Constructing productivity: Investigating the types of spaces preferred for a range of work tasks

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ABSTRACT: The type and range of tasks that knowledge workers conduct has received considerable attention by a myriad of research domains over the last century. However, the relative value of various typical workspace types for performing a variety of typical work tasks has received relatively scant research attention. In addition, existing research indicates that natural environments may be beneficial spaces for conducting a diverse range of work tasks, yet the relative value of conducting work tasks in natural environments compared to typical work environments is still not well understood.

To this end, this paper reviews the results of a survey of knowledge workers that was conducted in Delft, The Netherlands in 2012. The primary goal of the survey was to identify the types of work environments that promote the performance of knowledge workers, in regards to a diverse range of work tasks.

Participants were presented with images of different physical environments, including typical work environments, such as an open floor workspace, cellular office, and lounge, as well as several different natural environments. The participants then ranked the different physical environments in descending order, from best to worst, in terms of their perception of how well the workspaces promoted their performance on the work tasks.

The results of the survey indicated that knowledge workers prefer a much broader and diverse range of work environments than are currently provided in office buildings. Notably, natural environments were found to be considerably more preferred than traditional work spaces for conducting a number of work tasks, particularly creative work tasks, such as brainstorming. In addition, at least one type of natural environment was ranked as at least the third best work environment for every work task evaluated.

KEYWORDS: Worker Performance, Creativity, Plants, Office Design

INTRODUCTION

Physical work environments influence worker performance and well-being in a myriad of ways. For instance, existing research indicates that the level of influence of physical work environments on the performance of knowledge workers varies based on the type of work task (Meusburger, 2009). Moreover, the effects of specific types of physical work spaces on worker performance have been found to vary by work task. For instance, Forster (2009) found that certain physical workspace types can prime occupants to be creative, while Amabile (1999) found that work projects that were rated high in creativity had significantly different physical work environments from those rated low in creativity. Moreover, Leung et al. (2012) found that knowledge workers were more creative when they conducted brainstorming activities in open spaces, compared to brainstorming in an enclosed, narrow work space, such as a cellular office. In contrast, a review of existing literature by Davis, Leach, and Clegg (2011) indicated that conducting complex tasks in isolation increases task performance, and allows creative workers to avoid overstimulation and other environmental stressors associated with non-private workspaces. Thus, it is apparent that various workspace types are more and less suitable for conducting different work tasks, and thereby affect worker performance.

Interactions with natural environments and biota, particularly forests and vegetation, have been found to benefit worker performance, as well as individual well-being and comfort, in research conducted by a variety of scientific disciplines in diverse cultures throughout the world. For instance, the presence of vegetation has been found to improve occupants' overall comfort as well as thermal comfort, space use rates, and their perceptions of the quality of their environments, including greater air quality, acoustics, and visual comfort and light levels (Bergs, 2002; Fjeld, 2002; Hellinga & de Bruin-Hordijk, 2010; John Hesselink et al., 2008; Mangone, Kurvers, & Luscuere, 2014; Stiles, 1995; Vink, Groenesteijn, Blok, & de Korte, 2008).

Moreover, researchers have found that plants can improve worker productivity between 10-15%, and increase creativity by 11-30% (Atchley, Strayer, & Atchley, 2012; John Hesselink et al., 2008; Knight & Haslam, 2010; Lohr, Pearson-Mims, & Goodwin, 1996; Marchant, 1982; Nieuwenhuis, Knight, Postmes, & Haslam, 2014; Shibata, 2004). Specifically, worker performance on tasks requiring substantial concentration, such as focus related work tasks, has been found to improve when participants interact with natural environments and plants (Berman, Jonides, & Kaplan, 2008). In addition, a study by Vink et al. (2008) found that knowledge workers occupied a garden lounge space 16.9% more than a typical office lounge space, even though the garden space did not provide seating. Moreover, occupants of the garden space conversed 20.6% less than occupants of the typical lounge space, yet the percentage of conversations that were work related were greater in the garden

space. Hence, gardens were found to be preferred by occupants, as well as increase occupant use rates of informal meetings spaces, even when more comfortable lounge spaces were available. These findings suggest that natural environments can be beneficial informal meeting and work break environments. Moreover, the occupation of natural environments can promote occupants to focus on work related topics in informal meeting conversations. Taken together, the results of these studies also indicate that vegetation may not function as a distraction stimulus, but rather as a positive stimulus, even during cognitively demanding tasks. Therefore, natural environments may be beneficial environments to conduct a diverse range of tasks.

However, the suitability of natural environments for a range of work tasks has not yet been thoroughly evaluated. Moreover, the comparative effectiveness of the various workspace types commonly present in work environments on improving the performance of occupants, with regard to a diverse range of work tasks, has yet to be evaluated. Thus, the focus of the study presented in this paper was to evaluate the effect of a diverse range of commonly used office workspace types, as well as natural environments, on worker performance, with regard to a diverse range of work tasks that have been identified in existing literature.

1.0 METHODS

1.1. General overview of survey

The goal of this research project was to evaluate the relative value of various existing and innovative workspaces, in terms of promoting the performance of knowledge workers when conducting various work tasks. This research question was evaluated through the development and administration of a semi-structured, questionnaire based survey to 54 knowledge workers. The survey included both brief and extended responses.

1.2. Participant work environment context

The survey was conducted at the Delft University of Technology Faculty of Architecture and the Built Environment building (BK City) in Delft, The Netherlands, in the fall of 2012. The Faculty of Architecture was located in a separate building until May 2008, when the building burned down. An existing building on campus, whose construction began in 1917, but due to numerous issues did not have an official occupant until 1948, was subsequently renovated and renamed ‘BK City’. In September 2008, the Faculty of Architecture moved into BK City. The new work environment was designed to provide a variety of workspace types for the faculty, including cellular offices, open floor work spaces, public and private informal meeting spaces, lab rooms, lounges, cafes, and public and private lecture spaces. Thus, the participants had experience working in a range of work types.

1.3. Participants

The faculty members at BK City are comprised of educators and researchers, and are organized into four departments : Architecture, Architectural Engineering + Technology, Real Estate + Housing, and Urbanism. Since the target job type for this survey was knowledge workers, the research faculty within BK City were categorized as the survey population. In the fall of 2012, there were 126 staff members who were actively involved in research projects and were physically working at BK City, 81 males (64.3%) and 45 females (35.7%). The mean age of the researcher population was 42.1 years (SD=10.72).

For the pilot study, 10 volunteer researchers were interviewed. These volunteers were randomly selected from the researcher population at BK City. There were 7 male participants (70%) and 3 female participants (30%), with a mean age of 37.1 years (SD=11.51).
For the second phase of the survey, a stratified sampling approach was employed to enlist participants, in order to ensure that the knowledge workers from the four departments were proportionately represented, as well as to ensure that the participants represented the broad range of perspectives present within BK City (Foster, 1995). 54 volunteer researchers were interviewed. There were 31 male participants (57.4%) and 23 female participants (42.6%), and their mean age was 41.4 years (SD=10.31). The distribution of the participants among the four departments was similar to the distribution of the BK City researcher population distribution among the four departments.

Figure 1: Open workspace.

Figure 2: Lounge.

Figure 3: Informal public meeting.

Figure 4: Lab.

Figure 5: Informal private meeting.

Figure 6: Cellular Office.

Figure 7: Forest Amphitheatre.

Figure 8: Meadow.

Figure 9: Dense Forest.

Figure 10: Park.

Figure 11: Formal Meeting.

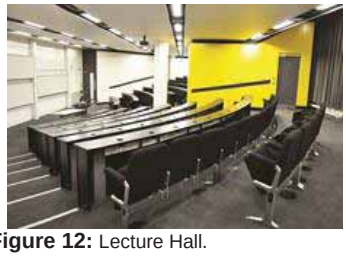


Figure 12: Lecture Hall.

Figure 13: Cave.

Figure 14: Gym.

Figure 15: Café.

1.4. Work task selection process

Existing literature has identified a range of work tasks that knowledge workers typically conduct. The range of work tasks that were identified and evaluated in this research project, as defined in Table 2, were identified based on evidence from an extended literature review. Special attention was given to identifying work tasks that extant research indicates may have different physical work environment requirements. The results of this review included a broad range of creative and non-creative work tasks, including work tasks identified by Olgaye's stage based creative process model, as well as Treffinger's integrated model, among others (Davis et al., 2011; Funke, 2009; Robinson, 2012; Treffinger, 1995)**.**

1.5. Workspace type + image selection process

Based on the results of a literature review, ten different workspace types were identified as being representative of currently available work space types that office environments provide for knowledge workers to conduct various work tasks. Five different types of nature space types were included, in order to evaluate the influence of different types of natural environments on occupants' work performance, in regards to a range of diverse work tasks. Since the goal of the survey was to evaluate the performance of knowledge workers in existing workspace types and nature space types, the initial images that were selected to represent each space typology were selected based on their representativeness of typical work spaces for each typology. Extraordinary workspaces and natural spaces were avoided, such as spaces with excessive colors, flowers, and expensive furniture, in order to reduce the potential of participants to respond to unique qualities of these extraordinary images, instead of to the qualities of the typology. The perception of the qualities of the selected images, and their representativeness of the intended space types, were then evaluated by the participants during the pilot phase of the experiment, and were revised, and in some cases replaced, accordingly. A follow up survey of 33 participants was conducted, which evaluated the participants' perception of ten different spatial qualities in the images through a 7-point Likert scale self-report based survey. The measured spatial qualities included the perceived level of noise, light, privacy,

fascination stimuli, and naturalness. The results of this survey indicated the final image set was perceived by the participants as intended. The final image set is illustrated in Figures 1-15.

1.6. Survey method

The participants were first given pictures of the fifteen workspace typologies and asked to arrange them from the space they would most prefer to occupy in general, to the least. The participants were advised to spend one to two minutes on the task. The purpose of this exercise was for participants to familiarize themselves with the image set, since it was observed in the first round of the pilot study that participants didn't notice influencing spatial qualities of some of the images until the second question. Based on the participants' feedback, the addition of this exercise in the second pilot study corrected this issue.

Following the image orientation exercise, the participants were given some instructions before conducting the next part of the survey. For each work task, the participants were asked to consider the nature and typical work spaces as being equally accessible from their current location. In addition, the participants were instructed to consider the nature spaces to be comfortable to occupy, similar to a warm, spring day, without glare issues, temperature issues, or excessive winds. The nature spaces were to be considered as providing access to all the necessary facilities, including access to internet, electricity, secretary services, bathrooms, etc., and to be able to be furnished with any furniture desired for the specific work task. However, the participants were asked to identify any change in furniture that they desired. These instructions were developed based on the feedback of the participants of the first pilot study in order to ensure participants considered the nature spaces as equally comfortable and accessible as typical workspaces. This was because the goal of the survey was to evaluate the performance potential of forest typologies within office buildings, so occupants within these space typologies would not be subject to adverse weather conditions or lack of availability of resources.

Following these instructions, the participants were then asked to arrange the pictures of the workspace typologies, from the space they believed they would best be able to conduct the given work task to the space where they would least be able to conduct the work task. This process was repeated for the sixteen work tasks identified in Table 2. During the first pilot study, it was observed that most participants had difficulty ordering spaces after they identified the four or five best and worst performing spaces, with several participants reporting the spaces outside the four or five best and worst spaces were very similar in performance, and for some of the participants, these less important spaces were sometimes interchangeable. This finding is illustrated by the fact that several participants selected two and sometimes three spaces for fifth and sixth best and worst spaces for various work tasks. In addition, these participants took the most time to complete the interview. These findings indicate that the degree of accuracy of participant responses after identifying the four best and worst typologies was relatively less reliable. Thus, the spaces that were not selected for the four best and worst performing were not assigned a value in the analysis of the results presented in this paper. This method is believed to be the most accurate accounting of the research findings by the authors, based on participant feedback and responses. In addition, participants that were asked to order every workspace for each worktask, on average, took more than twice as long to answer each question (1 to 2 hours, compared to 30 to 60 minutes). However, one participant was able to order all workspaces for each work task without much difficulty or time. Thus, in the second pilot study, participants were asked to identify the four best and four worst workspace typologies for each work task. In general, this resulted in significant time savings, and the participants reported clear distinctions in performance between spaces.

1.7. Participant performance measurement method

This survey evaluated knowledge workers' perceptions of how well various workspace types promoted their performance on the evaluated work tasks. Knowledge workers have a unique perspective of their subtle interactions with their physical and social work environment that affect their personal work performance. Supervisor evaluations could provide another level of validation, in terms of assessing the effect of different physical workspaces on the participant's performance. However, without direct access to the workers' cognitive processes and behaviors, supervisors, facility managers, and co-workers are not able to comprehensively perceive the positive and negative effects of the social and physical work environment on their work task performance and creativity (Shalley, Zhou, & Oldham, 2004). Furthermore, self-reported creativity has been previously correlated to supervisor-reported creativity (Axtell et al., 2000). Nevertheless, future research should evaluate the performance of knowledge workers in the various workspace types evaluated in this survey. However, this type of evaluation was outside the scope of this research project.

This self-report method has several inherent weaknesses. For example, the experiment can be susceptible to common method bias and social desirability bias (Dul, Ceylan, & Jaspers, 2011; Robinson, 2012). However, the potential for these biases was reduced by informing the participants that there were no right or wrong answers, and that their responses were anonymous. They were also told that the goal of the survey was not to prove a hypotheses, but rather to learn what kind of environments improve and reduce their work performance for different work tasks. Furthermore, by allowing respondents to expand upon their responses, the authors were able to further assess if the participants' responses were being influenced by other biases. (Robinson, 2012).

2.0 RESULTS AND DISCUSSION

Overall, the forest workspace types, *n1-n4*, were preferred considerably more than traditional office workspaces, as described in Tables 1 and 2. For instance, in Table 1, the dense forest space, *n1*, was preferred more than the other tested spaces for four work tasks, and second most for six tasks, as shown in row 1 of Table 1.

Table 1: Participants' quantitative preference of workspace types.

Type of Worktask (1-17)

Participant Workspace Type Preference (from most preferred to least preferred, per worktask type)

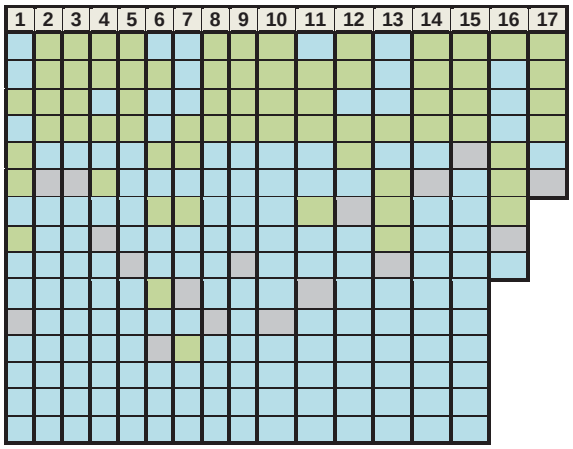
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
n1	4	6	3	2	0	0	0	0	0	0	0	0	0	0	0	0
n2	4	5	1	1	1	1	1	1	0	0	0	0	0	0	0	0
n3	0	0	3	7	3	0	1	1	0	0	0	0	0	0	0	0
n4	2	1	3	3	0	2	1	0	1	0	1	0	1	0	0	0
o1	0	0	2	0	5	0	4	1	1	0	0	1	0	0	1	0
o2	0	0	0	1	1	5	2	4	1	1	0	0	0	0	0	0
o3	2	1	0	0	2	0	1	1	0	1	1	2	1	3	0	0
o4	0	0	0	1	0	3	0	1	3	3	1	2	0	1	0	0
n5	0	0	0	0	1	3	1	1	0	3	2	3	1	0	0	0
o5	2	1	0	0	1	0	1	1	0	0	3	0	2	3	1	0
o6	1	1	1	0	0	0	0	0	1	2	2	4	3	0	0	0
o7	0	0	2	0	1	0	0	0	1	1	3	2	2	3	0	0
o8	0	0	0	0	0	1	2	0	0	1	1	1	4	5	0	0
o9	0	0	0	0	0	0	0	0	0	0	1	0	0	0	8	6
o10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5	9

Note : Workspace type definitions : n1=dense forest; n2=meadow ; n3=park ; n4=forest amphitheater; n5=cave; o1=lounge; o2=informal public; o3=cellular office; o4=informal private; o5=conference room; o6=open floor workspace; o7=lab; o8=café; o9=lecture; o10=gym

Table 2*:* Participants' workspace type preference, per work task.

Sum of Participants' Order of Preference of Workspace Types for all Activities (from most preferred (1) to least preferred (16))

Workspace Type



Note : Worktask definitions : (I) = individual task (G) = 2-6 person group task; (1)Administrative/non-technical work: email, calendar ,etc.; Take a break I(2) G(3): temporary break from work; Brainstorm I (4) G(5) idea generation; Focus/technical work I(6) G(7) complex work tasks, such as technical engineering and design tasks; Reflect I(8) G(9) think about decisions and ideas, but not making decision or judgment; Evaluate I(10) G(11) evaluate ideas + decisions; Informal meeting (12) casual meeting of 2-6 people; Formal meeting (13) : official meeting of 2-6 persons; Lunch I(14) G(15) self-explanatory; Listen to Lecture(16) 20-50 persons ; Gym (17) any exercise activities that can be performed in gym

Note : Work tasks defined and adapted from Robinson (2012), Funke (2009), and Treffinger (1995), among others

Note : Blue cell = typical workspace type; Green cell = forest workspace type; Grey cell = cave workspace type

In terms of individual work tasks, forest space types were perceived as the most beneficial work typology for 70% of the evaluated work tasks, and at least one forest typology was within the four most preferred space types for every work task. In addition, all of the forest workspace types were preferred more than typical workspace types

for a range of work-tasks, as shown in Table 2. For instance, with regard to group brainstorm tasks, the participants' preferred the four forest spaces more than the office workspaces, as shown in column 5 of Table 2. However, none of the forest types were the highest rated typology for individual and group focus work, administrative work, formal meetings, and for conducting group evaluations, as illustrated in Table 2. Nevertheless, the forest space types, particularly the dense forest typology, were among the most preferred workspaces for these tasks as well.

Interestingly, the cave, *n5*, was not highly rated for any work task, as shown in Table 1. However, as shown in Table 2, the cave environment was still more preferred than at least three to four typical work spaces for every work-task that was evaluated. Moreover, in a number of cases, the cave was more preferred than most workspaces, such as taking a break, going to lunch, group evaluation, and individual brainstorming tasks. It is important to note that the cave image used in the survey, as shown in Figure 15, was a spatially open, public cave environment. A more private cave typology may have generated different results. Nevertheless, this result indicates that the selection of nature types was based on more than the fact that they were a form of natural environment and made occupants feel they were away from their workspace. Furthermore, these results suggest that the type, and spatial qualities, of natural environments can substantially affect occupant preference.

In regards to typical office work space types, the cellular office, open floor workspace, and conference room were the only typical work space types to be rated as the best typology for some work tasks by the participants. Furthermore, these types were also within the four most preferred space types for several work tasks, although not to the extent of the forest types. The lounge, lab, and informal open workspace were also among the four highest rated space types for several work tasks. However, it is important to note that unlike the forest workspace types, every office workspace typology, other than the lounge and private informal space typology, were consistently also among the worst rated spaces for at least several work tasks.

This may be partly due to the fact that some types were perceived by the participants to be more appropriate for either individual or group work. Indeed, the comments of the participants corroborate this possibility. For example, participants noted that they considered the conference room primarily suitable for group work. However, it should be noted that this observed perception was based on the spatial qualities of the workspace types, and the forest types provided similar scale spaces, as shown in Figures 1-15. For example, a number of participants noted that the dense forest was much like a natural version of a conference room, including the same spatial constraints and privacy levels. Nevertheless, the forest spaces were perceived as providing more useful and accommodating workspace for a broader range of individual and group tasks. Thus, these results indicate that the development and integration of natural environments into office buildings can reduce project construction and operation costs, as well as increase building space use and efficiency rates, by reducing the quantity of different spaces that need to be constructed and maintained. In other words, by providing workspaces that promote the performance of multiple work tasks, the quantity of individual workspaces for individual worktasks can be reduced for a given project.

If the nature types aren't considered in the analysis, the highest rated spaces for every work task are the cellular office, lounge, open floor, conference. In addition, the café typology was the highest rated space typology for group lunches. In this analysis, these spaces also make up the majority of the four highest rated types for conducting every work task, excluding listening to a lecture and exercising. These results suggest that the other typical workspace types are less necessary. For example, the results indicate that lounge spaces, as well as informal meeting spaces, could be substituted for a dedicated café space. However, existing research indicates that the diversity and quantity of available spatial types may also impact worker performance. (Duffy & Powell, 1997; Gruys, Munshi, & Dewett, 2011; Meusburger, 2009; Vink et al., 2008) Indeed, informal public and private meeting spaces, as well as lab space, are consistently among the second and third highest rated types for several work tasks, and may therefore provide support spaces that have an adverse effect on worker performance when absent. Hence, further research is necessary to determine the effects of various work space typology combinations and quantities on worker performance.

CONCLUSION

In general, the results suggest that knowledge workers benefit from access to a diverse array of physical workspace types. Furthermore, the results indicate that existing workspace types are not the best physical workspaces for knowledge workers to conduct a variety of key work tasks, in terms of optimizing worker performance and creativity. Indeed, forest space types were found to be more preferred than typical office workspace types for the majority of work tasks conducted by knowledge workers. Therefore, forest workspace types can be developed as adaptable work environments for a range of work tasks, which will improve worker performance and the space efficiency of office environments. By providing workspace for multiple tasks, office construction and maintenance costs can also be reduced. However, it is important to note that the perception of occupying an interior, constructed forest environment as being similar to occupying a natural environment depends on the design of the space. To this end, the results of the presented survey suggest that further research into determining effective design strategies of incorporating natural environments into office buildings could generate workspace typologies that substantially improve worker performance. Thus, the results of this survey demonstrate that the development and evaluation of innovative physical workspace types for various work tasks has considerable potential to improve worker performance, as well as office building costs.

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