilities to improve and optimise the work environment.

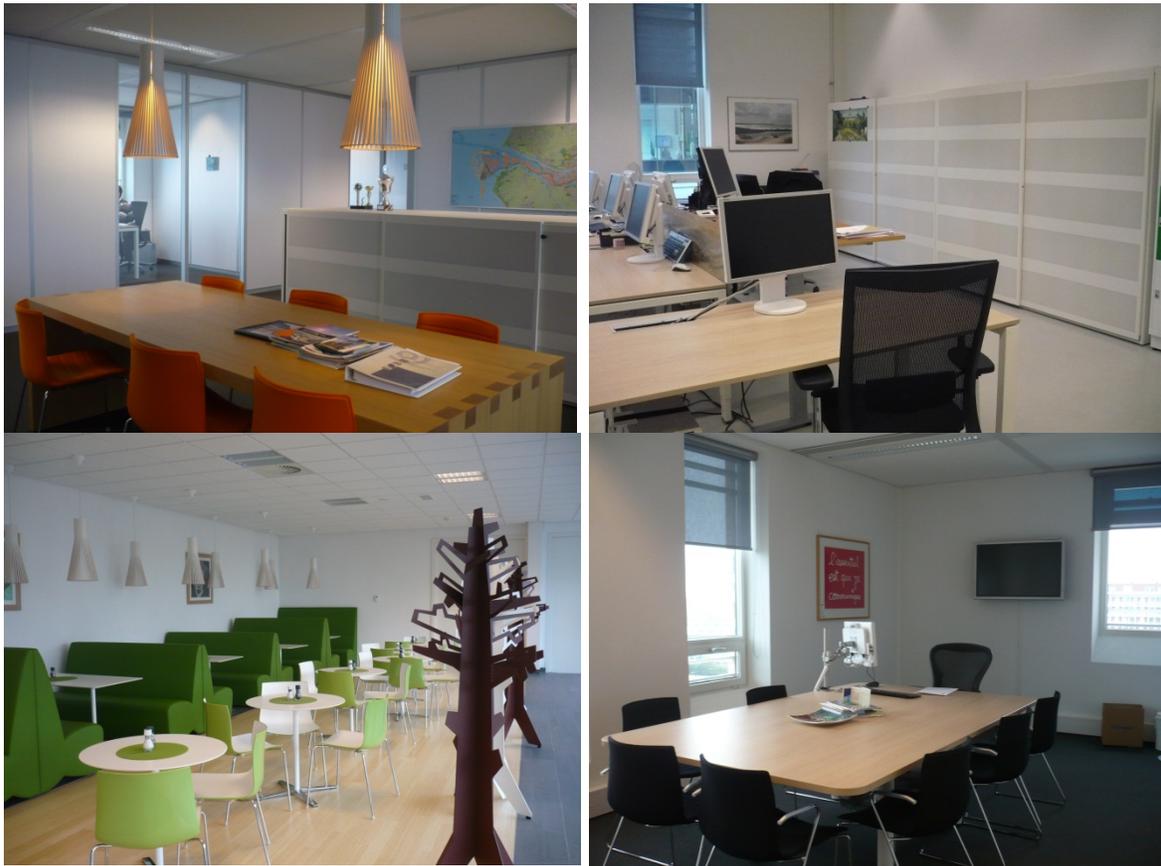


Figure 1: Impression of the DCMR work environment

## 2 METHOD

### 2.1 Respondents

In November 2010 all 503 employees who worked in the new building at that moment received an invitation to fill out the questionnaire by e-mail. 377 employees, 75% of the population, filled out the questionnaire. In November 2012 533 employees received an e-mail invitation to fill out the questionnaire. This resulted in a response rate of 73% (389 respondents). The sex, age and level of education distribution of respondents are shown in table 1.

Table 1. The distribution of the respondents in 2010 and 2012 over sex, age and level of education categories.

<b>Sex</b>	<b>2010</b>	<b>2012</b>
Male	60,2%	58,6%
Female	39,8%	41,4%
<b>Age</b>	<b>2010</b>	<b>2012</b>
< 31 years	6,6%	5,7%
31 - 40 years	26,0%	25,7%
41 - 50 years	40,1%	34,2%
51 - 60 years	21,2%	26,7%
> 60 years	6,1%	7,7%
<b>Level of education</b>	<b>2010</b>	<b>2012</b>
Primary education	0,0%	0,3%
Secondary education	5,0%	3,1%
Vocational secondary education	13,8%	15,2%
Undergraduate (Bachelor level)	50,9%	48,1%
Postgraduate (Master level)	29,7%	32,6%
Other	0,5%	0,8%

All of the employees at the organisation are knowledge workers. The respondents performed mostly general desk work (approximately one third of their time at the office), around 12% of their time was spent on desk work that requires concentration, 14% on desk work that requires interaction and approximately 19% of time on planned and unplanned meetings (see table 2 for an overview of the activities performed in 2010 and 2012).

Table 2. The mean percentage of time at the office that is spent on various work activities in 2010 and 2012.

<b>Distribution of activities/mean percentage of work time</b>	<b>2010 measurement</b>	<b>2012 measurement</b>
General desk work	32,7%	34,7%
Concentrated desk work	12,1%	12,6%
Interactive desk work	14,1%	13,8%
Planned meetings	11,7%	13,1%
Unplanned meetings	7,1%	6,1%
Telephoning	6,5%	6,0%
Reading (> 30 minutes)	5,7%	5,0%
Archiving/document management	5,3%	5,3%

Other	4,8%	3,4%
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## 2.2 Questionnaire

The Work Environment Diagnosis Instrument (WODI) was used to evaluate the new DCMR office. WODI Light is an online questionnaire developed in order to measure employee satisfaction with the work environment and the perceived support of productivity (Maarleveld et al., 2009). The questionnaire consists of 41 items, containing questions about the satisfaction with the work environment, the activities employees perform in the building, the importance of certain aspects in the work environment and the support of productivity by the work environment. Since the indoor climate is an important aspect for DCMR, several questions regarding this aspect were added to the questionnaire.

29 questions regarding the satisfaction with the work environment were selected for statistical analyses. These questions were scores on a 5-point Likert on satisfaction ranging from (1) very dissatisfied to (2) dissatisfied, (3) neutral, (4) satisfied and (5) very satisfied. Furthermore, 3 items regarding the perceived support of productivity were selected for the analyses. These items were scores on a 5-point Likert ranging from very unsupportive (1) unsupportive (2), neutral (3), supportive (4) to very supportive (5). The 5-point Likert scale is a very commonly used scale worldwide that offers respondents the possibility to express themselves when they feel positive, negative but also when they feel truly neutral about a given topic.

People could also make remarks about the work environment at the end of the questionnaire in an empty field. In total 273 additional comments were made in 2010 and 202 additional comments were made in the 2012 measurement. This input is used for a further explanation of the results.

## 2.3 Data reduction

The 32 items regarding the satisfaction with the work environment and perceived support of productivity were combined to form 8 factors. In each factor 3 to 6 items were combined, resulting in a Cronbach's alpha ranging from 0,601 to 0,911 (table 3). The average item scores were calculated resulting in factor scores.

Table 3. An overview of the factors that are used for analyses, the items that the factors are comprised of and the Cronbach's alpha of the combined items.

Factor	Items	Cronbachs alpha
Organisation	Organisation Content and complexity of work Sharing own ideas about work environment	0,601
Subdivision office	Subdivision office Number, diversity and functionality spaces Positioning of office spaces	0,745
Architecture	Architecture and appearance building	0,668

	Openness and transparency Interior design and atmosphere	
Functionality workspace	Functionality and comfort workspace Privacy Possibilities for concentration Possibilities for communication Acoustics	0,757
Facilities	Archive and storage facilities Facilities and facilities management IT facilities Possibilities for working somewhere else	0,635
Productivity	Support of own productivity Support of team productivity Support of organization productivity	0,874
Indoor climate	Indoor climate (general) Temperature Ventilation Air quality Indoor climate personal control	0,911
Lighting	Lighting (general) Access of daylight Control daylight Control artificial lighting Lighting work surface Reflection on computer screen	0,807

#### 2.4 Analyses: comparison first and second measurement

The average factor scores of the first and second measurement were compared by conducting independent samples T-tests.

#### 2.5 Analyses: comparison with the benchmark

Because WODI was used for several other evaluations by the Center for People and Buildings and the data are collected in a larger database, it was possible to create a benchmark to compare with the DCMR scores. The benchmark was created based on the data of all cases within the database with similar office concepts (a mixture of open and enclosed spaces and flexible use of workplaces). The benchmark represents the average satisfaction and perceived support of productivity scores of 4088 respondents derived from 36 different case studies.

For the comparison 23 items were used. The factors organisation, subdivision of the office, architecture, functionality of the workspace, facilities and support of productivity are comprised of the items that are shown in table 1. For indoor climate and lighting only the two individual items regarding the experience of the indoor climate (overall) and lighting (overall) were used for comparison, since the additional questions about these issues were not always addressed in other WODI case studies.

The average scores on the six factors and two individual items of the benchmark and the DCMR second measurement are compared with an independent samples T-test.

### 3 RESULTS

#### 3.1 Results first measurement

In November 2010 the employees were in general quite satisfied with the working environment (figure 2).

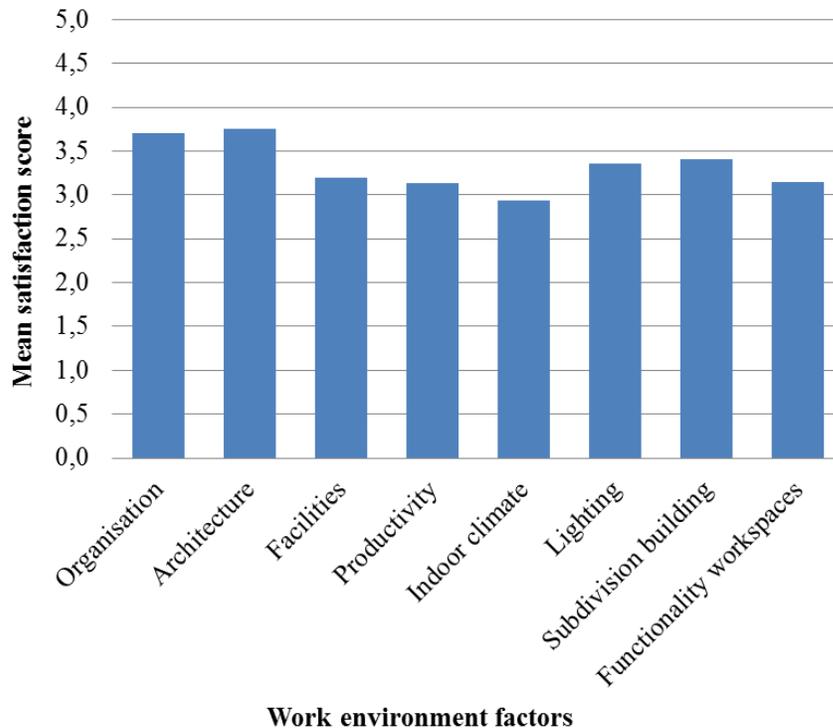


Figure 2: The mean satisfaction scores on a 5-point Likert scale regarding work environment factors from the 2010 measurement.

The mean score for the architecture of the building is the highest among all factor scores ( $M=3.75$ ,  $SD=0.67$ ). The indoor climate is rated lowest among all factors ( $M=2.94$ ,  $SD=0.88$ ).

To find out what could be the main dissatisfier when it comes to the indoor climate, the scores on the individual indoor climate items were analysed. The results show that employees are generally least satisfied with the control over the indoor climate ( $M=2.74$ ,  $SD=0.98$ ).

#### *Additional comments*

91 respondents commented on the indoor climate, from which the largest group commented on the lack of sun blinds (14 comments) and not having the possibility to open the windows (12 comments). This could explain the low score on the control over the indoor climate.

When it comes to the facilities, employees did complain about the computer facilities and network access (25 comments), the number of toilets (12 comments) and cleaning (8 comments). 25 respondents commented on noise and auditive distraction within the work environment.

*First measurement compared to the benchmark*

Compared to the benchmark, the DCMR first measurement scored significantly higher on six of the eight work environment factors (table 4). On the factor lighting DCMR scored significantly lower than the benchmark. There was no difference in scores on the satisfaction with the facilities.

Table 4: A comparison of the average factor or item scores between the benchmark and the DCMR first measurement (on a 5-point Likert scale).

Factor / item		N	Mean scores	Std. Deviation	Significance (2-tailed)
Organisation	Benchmark	3850	3,51	0,708	0,000
	DCMR first measurement	370	3,70	0,614	
Architecture	Benchmark	3876	3,52	0,802	0,000
	DCMR first measurement	372	3,75	0,674	
Facilities	Benchmark	3318	3,21	0,646	0,707
	DCMR first measurement	339	3,20	0,656	
Support of productivity	Benchmark	3526	2,98	0,842	0,001
	DCMR first measurement	360	3,13	0,687	
Indoor climate	Benchmark	2737	2,64	1,127	0,000
	DCMR first measurement	374	3,03	1,077	
Lighting	Benchmark	2686	3,45	0,933	0,046
	DCMR first measurement	376	3,35	0,926	
Subdivision building	Benchmark	3893	3,25	0,906	0,000
	DCMR first measurement	371	3,41	0,660	
Functionality workspaces	Benchmark	2739	3,05	0,796	0,012
	DCMR first measurement	369	3,15	0,731	

The comparison between the results of the first DCMR measurement and the average results of other flexible office users (benchmark) are shown in figure 3.

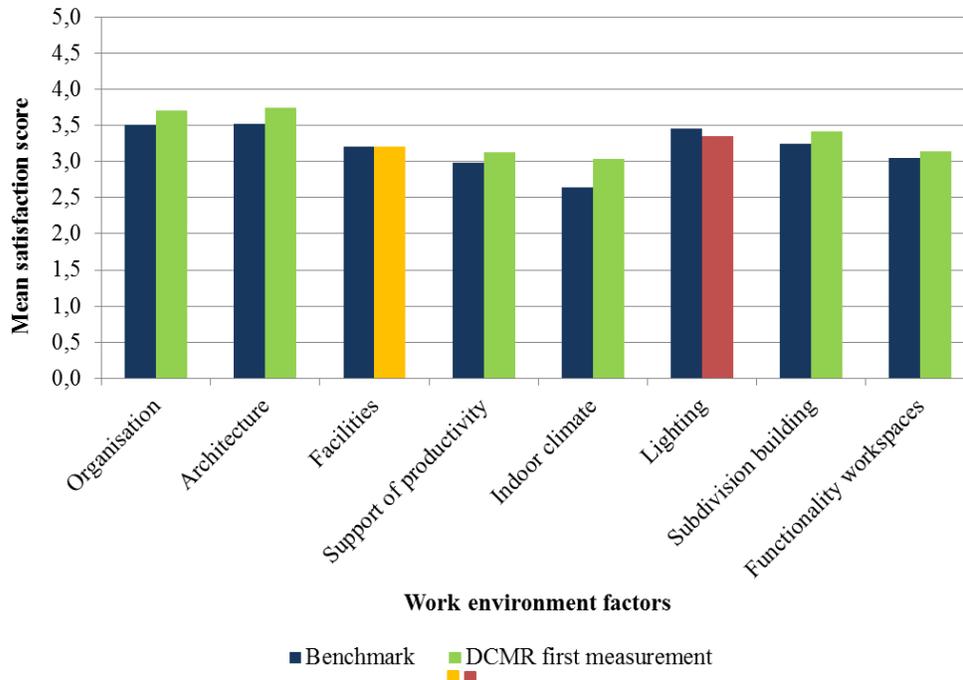


Figure 3: DCMR mean satisfaction scores from 2010 on a 5-point Likert scale compared to the benchmark. Blue = benchmark scores, Green= the 2010 measurement scores significantly higher than the benchmark, Yellow= the 2010 measurement scores with no significant difference, Red= the 2010 measurement scores significantly lower than the benchmark.

### 3.2 Interventions in the work environment after the first measurement

After the first measurement, the organisation undertook several studies to investigate the quality of the indoor climate. The research focussed on the air quality, the circulation of air and the temperature inside the building. The CO<sub>2</sub> values and amount of fine dust were up to standards. The relative humidity of the air however appeared to be generally lower than 30%. The relative air humidity turned out to be most problematic in the 24-hour helpdesk area where employees are answering questions or handle complaints about environmental issues. Several improvements were made following the indoor climate studies: from that moment the air handling units were turned off at night and several sensors were placed in the building for monitoring the relative air humidity. Control panels for adjusting the temperature +3 to -3 degrees were adjusted by adding the possibility to read the actual temperature on the display, which was not possible before and during the first evaluation.

In a reaction to the complaints on the lack of sun blinds on one side of the building, sun blinds were installed. Secondly, the lighting system was adapted because sensors were observed to be too sensitive; when employees walked through the nearby corridor, lights in the offices went on. The sensors were adjusted so that they are directed to the rooms, instead of to the corridor. A second adaptation regarding lighting was the addition of light

switches. The possibility to control whether the lights are on or off in the offices was added, since this was not possible during the 2010 measurement.

Because of the problems regarding noise and auditive distraction within the office, several interventions were implemented to improve the acoustics of the building. Acoustic panels were installed in the enclosed meeting rooms and the open office spaces with a direct connection with the corridor zone. Furthermore, the complaints about the IT facilities in the first WODI measurement were passed on to the IT department and have been embedded in the new IT plan.

### 3.3 Differences between first and second measurement

Significant differences between the first and second measurement were found for the satisfaction with the organisation ( $t(748)=-2.52$ ,  $p=0.012$ ), the satisfaction with the facilities ( $t(667.073)=-6.31$ ,  $p=0.000$ ), the satisfaction with lighting ( $t(650.520)=-3.87$ ,  $p=0.000$ ) and the perceived support of productivity ( $t(723)=-3.561$ ,  $p=0.000$ ). All significant differences are in favour of the second measurement.

No significant differences were found for the satisfaction with the architecture ( $t(747)=-0.33$ ,  $p=0.974$ ), indoor climate ( $t(745)=1.208$ ,  $p=0.227$ ), subdivision of the building ( $t(744)=-1.222$ ,  $p=0.222$ ) and the functionality of the workspaces ( $t(730.708)=-0.979$ ,  $p=0.328$ ).

In figure 4 the results are visualised.

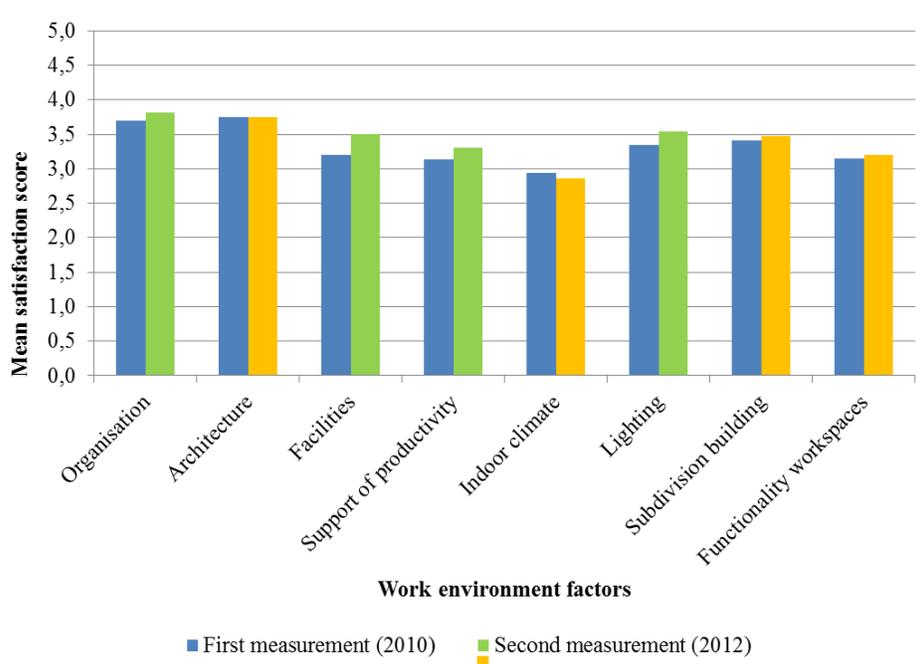


Figure 4. A comparison between the average factor scores (on a 5-point Likert scale) of first and the second measurement. Blue = the first measurement scores, Green= the second measurement scores significantly higher than the first measurement, Yellow= the second measurement scores with no significant difference.

*Additional comments*

Despite the adaptations in the indoor climate systems that we done after the first measurement, the open question still resulted in 45 complaints about dry air and in 27 of these complaints the negative effect on their health was specifically mentioned: dry and irritated eyes, having headaches, sore throats and sneezing. Only 5 employees reported a reduction of indoor climate related health complaints.

Noise and distraction were other issues that still existed during the second measurement, in spite of the installation of the acoustic panels. 22 employees made a comment on this issue. Employees remarked that especially the areas with many open workspaces were still too noisy. Fewer remarks were made about the IT facilities in 2012 (9) compared to 2010 (25).

*Results compared to the benchmark*

Compared to other similar office concepts, employees of the DCMR organisation gave significantly higher satisfaction scores on most office factors (table 5).

Table 5: A comparison of the average factor or item scores between the benchmark and the DCMR second measurement (on a 5-point Likert scale).

Factor / item		N	Mean scores	Std. Deviation	Significance (2-tailed)
Organisation	Benchmark	3850	3,51	0,708	0,000
	DCMR second measurement	380	3,81	0,547	
Architecture	Benchmark	3876	3,52	0,802	0,000
	DCMR second measurement	377	3,75	0,609	
Facilities	Benchmark	3318	3,21	0,646	0,000
	DCMR second measurement	352	3,50	0,566	
Support of productivity	Benchmark	3526	2,98	0,842	0,000
	DCMR second measurement	365	3,31	0,638	
Indoor climate	Benchmark	2737	2,64	1,127	0,000
	DCMR second measurement	388	2,86	1,028	
Lighting	Benchmark	2686	3,45	0,933	0,844
	DCMR second measurement	387	3,46	0,833	
Subdivision building	Benchmark	3893	3,25	0,906	0,000
	DCMR second measurement	375	3,47	0,660	
Functionality workspaces	Benchmark	2739	3,05	0,796	0,000
	DCMR second measurement	375	3,20	0,634	

Satisfaction scores and the score on perceived support of productivity are higher in comparison with the benchmark on all factors, except for the factor lighting, which does not differ significantly with the benchmark. In figure 5 the results are visualised.

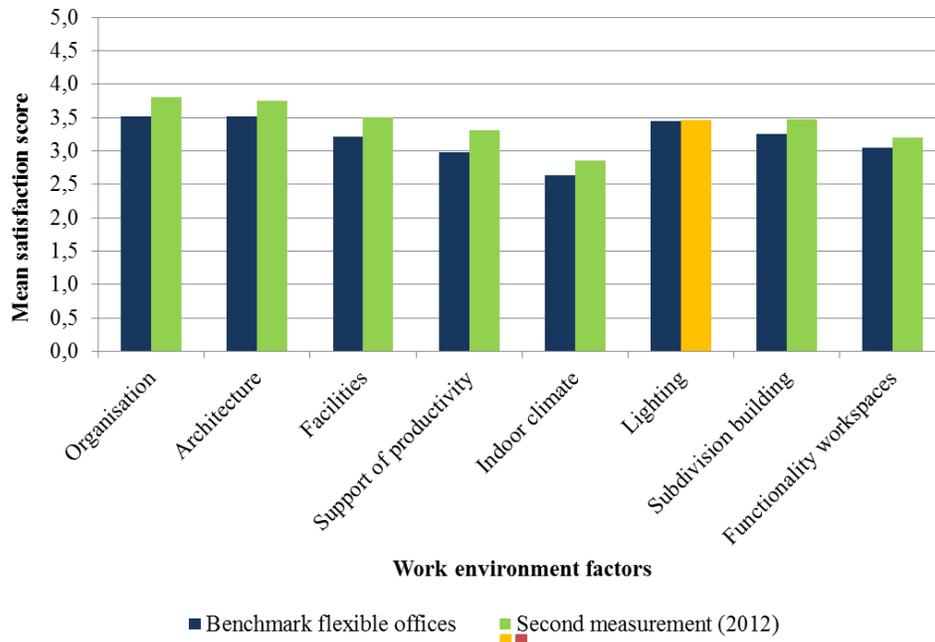


Figure 5: DCMR mean satisfaction scores from 2012 on a 5-point Likert scale compared to the benchmark. Blue = benchmark scores, Green= the second measurement scores significantly higher than the benchmark, Yellow= the second measurement scores with no significant difference.

#### 4 CONCLUSION AND DISCUSSION

Employees are in general quite satisfied with the office environment. Respondents are more positive about the organisation, lighting, facilities and the support of productivity during the second measurement almost three years after moving to the new office building and after the interventions in comparison with the first measurement, one year after moving.

The total of interventions that the organisation implemented after the first measurement could have had a direct or indirect effect on the satisfaction scores and the perceived support of productivity. One other reason for the higher satisfaction scores might be that employees are getting used to the work environment and the flexible use of workspaces after a few years.

The adaptations to the lighting system probably have had a direct positive effect on the satisfaction scores on lighting. Furthermore, the attention from the IT department for the problems with the IT facilities seem to have positively influenced the facilities score. The finding that people are more satisfied with the own organisation during the second measurement, could possibly be explained by the serious attention that the organisation

had for the user experience and the attempts the organisation undertook to improve the environment.

However, the two measurements and the attention for the satisfaction of the employees could have caused a form of reactivity like the well-known Hawthorne effect or a social desirability bias. Yet the results on indoor climate, which received a lot of attention during the improvements but did not result in higher satisfaction scores during the after measurement, do not support this assumption.

The improvements on the indoor climate did not seem to have had a direct effect on the satisfaction with the indoor climate, since the satisfaction scores on that factor did not show a significant improvement. Still after the interventions, the respondents complained about dry air and related health problems. Furthermore, people stated that they were still missing the possibility to open a window. The DCMR is planning on communicating the issues regarding indoor climate and other technical factors with their employees more extensive than they did before. They will inform the employees about current investigations and will let them know whether changes can or cannot be made. The information might help employees to understand certain issues and know what to expect when it comes to technical improvements within the work environment.

During the second measurement, complaints regarding distraction and possibilities for concentration also continued to exist. While the installation of the acoustic panels might have had some effect, the results show that the acoustics within the open and half-open spaces still needs some special attention. It is important to try to resolve this issue, because the possibilities to concentrate is a strong predictor for the perceived productivity (Maarleveld & de Been, 2011). It seems to be not only a problem which can be solved by altering the layout of the work environment; behaviour is an important factor in realising a more pleasant environment for concentrated work. The DCMR is planning to communicate on how employees discuss with each other what effects conversations and noise levels have on them to make other employees realise what the consequences of certain behaviours are.

While the results on indoor climate and concentration possibilities seem negative, a positive indirect effect of the interventions on indoor climate and acoustics on the other work environment factors, like the perceived support of productivity, cannot be ruled out. Moreover, when comparing this case study to the benchmark, the DCMR scores above average on indoor climate and almost all the other work environment factors as well. The comparison with the reference benchmark shows that the new office building and flexible concept performs relatively good compared to other organisations that implemented the same innovative flexible office concept.

## **5 PRACTICAL IMPLICATIONS**

Measuring the appraisal of the DCMR office environment will help in the understanding of the experience of employees in a new office building with a flexible office concept. Although combi offices with flexible use of workspaces are still mostly a Dutch

phenomenon, it seems that organisations in other countries are more and more considering adapting and innovating their office concepts.

This research also gives insight into the effects of several specific interventions within the work environment on employee experience. A description of more case studies in which interventions are done to improve the experience and the following effects supported by data, will give organisations evidence based knowledge on which they can decide which interventions would suit them best in reaching their goals of higher employee satisfaction and support of productivity.

Other organisations can learn from the specific details of the DCMR concept and the ambition of DCMR to optimise the office concept by focussing on the experience of actual users of the building: the employees.

### **Acknowledgements**

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