POST-OCCUPANCY EVALUATION OF EMPLOYEES' WORK PERFORMANCE AND SATISFACTION AS RELATED TO SUSTAINABLE DESIGN CRITERIA AND WORKSTATION TYPE

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ABSTRACT

This case study investigated employees' work performance and satisfaction in relation to sustainable design criteria used to design the interior of their office building. The case study is part of ongoing research to continue testing a questionnaire for validity and reliability, which will contribute to the development of sustainable design/occupant scales relating to satisfaction and performance. A self-administered, Internet-based questionnaire was developed that reflects a set of recognized sustainable design guidelines. It was submitted to over 200 employees of a business housed in a newly built office building in a mid-western city. Generally positive results were found for employees' satisfaction with the new facility (site, building, and interior) and their performance as related to sustainable design criteria in the new facility. Dissatisfaction with acoustic and privacy conditions were found for employees of open-office workstation types (cubicles). Exploration of prior workstation types showed that moving from private offices to cubicles decreased employees' satisfaction with new cubicles compared to moving from cubicles in a prior building to cubicles in the new building, though dissatisfaction with these two criteria was found despite prior workstation type. These findings concur with other sustainable design studies and demonstrate that the questionnaire can be used by sustainable designers to document and explore design outcomes.

KEYWORDS

sustainable design, indoor environmental quality, work performance, satisfaction, workstations, cubicles, acoustics and privacy

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1. INTRODUCTION

The aim of this study was to investigate employees' satisfaction and work performance in relation to the sustainable design criteria used to design the interior of their office building to meet the requirements of a sustainable design program. A post-occupancy evaluation (POE) (i.e., a survey that asks occupants to evaluate their work environment in a systematic and rigorous manner after it has been built and occupied for some time) was conducted one and a half years after the building was occupied. Most of the occupants were employees who had worked for the same business in a prior building that had not been designed to meet sustainable design criteria. The new building was designed to meet the US Green Building Council's LEED®-NC, version 2.2 sustainable design guidelines and achieved a high level of LEED certification. Two hundred fifty-eight people are employed and occupy this four-story building. This study focused on the indoor environmental quality (IEQ) of employees' workstations, specifically, their overall satisfaction with and perceived performance based on IEQ design criteria in their new facility.

The broader contribution of this study is to expand the scope of POE research by developing and testing an instrument that directly reflects the IEQ criteria in recognized sustainable design guidelines. A master question bank has been developed that reflects these IEQ criteria. The question bank was developed to support evaluation and feedback needs for the Buildings, Benchmarks, and Beyond State of Minnesota Sustainable Building Guidelines (B3-MSBG), which are similar to—but more comprehensive in some areas—than the LEED guidelines. The goal is to create a broadly applicable, sustainable design, post-occupancy evaluation instrument that can be used by designers to measure sustainable design outcomes that are correlated to intended outcomes of each occupant-related sustainability indicator or credit. The instrument has been tested in several sustainable buildings; this report relates to the third building tested and was performed as a case study.

Upon completion of reliability and validity testing, the POE instrument (questionnaire) will be a publicly available set of valid and reliable questions that design teams can use to evaluate their design solutions. The correlation between design solutions and intended outcomes verifies proper construction, implementation, and operation of IEQ strategies. Furthermore, even when properly implemented and operated, IEQ design strategies may not achieve intended results. Evaluating occupants' perceptions contributes to measuring sustainable design success. As is known by the reader, when following a set of guidelines, designers can select from a set of IEQ criteria or credits to include in a design solution. But, more research is necessary to identify the most effective IEQ strategies and their relationship to occupants' satisfaction and performance, both of which can affect the business owners' economic bottom line. As researchers continue to collect data with this POE instrument, a database of multiple building and occupant responses will also be available for continued study by the public.

1.1. Rationale

Businesses share a common construct, the relationship between the cost of their employees and the effect their performance has on the businesses' economic success. Employees are the second most costly part of doing business regardless of the focus of the company (Chilton & Baldry 1997). What adds to business expenses are employee issues such as turnover, retention, illness, job-related illnesses, stress, headaches, and distractions, some of which are influenced by design of the physical environment of the building in which the business is housed.

Within the designed work environment, there are many features that are known to affect employee performance such as daylighting, electric lighting, temperature, furnishings, and

indoor air quality (IAQ) (Fischer, Tarquinio, & Vischer 2004). It has been shown that the well-designed work environment can lead to a higher level of employee satisfaction and a lower level of employee turnover, which ultimately improves employee retention. Therefore, employers can reduce recruitment and training costs (Bonda & Sosnowchik 2007). Further, employee performance is enhanced with increased satisfaction with their jobs and with the physical environment (Lee & Guerin 2009), thereby also improving business profits.

Researchers have found that sustainable design criteria, especially those criteria related to IEQ, are associated with improved employees' satisfaction with their work environments and their enhanced work performance (Abbaszadeh, Zagreus, Lehrer, & Huizenga 2006; Heerwagen & Zagreus 2005; Lee & Guerin 2009). Specifically, Heerwagen (2002) found that environments that include daylighting and better access to window views have played a key role in employees' performance improvements due to psychological factors like satisfaction. Findings from the Center for the Built Environment (CBE) occupant survey comparing 21 LEED-rated/sustainable buildings to 160 non-sustainable buildings indicated that occupants in sustainable buildings were more satisfied with thermal conditions and IAQ than those in non-sustainable buildings (Abbaszadeh et al. 2006). It has also been found that when occupants had control over their thermal environment, they are more satisfied with the temperature of their workplace compared to occupants who did not (Huizenga, Abbaszadeh, Zagreus, & Arens 2006). An experiment conducted in a full-scale office laboratory found that personal control over lighting and ventilation is related to employees' improved environmental satisfaction (Newsham et al. 2009).

However, other research indicates that employees do not always show high satisfaction levels or enhanced work performance in green buildings. Clements-Croome and Baizhan (2000) found that occupants showed a low level of self-assessed productivity when their overall dissatisfaction with the indoor environment was high. Similar results were found when comparing sustainable buildings to non-sustainable buildings. For example, lower satisfaction levels with sustainable IEQ criteria such as thermal comfort, acoustic conditions, and visual privacy have been found in sustainable buildings rather than non-sustainable buildings (Lee & Kim 2008; Paul & Taylor 2008). These findings suggest that there could be other intervening factors affecting employee satisfaction. For example, Lee (2010) found that there was significantly lower employee satisfaction with visual privacy, noise level, and sound privacy when employees were housed in open-plan workstations as compared to those who were housed in enclosed private offices, all in sustainable buildings. Although it has long been known that employees find dissatisfaction with open-plan workstations, delving into the factors influencing their dissatisfaction must continue. Further, it needs to be noted if any influencing factors support, contradict, or override the benefits of using sustainable design criteria.

Although open-plan cubicles are not a component of sustainable design, they have become the dominant choice of furnishings in today's workspaces in commercial buildings (Brill, Weidemann, & BOSTI Associates, 2001; Vischer, 1996) primarily for economic reasons (Laing, 2006). Businesses are using more open-plan workstations because of the reduced space needed and flexibility of reconfiguration they allow (Duffy, 2000; Veitch, Charles, & Farley, & Newsham, 2007; Vischer 2005), both of which affects the business economic bottom line. In addition, open-plan workstations are sometimes used in sustainable design as part of a strategy to reduce building size (thus impacts) as well as provide greater access to daylight and views compared to interior private offices. Workstations are part of the building, not just furnishings; they can enhance or hinder IEQ criteria; and they are part of the business environment.

Designers must consider the influence the type of employees' workstation may have on their perceived performance and satisfaction to be able to create a more successful and profitable solution for their clients, i.e., the business. Employees' satisfaction and evaluation of their workstations are related to their perception of their own abilities or 'self-schema' to get their job done as efficiently as possible (Fischer, Tarquinio, & Vischer 2004; Van der Voordt 2004), which in turn is crucial to the quality of employees' work output (Block & stokes 1989; Gensler 2008). Further, in moves within, or from one building to another, employees often must change from one type of work environment to another such as from a private or shared enclosed (private) office to an open-plan workstation, i.e., workstation with partitions or cubicles. There is a need to determine if employee satisfaction is based on the functioning of their open-plan workstation in their new facility or if it is based on their loss of a private office. There is little research on the effect that change of employees' workstation type has on their satisfaction or performance. It is useful to explore these issues with greater depth. Therefore, questions in this POE were asked about change in workstation type from their former to their current workstations.

2. METHODS

2.1. Data collection

A self-administered, Internet-based, questionnaire was developed and submitted to employees of a business housed in a newly built office building in a mid-western city. The building was designed by an architecture and design firm based in the Midwest. The design team used the US Green Building Council's LEED®-NC, version 2.2, green building rating system to design a building that meets various sustainable design criteria thresholds (attains points or credits). The project achieved a high level of LEED certification (both the building and its exact certification level must remain undisclosed to preserve client anonymity). Some features of the research setting relevant to IEQ include: employee participation in planning process; under-floor displacement ventilation with workstation air flow control; CO^2 threshold sensors in occupied areas; increased ventilation rates; low volatile organic compound (VOC) adhesives, sealants, paints, finishes, and carpeting; occupant controllable task lighting; extensive daylighting design including atriums, high exterior windows, interior windows for borrowed light, light interior finishes for reflectivity, low cubicle partitions (for light and view access), dimming daylighting controls, and extensive access to views; sound masking; and breakout areas for private conversation.

In this study, the IEQ criteria that affect occupant satisfaction and performance were investigated, which included thermal comfort, indoor air quality (IAQ), electric and daylighting design, acoustics, views, and overall aesthetics and furnishings. All of these were queried at the scales of the facility (site, building, and interior) and workstation. Workstations were defined as the occupant's primary workspace and included private enclosed offices, shared enclosed offices, and open offices with panels (open-plan cubicles) that ranged in height from 57 to 68 inches. The questionnaire was developed for the purpose of evaluating intended occupant outcomes from use of the B3-MSBG developed by the Center for Sustainable Building Research (CSBR) at the University of Minnesota. However, the questionnaire differs from other POE questionnaires in that questions directly relate to each sustainable design criteria that are common to many sustainable design guidelines such as LEED. This provides researchers with occupant perceptions of each indicator or credit in sustainable

guidelines, allowing the success of the guidelines to be evaluated as well as the success of the design solution. The instrument had been pre-tested by office employees not related to the test building and piloted in two previous buildings for clarity, language, accuracy, and bias. Validation and reliability testing is ongoing; this study continued the testing and development of this instrument.

Statements related to employees' satisfaction and work performance as related to sustainable design criteria were evaluated on a Likert-type scale (1–7). For satisfaction, 1 was "very dissatisfied" and 7 was "very satisfied." For occupants' perception of their work performance as affected by their work environment, 1 was the environment "hindered their work performance" and 7 was the environment "enhanced their work performance." There were no descriptive words used to distinguish intervals. However, in the discussion of the findings, the research team does assign qualitative descriptors for ease of readability. Variables included sustainable criteria such as thermal comfort, acoustics, indoor air quality, electric lighting, daylighting, views, privacy, and furnishings. Questions were also included about the facility's distance from home, employees' workstation type, and demographics. Open-ended questions to allow in-depth analysis of employees' responses were also included. Additional custom questions were added to address the design team's interest in getting feedback on other design goals. Employees were notified by their employer of the questionnaire, were allowed to complete it during business hours, and were offered a small incentive upon completion of the survey.

2.2. Analysis and limitations

Descriptive statistics and independent-samples *t*-test were used for the data analysis of this study. Descriptive statistics focused on frequencies of employees' demographic characteristics and central tendency (Mean) and variability (Standard Deviation) of employees' satisfaction with sustainable criteria and perceived work performance. Independent-samples *t*-test was used to compare satisfaction and work performance of two different groups of employees based on their workstation type and whether or not they had changed workstation types from the prior building to the new building. Performance is also affected by employees' satisfaction with their physical environment (Fischer et al. 2004; Van der Voordt 2004), therefore, they must be evaluated together to determine any mutual influence or interaction.

To address the issue of whether perceived satisfaction can be separated from perceived performance, discriminant validity was examined. Discriminant validity refers to the extent that one theoretical construct differs from another. As evidence of discriminant validity of the measurement scales, none of the confidence intervals of the correlation estimates included 1.00. Further evidence supporting discriminant validity is indicated by the fact that the variance extracted estimates exceeded the square of the correlation estimates. Also, three different item analysis approaches were undertaken to test and validate the POE instrument. First, descriptive statistics were analyzed to reveal problems with individual scale items that could complicate or temper further analysis. All items demonstrated good variances (i.e., kurtosis) and normal distributions (i.e., skewness). Exploratory factor analysis results for both the item set as a whole and for each of the constructs independently (i.e., satisfaction vs. performance) were then reviewed. Evidence for the construct validity included appropriate items that loaded at least .65 on their respective hypothesized component and loaded no larger than .30 on other components in a factor analysis. Further, the sample was divided into two subsamples, calibration sample (N = 101) and validation sample (N = 102), via random sample selection. In each sub-sample, the items were factor analyzed. The factor solution from the

validation sample was deemed equivalent to the one from the calibration sample. As a final step, confirmatory factor analysis for each construct was taken independently and its diagnostic results were examined. At this stage, the magnitude of item error variances, prevalence of large modification indices, and significance of residual covariation were checked. Results from each of the three item analysis techniques were considered collectively in reaching a final decision regarding the quality of the POE instrument. In summary, the measurement items were clean, with evidence for reliability and validity, which enabled the authors to proceed to mean comparison analyses.

A limitation of the study is that all data were self-report. Therefore, data are employees' perceptions of their work performance, not actual measurement of employee records. Another potential limitation is that this is a case study of one building; more data must be collected across many different buildings to ensure a robust sample size to generalize the significant findings. The sample was adequate for exploring perceived effect of sustainable design criteria on work performance and satisfaction, was representative of the building population, and was large enough to contribute to the testing of the questionnaire. However, a fully representative sample of the entire population of employees in sustainable buildings was not achieved. As in any POE study, further research is needed to replicate and extend the present research. These limitations were taken into consideration in the conclusions drawn from the data of this study. As this process continues, it is appropriate to add the data from this building to the POE body of knowledge.

3. RESULTS

The questionnaire was sent to all 258 employees; 203 employees (78.7%) who responded had worked in the prior building. The respondents' ages ranged from 19 to 74, and 35.3% were between 35 and 44 years old; 55.2% were male and 44.8% were female. The majority of respondents (77.3%) currently work in open-plan workstations with partitions (cubicles); 22.2% have private, enclosed offices. This is a change from the previous building where 24.1% of the employees had worked in cubicles and more than half of the employees (56.2%) had a private enclosed office.

Building A was the prior building; employees had worked in that building for several years. Building B was the sustainable building; employees had worked in it for less than two years. Comparison data were only used to inform questions about change of workstation type from Building A to Building B. The two buildings were located about 17 miles from one another. The business conducted in the building was generally information processing conducted via computer, on the telephone, and face-to-face.

In the discussion of these results, the researchers interpreted the intervals on the scales with qualitative terms such as "somewhat satisfied" or "somewhat hinders" as shown in Figure 1.

3.1. Overall satisfaction and work performance with facility

Employees were satisfied with their facility and perceived that facility environment somewhat enhanced their work performance (Table 1).

Open-ended responses from employees provided some insight into their perceptions.

- *"Overall, very satisfied with facilities, great place to work!"*
- *"The facility is beautiful, inviting and generally comfortable physically."*

FIGURE 1. Researchers' descriptors of scale intervals; used for discussion only

Satisfaction		Performance	
1–1.99	Very dissatisfied	1–1.99	Hinders performance
2–2.99	Dissatisfied	2–3.99	Somewhat hinders performance
3–3.99	Somewhat dissatisfied	4–5.99	Somewhat enhances performance
4–4.99	Somewhat satisfied	6–7	Enhances performance
5–5.99	Satisfied		
6–7	Very satisfied		

TABLE 1. Overall satisfaction and work performance with facility

Variable	Mean (SD)
Overall satisfaction with the facility (site, building, and interior environment)	5.26 (1.41)
Overall effect of the facility (site, building, and interior environment) on work performance	4.98 (1.48)

- *"I do like the building. It makes me think differently about sustainability and green building in my personal life. I think it is a positive image for [employer]."*
- *"The facility is the nicest building that I have had the pleasure to work in, also, people that I bring in to show the building to are VERY impressed with what this company has done to prove that employees are a valued resource.*
- *"It is a great building and is a joy to come to work. I was skeptical of the increased productivity metric, but can attest that there are intangible benefits to this building. It is great to see an effort to actually quantify these benefits!"*

It is important to note that these data were collected over one year after the move into the new facility, which is determined to be enough time to reduce the novelty of a new environment, although there was no effort to control for this.

3.2. Effects of sustainable design criteria on work performance

The effects of sustainable design criteria related to IEQ on work performance was further investigated. Descriptive analysis shows employees' perceived work performance as related to thermal comfort, acoustics, electric lighting, daylighting, IAQ, views, privacy, and the comfort level of furnishings (Table 2). Employees' perceived the work environment somewhat enhanced their performance with daylighting (M = 4.96, SD = 1.73), IAQ (M = 5.37, SD = 1.28), view (M = 4.88, SD + 1/61), thermal comfort (M = 4.17, SD = 1/74), electric lighting (M = 4.76, SD = 1.51), and comfort level of furnishings (M = 4.95, SD + 1.48). However, employees reported that acoustics (M = 3.53, SD = 1.89) and privacy (M = 3.18, SD = 1.85) somewhat hindered their performance.

Open-ended responses indicated that the loss of private work environments (which increased from 24.1% of the occupants working in cubicles to 77.3% working in cubicles) might have influenced some employees. This is further explored in the workstation type question next.

TABLE 2. Effect of sustainable design criteria on employees' work performance.

Sustainable Design Criteria	Mean (SD)
Overall effect of daylighting	4.96 (1.73)
Overall effect of indoor air quality	5.37 (1.28)
Overall effect of view	4.88 (1.61)
Overall effect of acoustics (sound privacy, background noise)	3.53 (1.89)
Overall effect of privacy	3.18 (1.85)
Overall effect of thermal comfort (temperature, air velocity, humidity)	4.17 (1.74)
Overall effect of electric lighting	4.76 (1.51)
Overall effect of the comfort level of furnishings	4.95 (1.48)

- *"Daylight and air quality are exceptional."*
- *"The office in [the previous building] was just more conducive to getting things done without interruptions."*
- *"To me personally, the work environment [in the previous building] was much more conducive to getting my work done efficiently. The offices were much more private, less noise."*
- *"It is much harder to get things done in this building [as compared to the previous building] due to the noise and open atmosphere."*

3.3. Comparison of overall satisfaction and work performance by workstation type

Acoustics and privacy conditions in the building were found to be negatively related to work performance, and measures of these design criteria are often related to workstation type. In this study, it was found that employees in enclosed private offices, enclosed offices shared with other people, and open-plan workstations with partitions (cubicles) showed positive satisfaction levels (Table 3). Generally, employees showed positive satisfaction level, regardless of workstation type. Employees in enclosed offices were more satisfied with the facility (site, building, and interior environments) compared to employees in cubicles. Regardless of workstation type, employees perceived that the overall facility "somewhat enhances" or "enhances" their work performance, and employees perceived a positive effect of the facility on their work performance. Based on these results, a closer look at workstation type was warranted specifically to investigate the effect of changing from one office/workstation type to another with the move to the new building. Examples of the open-ended responses related to workstation type follow.

- *"The enclosed private office in [the previous building] facilitated concentration and avoided noise and interruptions by co-workers."*
- *"Privacy is non-existent. I frequently go to a more private area for phone conversations so that I do not disturb my neighbors."*
- *"It was easier to concentrate with the privacy of higher and enclosed offices. Sounds travel all over in this building [current building]. Not just talking, phones and normal work conversations but long distance sounds."*

TABLE 3. Satisfaction and effect on work performance by workstation type.

Workstation Type		Overall Satisfaction	Overall Work performance
Enclosed office, private	Mean	5.80	5.67
	SD	1.21	1.29
	N	47	47
Enclosed office, shared with other people	Mean	6.50	7.00
	SD	.71	.
	N	2	2
Workstation with partitions (Cubicles)	Mean	5.16	4.80
	SD	1.40	1.43
	N	172	171

3.4. Comparison of satisfaction and work performance by workstation type change

As shown in Table 4, employees who changed workstation type from enclosed private offices in the previous building (hereafter known as Building A) to cubicles with partitions in the current building (hereafter known as Building B) showed positive satisfaction levels with the new facility. Further, there were no significant mean differences when compared to employees who had always worked in cubicles with partitions (t (119) =-1.68, p>.05). These employees also perceived that the overall facility of Building B has a positive effect on their work performance regardless of workstation type and whether or not they changed workstation type (t (119) = –1.61, p > .05). Thus, prior workstation type does not appear to significantly affect employees' overall satisfaction or perceived effect on their work performance. However, employees who changed from enclosed private offices in the Building A to cubicles with partitions in Building B showed dissatisfaction with acoustic conditions, whereas employees who moved from cubicles in the Building A to cubicles in the Building B showed satisfaction with acoustic conditions (t (118) = –2.68, p < .01). Furthermore, employees who moved from enclosed private offices to cubicles with partitions indicated that acoustic conditions, such as sound privacy and background noise, and privacy conditions "somewhat hindered" their work performance. Employees who had been working in cubicles with partitions in Building A and remained in similar workstations in Building B also perceived that these two sustainable design criteria have an overall negative effect on their work performance (see Table 5). For these two sustainable design criteria, there were mean differences of effect on work performance between the two groups: most employees who had changed their workstation type from enclosed private offices to cubicles with partitions tended to show more negative responses about the effect of acoustic conditions and privacy conditions on their work performance compared to employees who were always in cubicles with partitions, i.e., acoustic conditions (t (119) = –3.93, p < .001) and privacy conditions (t (118) = –3.03, p < .01). They stated that:

- *"Moving from an enclosed office in the previous building (A) to an open cubicle in the new facility (B) is the number one thing that hinders my productivity. The number two thing*

TABLE 4. Satisfaction and effect on work performance in new facility by prior workstation type

Variables	Mean (SD)		*t*	df	Sig.
	Private in A to Cubicle in B (N=74)	Cubicle in A to Cubicle in B (N=47)			
Satisfaction					
Overall satisfaction with the facility (site, building, and interior environment)	4.76 (1.58)	5.21 (1.23)	–1.68	119	.095
Overall satisfaction with acoustic conditions	**3.62 (1.71)**	**4.47 (1.68)**	**–2.68**	**118**	**.008****
Overall satisfaction with thermal comfort conditions (temperature, air velocity, humidity)	4.07 (1.96)	3.62 (1.81)	1.27	118	.207
Overall satisfaction with lighting, daylighting, and views	4.52 (1.53)	4.72 (1.81)	–.66	118	.511
Overall satisfaction with indoor air quality conditions	5.32 (1.35)	5.13 (1.36)	.76	118	.446
Overall satisfaction with furnishing, adjustability, finishes, and privacy	3.84 (1.62)	4.28 (1.50)	–1.49	119	.138
Overall satisfaction with personal controls (temperature, lighting, etc.)	3.90 (1.62)	3.74 (1.78)	.51	118	.613
Performance					
Overall effect of the facility (site, building, and interior environment) on work performance	4.45 (1.57)	4.89 (1.36)	–1.61	119	.110
Overall effect of acoustic conditions (sound privacy, background noise, etc) on work performance	**2.28 (1.26)**	**3.38 (1.82)**	**–3.93**	**119**	**.000*****
Overall effect of privacy conditions on work performance	**2.11 (1.16)**	**2.87 (1.60)**	**–3.03**	**118**	**.003****
Overall effect of thermal comfort conditions (temperature, air velocity, humidity) on work performance	4.26 (1.76)	3.72 (1.70)	1.65	119	.103
Overall effect of electric lighting on work performance	4.55 (1.51)	4.68 (1.64)	–.46	118	.650
Overall effect of daylighting conditions on work performance	4.70 (1.73)	4.74 (2.10)	–.12	119	.905
Overall effect of indoor air quality conditions on work performance	5.24 (1.38)	5.17 (1.13)	.30	119	.762
Overall effect of view conditions on work performance	4.41 (1.60)	4.66 (1.82)	–.81	119	.421
Overall effect of the comfort level of the workstation furnishings on work performance	4.35 (1.55)	4.79 (1.41)	–1.57	117	.120

*$p < .05$, **$p < .01$, ***$p < .001$

that hinders my productivity is the constant flow of people taking tours of the building that walk by and disturb me when I'm working."

- *"I felt more productive at the current building (A) due to having an office rather than a cubicle where you can hear others talking on the phone or in private conversations about work or home..."*
- *"To me personally, this building [Building A] was much more conducive to getting my work done efficiently. The offices were much more private, less noise."*

What is important to note, however, is that employees in cubicles in Building B are dissatisfied with the acoustic and privacy conditions, regardless of which type of workstation they had before the move.

Although the impact of prior workstation type was statistically significant in how it affects satisfaction with acoustic conditions and the effect of acoustic and privacy conditions on work performance, employees' satisfaction by workstation type change varied across acoustic and privacy condition variables. As shown in Table 5, there were mean differences between employees who moved from private offices to cubicles and employees who remained in cubicles in the satisfaction with background noise (t (118) = –2.06, $p < .05$) and with the sound privacy in the workstation (t (119) = –2.02, $p < .05$). In these two variables, employees who moved from private offices to cubicles showed decreased satisfaction level compared to employees who did not change workstation type: employees who moved from private office to cubicles were dissatisfied with the background noise and were very dissatisfied with the sound privacy in the workstation, while employees who have always worked in cubicles were somewhat dissatisfied with the background noise and were dissatisfied with the sound privacy. However, it must be noted as with Table 4 above, that satisfaction with all acoustic conditions was low in cubicles, regardless of change. Employees stated about Building B:

- *"There is NO privacy at our work stations. You can hear phone conversations, people eating their lunches."*
- *"Since we are in cubicles, I can hear everybody's phone conversations, personal conversations, etc. It is very distracting."*

TABLE 5. Acoustic and privacy conditions by workstation type change as related to satisfaction.

Variables	Mean (SD)		t	df	Sig.
	Private to Cubicles (N=74)	Cubicles to Cubicles (N=47)			
The ability to understand desired sound in the workstation	4.27 (1.49)	4.40 (1.38)	–.50	119	.621
The background noise in the workstation	2.81 (1.52)	3.45 (1.84)	–2.06	118	.041*
The sound privacy in the workstation	1.62 (0.98)	2.04 (1.32)	–2.02	119	.046*
The visual privacy in the workstation	2.75(1.50)	3.15 (1.68)	–1.35	118	.181

*$p < .05$, **$p < .01$, ***$p < .001$

- *"It can be very distracting hearing EVERTHING going on around you, but can be very beneficial when I hear conversations that pertain to something I am working on. Overall, I would say it's better to be in an open setting. if the background noise gets that bad, I can always put on some headphones."*
- *"My office has no privacy because it's all glass."*
- *"Due to the glass, I get a lot of sound from the cube area bouncing into my office - can be very noisy when on phone. "*
- *"There is no way to have a private phone conversation at your cubicle. Neighbor and I sit facing each other, with just the cubicle wall between us. It is very distracting when he is on the phone."*
- *"Lack of privacy due to tour groups — would be nice to have blinds on my exterior window that could be shut when I am having meetings in my office to cut out the tour distractions."*
- *"The cubicle design is poor. Replacing existing cubicle walls with taller walls to reduce background noise and add some privacy would be an improvement."*

4. DISCUSSION

This study provided empirical evidence that designing an office building with attention to sustainable IEQ criteria is associated with positive outcomes including employees' overall satisfaction with the facility and their perceived effect of specific design criteria on their work performance (e.g., daylighting, IAQ, and view).

The findings of this study suggest that workstation type is a major intervening factor that may affect employee satisfaction and work performance as related to specific design criteria. Although the transition from private offices to cubicles further increases the negative effect of acoustics and privacy on perceived work performance, both groups (employees who moved from private offices to cubicles and employees who remained in cubicles) showed a negative effect on work performance from acoustic and privacy conditions. This finding confirms other research on privacy and acoustic constraints in open-office workstation types. It seems that seldom are employees in other than enclosed private offices satisfied with these two attributes, which confirms other studies on acoustics (Van der Voordt 2004). A specific contribution of this study is the finding that employees are dissatisfied with background noise (M=2.81–3.45) and sound privacy (1.62–2.04) (see Table 5). With this information, interior designers can address these design components more thoroughly. Another finding is the low satisfaction with visual privacy (2.75–3.15). Often employers try to ameliorate the effects of open office planning by adding white noise and areas for private conversations. Despite that these strategies were used in this building, the acoustic and privacy satisfaction results echo other research in terms of areas of dissatisfaction with open office planning. Although it is well known that there is dissatisfaction with acoustics and privacy in open-office planning, knowing which components of acoustics and privacy are dissatisfactory is helpful to designers.

These results confirm the necessity of including deeper acoustics and privacy investigations related to occupant satisfaction and performance by workstation type. Seldom have these factors shown such a strong relationship in other studies. Further, the building was designed to meet high acoustic standards, a component of the B3-MSBG guidelines. LEED CI does not include acoustics and privacy criteria in its IEQ category, and B3-MSBG does not thoroughly deal with audio privacy. Based on these results, these criteria should be included in sustainable guidelines.

4.1. Implications

With regards to research in this area, much would be gained if future efforts strongly addressed open-office planning as it relates to employees' satisfaction and its effect on their work performance across a range of IEQ criteria. Even in projects such as this one, with careful attention to designing for IEQ criteria, the challenges of open-plan offices in the areas of acoustics and privacy were concerns and more evidence-based guidance for designers is needed. However, one of the lessons of this project is that careful attention to a broad range of sustainable IEQ design criteria can lead to overall satisfaction, and overcome areas of specific dissatisfaction such as specific problems with acoustics and privacy. Thus, further study on how an overall sense of satisfaction is related to satisfaction or dissatisfaction with components of the environment is also useful and may help inform a holistic approach to IEQ design in terms of its integrated effect on occupants. For example, although not covered in this report, the POE instrument used in this study also identified zone location of respondents' workstations. Administering additional acoustic and privacy questions to dissatisfied respondents identified by zone can help designers uncover location-specific or subject-specific acoustic issues, which might then be resolved. Deeper acoustic and privacy questions that reflect specific sustainable design guideline criteria can be included in follow-up studies and therefore can also be added to the growing database of knowledge.

The results of this study may also be used by designers to better understand the design factors that are associated with strategic business management. While many designers have focused on improving design quality to satisfy their clients, the changes in the business environment in recent years now demand much more of designers. From a client's viewpoint, generating satisfied employees may be the key goal of sustainable design. Perhaps most critically, clients may expect to increase their profitability via improved employee performance in sustainable work environments. Hence, the results presented here provide practitioners with insight on the benefits of attention to sustainable IEQ design criteria that help to meet their clients' strategic goals.

In the last 10 years, evaluations have been conducted on hundreds of sustainable or green buildings. Initially, and still, the purpose of many of these studies was to test the physical performance of the building systems, e.g., energy consumption, thermal balance, or indoor air quality. With the advent of sustainable design guidelines such as LEED and the B3-MSBG, the importance of the occupant's quality of life was recognized, and design of the interior environments of these buildings is being addressed in a more comprehensive way. Credits or points can be achieved for designing for occupant health, safety, comfort, and the function of their workspaces. This is a major shift for the design professions—from building-centered evaluation to inclusion of occupant-centered evaluation. Studies such as these are increasing in number and complexity. The results from this study can add to the growing body of knowledge, specifically on acoustics and privacy conditions and workstation type. Continued testing of the POE instrument is necessary to complete its development as a valid and reliable tool for many building types. More importantly, the continued development of this POE instrument and its access to the public will contribute to the design of interior environments that support people's needs and contribute to the business' economic success. Finally, these findings also show the strong relationship acoustics, a B3-MSBG IEQ sustainable criteria, has to occupant performance. Acoustics and privacy must be addressed as in all sustainable design guidelines.

5. CONCLUSIONS

This study investigated employees' perceptions of the effect of sustainable design criteria on satisfaction and performance and found mostly positive results from use of sustainable IEQ design criteria in the new building. Despite careful attention to accommodate the acoustic and privacy issues in open plan offices, dissatisfaction with these criteria were found for employees of these workstation types. This result concurs with many other researchers (Lee & Kim 2008; Paul & Taylor 2008) who have investigated acoustic and privacy issues in office environments in both sustainable and non-sustainable buildings. Additional study is warranted to find the most acceptable design response to this issue.

An exploration of prior workstation types showed that moving from private offices to cubicles decreased satisfaction with new cubicles compared to moving from cubicles in a prior building to cubicles in the new building, though dissatisfaction was found despite prior workstation type. Although this may be no surprise, these data can provide rationale for business owners to prepare employees for the move and change in workstation type. This idea also supports use of open plan cubicles as a component of sustainable design as they offer more flexibility in current and future space allocation and use, reduced spatial allocation, which reduces real estate and conserves use of materials. Perhaps some of the dissatisfaction related to open-office workstations can be ameliorated by employee education or preparation. Additionally, business owners can align this change to their business goals such as increased communication or collaboration, providing employees with a different culture from which they can benefit.

These findings contribute to designers' abilities to weigh the potential costs and benefits of alternative approaches to office design. Further, for the building owner and designers, the outcomes of this study can serve as a baseline for future studies to track employees' perceptions over time, to indicate whether alterations in the building are successful, and to inform the design of new facilities.

Because of the large numbers of variables that can affect employees' performance and satisfaction, it is important for designers to understand how individual variables affect the end users of the space, specifically variables that are within designers' control. With a better understanding of how these variables affect employees' performance, designers can make informed decisions about which variables are the most important ones and warrant spending project dollars to ensure the highest level of employees' performance and satisfaction for their clients.

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