



Indoor Environment Quality + Workplace Environment Science Teaching Student Services Building (STSS) Report 1

**November 2011, Minneapolis, MN
Sustainable Post-Occupancy Evaluation Survey (SPOES)
B3 Guidelines**

**Denise A. Guerin, PhD
(contact: dguerin@umn.edu)
Kara Freihoefer, PhD
Hye Young Kim, PhD
Theresa Bauer, MA
Angelita Scott, MS**

*College of Design
University of Minnesota*

1.0 Overview

The purpose of this report is to examine the connection between sustainable design criteria used in the design of the Science Teaching Student Services Building (STSS) and employees' satisfaction with their work environments. The STSS facility was designed using the B3 Guidelines (formerly known as the Minnesota Sustainability Guidelines or MSBG) and completed for occupancy in 2010 fall semester. The B3 Guidelines track specific state-funded buildings as a means of demonstrating real outcomes aimed at the conservation of energy resources, creation and maintenance of healthy environments, and occupants' satisfaction with their work environments. The Sustainable Post-Occupancy Evaluation Survey (SPOES) was developed to assess human outcomes in classroom and workplace settings in compliance with the project tracking requirements for the B3 Guidelines goals. The survey was conducted at about 12-months post occupancy in November 2011 and serves as the first of two required POE events.

This SPOES report focuses on employees' satisfaction with the physical environment as related to 15 overall indoor environment quality (IEQ) criteria such as lighting, thermal, and acoustic conditions in their primary workspaces, i.e., offices. Employees' satisfaction with the facility (site, building, and interior) and the effect of the facility's physical environment on their perceptions of their work performance and health are included. Finally, a brief look at employees' commuting and physical activities within the building are also reported. The report provides descriptive information about employees' perceptions of the IEQ of their work environments. In addition, this information serves the broader development of knowledge regarding the influence of IEQ on employees.

2.0 Method

SPOES consists of a self-administered, Internet-based, questionnaire submitted to and completed by employees. The SPOES questionnaire has been tested for **validity** (measures what it is intended to measure) and **reliability** (repeatability or replicability of findings) in studies involving similar facilities and employees. Employees rate their level of satisfaction on a **Likert-type scale** (measurement scale) from 1 (very dissatisfied) to 7 (very satisfied) with IEQ of the facility and their primary workspaces. They also rate the influence of their physical environment on their perception of their work performance and health on a scale from 1 (hinders) to 7 (enhances). There were no physical measurements taken of environmental conditions such as temperature or acoustic level. This study is limited to employees' perceptions.

The report provides a descriptive summary of the results stated as a **mean** (M = average of all responses), **standard deviations** (SD) (how different scores are from each other and the mean), and **number of responses** (N) for questions analyzed. The mean for a 7-point scale is 4.00. Lower or higher means reflect stronger tendencies towards dissatisfaction/satisfaction and hinders/enhances. Means that are close to the center of the scale (4) are considered to be neither dissatisfied/hinders or satisfied/enhances.

When interpreting **mean** responses, the following labels were used:

1-3.99 dissatisfied (hinders)

4-4.49 neither satisfied (enhances) or dissatisfied (hinders)

4.5-7 satisfied (enhances)

An IEQ Score is also calculated for employees' satisfaction with IEQ in their primary workspaces. This is a statistical combination of all IEQ scores, which results in a single IEQ score for all employees on all IEQ variables and is reported in an IEQ Scorecard.

2.1 Description of the Questionnaire

Employees first rate their level of satisfaction with the facility and the influence of their physical environment on their perception of their work performance and health. Then they respond to questions about their satisfaction with their primary workspaces in relation to the IEQ criteria. The questionnaire uses the IEQ criteria from the B3 Guidelines and relates each of them to employees' satisfaction with their physical environment. Additional questions are also asked to delve deeper into IEQ conditions at the primary workspace.

Criteria include (in alphabetical order):

- | | |
|---------------------------------|---------------------------------------|
| 1. Acoustic Conditions | 9. Lighting Conditions |
| 2. Appearance | 10. Personal Adjustability Conditions |
| 3. Cleaning and Maintenance | 11. Privacy |
| 4. Daylighting Conditions | 12. Technology |
| 5. Electric Lighting Conditions | 13. Thermal Conditions |
| 6. Function | 14. Vibration and Movement |
| 7. Furnishings | 15. View Conditions |
| 8. Indoor Air Quality | |

2.2 Limitations

Employees' participation is voluntary, and responses are self-reported. As is true with all survey research, the responses indicate employees' perceptions. There were no physical measurements, e.g., temperature, humidity, or lighting levels, of the environment taken.

3.0 Sample Description

3.1 Description of Building

Built in 2010, the five-story, 118,000 square-foot STSS building houses instructional classrooms and administrative offices that service University of Minnesota (UMN) students (see Figure 1). It was designed according to the B3 Guidelines. The building also received LEED New Construction (NC) Version 2.2 Gold Certification. The STSS building is located along the East Bank of the Mississippi River in the heart of the UMN Minneapolis campus. The Mississippi River bisects the UMN Minneapolis campus into two campuses that are referred to as the West Bank and East Bank campuses.

The STSS building integrates both classrooms and student service offices into one facility. The building is occupied throughout the year by faculty, staff, students, and other transient individuals; however, the building has its highest occupancy loads during the fall and spring semesters (September through May). Some of the floors in the building have classrooms adjacent to student services and office areas. Floors 2, 4, and 5 have both classrooms and office areas. Floors 1 and 3 do not contain offices. Floor 1 contains 10 classrooms. Floor 3 contains four classrooms, student common areas, and the One Stop student service counter (registration, grades, degree planning, and student accounts).

The areas of interest for the study are floors 2, 4, and 5, which contain both office areas and classrooms. Only the office environments (workspaces) and employees were studied. The classrooms and their occupants on these floors were investigated under another study (see *STSS-1C SPOES Report*

on B3 Web site).



Figure 1. STSS building (Photo credit: <http://www1.umn.edu/twincities/maps/STSS/>)

3.2 Description of Respondents

The STSS has 93 workspaces, for a potential total sample size $n=93$. The response rate was approximately 75%. The majority of the respondents were between the ages of 18 to 24 (27%), followed by 25 to 34 (23%), and 35 to 44 (20%). There were no respondents 75 years of age or older. Of those responding, 46 were female (66%) and 24 males (34%). Sixty-four percent of the respondents had worked for UMN for three years or more, followed by 21% who had worked for UMN for one to two years. The majority (40%) of the respondents were student advisers or counselors. Seventeen percent were undergraduate student employees.

Approximately half (46%) of the respondents worked between 31-40 hours per week and 29% worked more than 40 hours per week. Most of these respondents spent 31 or more hours in the STSS building (71%). Approximately half of the respondents (47%) spent more than 75% of their time in their workspace, while 37% of the respondents spent between 51-75% of their time in their workspace.

Overall, 60% (42) of the respondents' workspaces were open. Open workspaces were classified as a cubicle with 5+ feet high partitions or a desk in an open office with no partitions, which were only located in the reception area on floors 4 and 5.

4.0 Findings and Discussion

4.1 STSS Facility (Site, Building, and Interior): Overall Satisfaction, Work Performance, and Health

Employees responded to questions concerning the STSS facility (site, building, and interior) and their overall satisfaction with the facility, overall perceptions of their work performance in relation to the facility, and their overall perception of their health in relation to the facility. Results indicated that

employees were **satisfied** with the (Mean = 5.24) STSS facility (site, building, and interior) and reported that their overall work performance was **enhanced** (Mean = 4.97) by the facility. Employees reported that their overall health was **enhanced** (Mean = 5.15) by the facility. Table 1 and Figure 2 show a summary and interpretation of their responses.

Table 1. Overall satisfaction, work performance, and health related to the STSS building.

STSS Facility (site, building, and interior)	Mean (1-7)	SD	N	Interpretation
Overall satisfaction	5.24	1.17	7	Satisfied
Overall work performance	4.97	1.44	7	Enhances
Overall health	5.15	1.22	7	Enhances

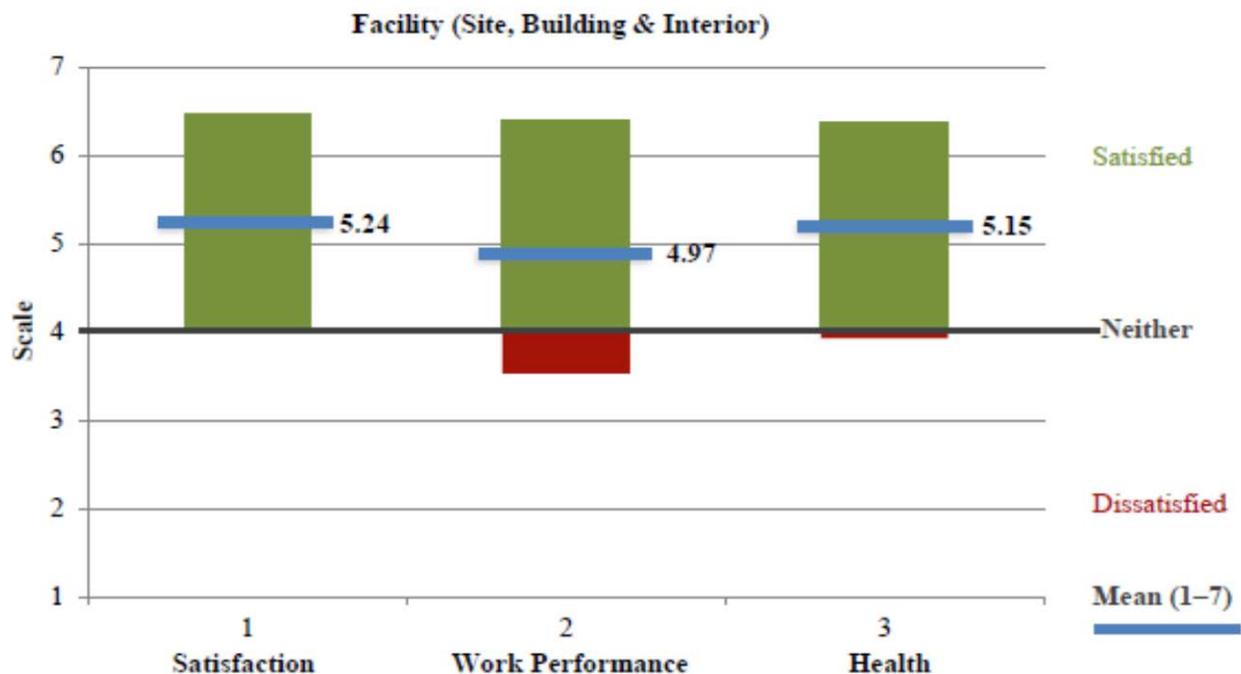


Figure 1. Overall satisfaction, work performance, and health related to the STSS facility

4.2 Primary Workspace: Overall Satisfaction, Work Performance, and Health

Employees responded to questions concerning their overall satisfaction and overall perceptions of their work performance, and health being as related to with their primary workspace (e.g., private office, workstation, or other primary workspace). Table 2 and Figure 3 show a summary and interpretation of their responses. Results indicated that employees were **satisfied** (Mean = 5.28) with their primary workspace, their overall work performance was **enhanced** (Mean = 5.28) by their primary workspace and their overall health was **enhanced** (Mean = 5.26) by their primary workspace.

Table 2. Overall satisfaction, work performance and health related to primary workspace.

Primary Workspace	Mean (1-7)	SD	N	Interpretation
Overall satisfaction	5.39	1.30	79	Satisfied
Overall work performance	5.28	1.20	79	Enhances
Overall health	5.26	1.20	79	Enhances

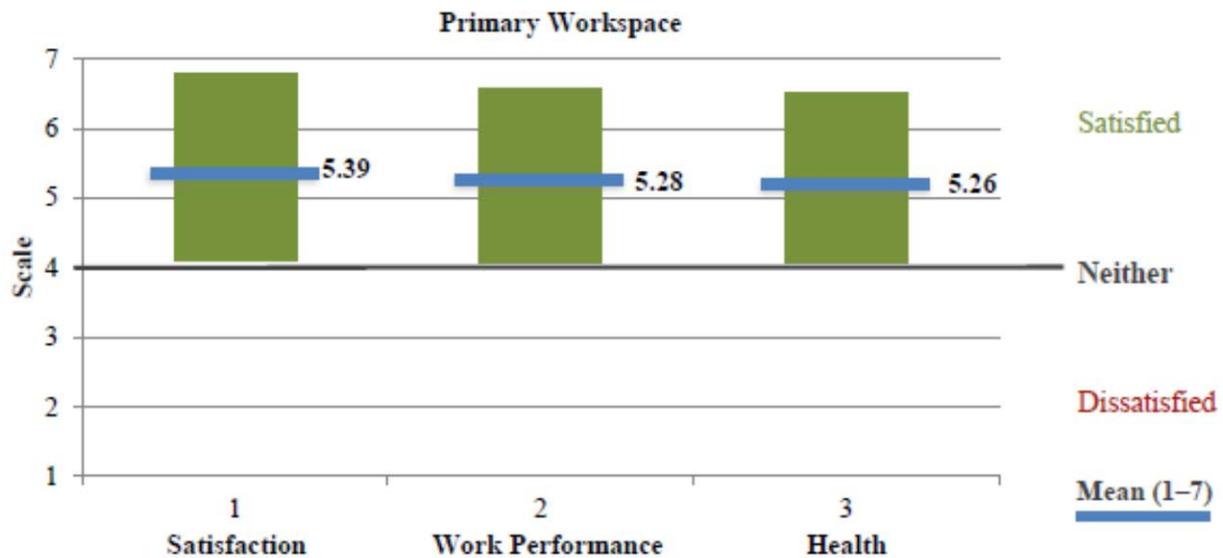


Figure 2. Overall satisfaction, work performance, and health related to primary workspace.

4.3 Primary Workspace: Satisfaction with Indoor Environment Quality (IEQ)

Employees responded to questions concerning their satisfaction with IEQ categories (thermal conditions, indoor air quality, acoustic conditions, etc.) related to their primary workspace (e.g., private office, workstation, or other primary workspace). Most of the criteria relate to an overall condition, however some criteria such as thermal conditions include additional questions about temperature, humidity, and air velocity to delve deeper into selected criteria. Table 3 and Figure 4 show a summary of the means, the standard deviations, and interpretation of their responses.

Table 1. Satisfaction related to IEQ in primary workspace

	Primary Workspace	Mean(1-7)	SD	N	Interpretation
1	Indoor air quality	5.83	1.43	79	Satisfied
2	Furnishings	5.67	1.16	79	Satisfied
3	Appearance (aesthetics)	5.63	1.19	79	Satisfied
4	Electric lighting conditions	5.52	1.30	79	Satisfied
5	Lighting conditions	5.42	1.36	79	Satisfied
6	Function	5.37	1.34	79	Satisfied
7	Vibration and movement	5.37	1.46	79	Satisfied
8	Technology	5.27	1.43	79	Satisfied
9	View conditions	4.96	1.79	79	Satisfied
10	Daylighting conditions	4.89	1.77	79	Satisfied
11	Acoustic conditions	4.71	1.77	79	Satisfied
12	Thermal conditions	4.53	1.65	79	Satisfied
13	Personal adjustability	4.35	1.64	79	Neither S/D
14	Cleaning and maintenance	4.34	1.75	79	Neither S/D
15	Privacy conditions	4.29	1.75	79	Neither S/D

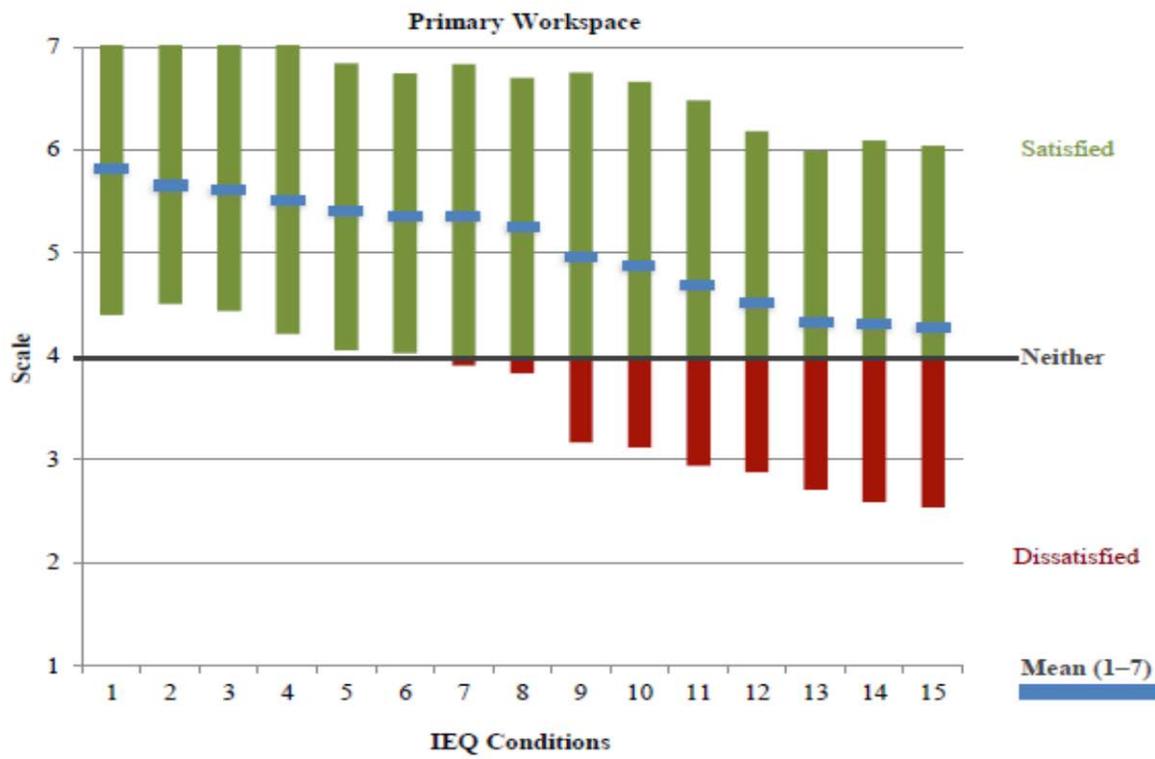


Figure 3. Satisfaction with IEQ criteria with the primary workspace (IEQ numbers 1-15 are included in Table 3 above)

Results indicate that employees were satisfied with the following IEQ conditions in their primary workspaces:

- Indoor air quality
- Furnishings
- Appearance
- Electric lighting conditions
- Lighting conditions
- Function
- Vibration and movement
- Technology
- View conditions
- Daylighting conditions
- Acoustic conditions
- Thermal conditions

Employees were neither dissatisfied nor satisfied with IEQ conditions for the following:

- Personal adjustability conditions
- Cleaning and maintenance
- Privacy conditions

4.4. IEQ Satisfaction Scorecard

The IEQ Satisfaction Scorecard is determined by developing weighted factors of all categories, which is more representative of a fair overall IEQ score. For example, it might be more important for an employee to have satisfying thermal conditions than to have satisfying indoor air quality. Thus, if the employee gives a high thermal satisfaction score and a lower indoor air quality satisfaction score, the overall IEQ satisfaction will be scored much higher than one with the inverse statistics.

The weighted scoring system was developed by employing the following procedures:

1. **Factor analysis** (a multivariate statistical procedure) was conducted to determine the importance of various IEQ categories.
2. The factor loading of each IEQ category was regarded as the individual weight.
3. The weighted sum score was used to calculate the final mean score illustrating how well a particular building performed in terms of satisfying its occupants' IEQ needs. This becomes the IEQ Score

As shown in Figure 5, the **IEQ satisfaction score** for STSS is **5.07**.



Figure 4. IEQ Satisfaction Score for STSS.

Overall, employees show a positive satisfaction with IEQ response, as indicated by the weighted mean score of 5.07. Satisfaction with **Appearance** of employees' primary workspace was identified as the category that contributed most to the IEQ Satisfaction Score, followed by satisfaction with the **IAQ** of the primary workspace. They determine IEQ satisfaction more strongly than other categories and differ only slightly from the ranking of the mean scores where **IAQ** and **Furnishings** were the top satisfaction scores. Overall **Daylighting Conditions** was the least contributing category to the IEQ Satisfaction Score, meaning that it was important to employees in their evaluation of IEQ and differed from the lowest ranked means from **Personal Adjustability**, **Cleaning and Maintenance**, and **Privacy**. This score of 5.07 validates the overall satisfaction score in Table 2 (Mean = 5.39). They are similar but the IEQ Score is slightly lower because it may reflect some other factors beyond IEQ such as location or size of primary workspace. The IEQ Scorecard gives us more refined knowledge.

5.0 Physical Activity Engagement and Commuting Practices

In the final section of the survey, employees responded to questions regarding their overall physical activity while at STSS (site, facility, and interior) and their commuting practices.

5.1 Physical Activity Engagement

Providing employees with opportunities for alternative paths of travel around the workplace, e.g., taking stairs as opposed to the elevator, provides opportunities to engage in additional types of physical activities. Engaging in physical travel throughout the work environment can be associated with healthier lifestyles.

Table 4. Overall physical activity (walking, stair use, etc.) affected by the STSS facility.

STSS facility (Site, facility, and interior)	Mean (1-7)	SD	N	Interpretation
Overall physical activity (walking, stair use, etc.)	4.78	0.94	79	Enhances

Results indicated that employees felt that STSS **enhanced** (Mean = 4.78) their physical activities (walking, stair use, etc.). Further, of the 79 respondents to this set of questions: 53% said the facility **enhances** their overall physical activity; 44% said it **neither enhances nor hinders**, and 3% said it **hinders**.

5.2 Commuting Practices

The STSS building is located on the East Bank campus along Mississippi River in the heart of the UMN Minneapolis campus. The East Bank campus is north of the metropolitan hub, providing bus and light rail transit service through the campus environment. The University provides several parking facilities, bike paths, and sidewalks throughout the campus and adjacent to the STSS building.

Table 5 provides results on employees' commuting mode of transportation. These results, although not related to IEQ, do offer the University insight into employees' commuting behaviors and opinions. These data can provide important information about commuting practices that can reduce transportation energy consumption.

Table 5. Primary mode of transportation.

Commuting Mode	Drive alone (or with children under 16)	Carpool or vanpool	Public transit	Bicycle	Walk	Other
Primary mode of transportation	38%	5%	30%	5%	14%	5%

The most frequent mode of transportation to STSS was driving alone (or with children under 16) (38%), followed by public transit (30%), walking (14%), bicycle (5%), carpool or vanpool (5%), and other mode of transportation (5%).

6.0 Conclusions

6.1 Summary

A post-occupancy evaluation was conducted of employees of STSS at approximately 12 months after it was first occupied. Seventy-five percent of the employees responded to the survey.

The survey included questions related to employees' overall satisfaction with the facility (site, building,

and interior) and influence of the facility on their overall work performance and health. Employees were satisfied with the facility (Mean = 5.24); they found the facility neither enhanced nor hindered their overall work performance (Mean = 4.97) and enhances their overall health (Mean = 5.15). In addition, similar results were reported when employees were asked these same questions about their primary workspaces (private office, shared office, laboratory, etc.). They reported overall satisfaction (M = 5.28) with their primary workspaces, their overall work performance (M = 5.28), and overall health (M = 5.26). As the range of scores was from 1-7, scores that showed satisfaction are in the mid-level range, although still positive.

Most of the survey questions related to employees' satisfaction with the IEQ categories in their primary workspaces (private office, laboratory, etc.). Employees' responses showed they were satisfied with the majority of the IEQ categories. The mean satisfaction scores ranged from 4.29 (Privacy Conditions) to 5.83 (Indoor Air Quality). Again, this shows a positive but moderate level of satisfaction. Employees responded neither dissatisfied nor satisfied with Personal Adjustability, Cleaning and Maintenance, and Privacy Conditions with scores ranging from 4.29 to 4.53.

From the employees' responses, an IEQ Score was developed and shows respondents' satisfaction with all categories and the contribution of each category to that satisfaction score. For STSS, the IEQ Satisfaction Score was 5.07. Finally, employees reported that STSS enhances their physical activity, which is one of the sustainable design criteria that influences occupant behavior.

6.2 Recommendations

Although the satisfaction scores are in a positive direction, and there were no dissatisfying IEQ categories, improvement may be possible. For IEQ categories that have physical measurement possible, e.g., thermal, acoustic, and lighting, it is recommended that these measurements be taken overtime in open, closed, and communal workspaces. Recommendations follow:

Lighting Conditions

- Identify performance criteria that are to be met to achieve goals.
- Determine if any task areas differ now from original intent.
- Develop additional quality lighting criteria as needed for special facility issues such as employees' ages, duration of task, influence of daylight quality or quantity.
- Conduct onsite measurements using Illuminating Engineering Society standards for employees' tasks.
- Log complaints related to lighting conditions overtime.

Acoustic Conditions

- Identify acoustic criteria for overall requirements.
- Determine if any task areas differ now from original intent.
- Develop any additional special acoustical performance requirements to support functional programming of facility (e.g., sources of recurrent noise that need to be controlled, special user populations that may have distinct auditory performance limitations, or multiple uses of facility spaces that may have different acoustic criteria. Investigate and choose appropriate acoustics modeling software for the project.
- Measure acoustic performance onsite with full systems running over a specified time period.
- Log noise and other sonic environment complaints.

Thermal Conditions

- Determine special thermal comfort requirements or problems that may be encountered in the facility due to work activities or sitting or design considerations.
- Determine if any task areas differ now from original intent.
- Review conditions that affect thermal comfort using ASHRAE Standard 55-2004 or *Human Factors Design Handbook*.
- Measure performance variables on site over time.
- Log complaints related to thermal conditions.

Privacy Conditions

- Identify employees' privacy concerns via focus groups or log complaints.
- Determine if any task areas or responsibilities differ from ordinal intent.
- Consider adding noise masking equipment and/or visual screening depending on nature of complaints.
- Educate and promote quiet behaviors among employees.
- Compare acoustic privacy problem areas with acoustic measurements to pinpoint specific problem areas.
- Eliminate causes or sources of peak events.

Cleaning and Maintenance

- Create an orderly protocol for maintenance requests.
- Provide office cleaning supplies in accessible areas.
- Schedule office clean-up days throughout the year.
- Clean highly utilized, public areas (restrooms) more frequently.
- Open showering rooms for staff to use.

Personal Adjustability

- Determine if adjustability issues arise with temperature, lighting, or furnishings via focus group.
- Identify personal, individual problem areas and relate to other IEQ issues via log of complaints.
- Provide education to employees about adjustability of any applicable adjustment options, e.g., furnishings, air diffusers, lighting, temperature control, etc.

It seems obvious that employees' satisfaction can be improved by addressing categories that had lower 'satisfied' or 'neither dissatisfied nor satisfied' scores. The above recommendations can help address change in these categories. However, what is not quite so obvious is that because appearance and indoor air quality of the primary workspace are the two IEQ categories that contribute most to employees' satisfaction, and these two categories received higher satisfied mean scores individually, employees' satisfaction could be increased with greater attention paid to these two categories.

This study investigated employees' satisfaction with the facility and primary workspaces. IEQ satisfaction is individual, but the results of the survey show a central tendency of moderate satisfaction to satisfaction with the facility and most of the IEQ categories. The results can be used as a diagnostic tool to aid in improving IEQ conditions for employees and to set the benchmarks from which improvement can be measured in the future.

Appendix A. Open-Ended Responses

Employees had the opportunity to raise specific concerns on the overall facility and their primary workspace. Important information can be gleaned from the open-ended responses given in three categories that employees found to be neither dissatisfied or satisfied (personal adjustability, cleaning and maintenance, and privacy conditions).

Personal Adjustability

- More storage areas in workspaces for poster boards, totes, books, etc.
- Lack of control/adjustability with thermal conditions (temperature and air velocity) in workspaces.
- Management of the natural daylight. Some respondents indicated that it can be overwhelming in the afternoon.

Cleaning and Maintenance

- Public restrooms are heavily used and need to be cleaned more frequently.
- Open public showers for staff.

Privacy Conditions

- Appreciates the privacy of a mother's room.

Appendix B. Glossary

Descriptive statistics

Statistics used to summarize large sets of data (i.e., means, frequencies, medians). Descriptive statistics describe only the sample under consideration and are not intended to infer results to the larger population.

Factor analysis

A multivariate statistical procedure that is used to identify and group together general dimensions or factors that underlie a large number of variables in a set of data. The procedure transforms the variables into new principal components or orthogonal factors. Variables within each factor are related to each other but have no relationship to variables in other factors.

Frequency

A descriptive statistic that provides information about how many of a particular response or measurements are observed.

Likert-type scale

A measurement technique, employed in questionnaires and interviews, that utilizes a range of standardized response categories such as strongly agree, agree, etc.

Mean

The average score of a set of data calculated by adding all scores together, then dividing by the number of scores.

N

The number of subjects or participants responding to the questions in the study

Reliability

The repeatability or replicability of findings; the same results are produced each time. Instruments and procedures should produce the same results when applied to similar people in similar situations, or on a second occasion.

Standard deviation

A statistic used to measure the variability of a group of scores (how different scores are from each other and the mean). For example, if the range of scores is 1-7 and the mean (average) is 5.0 with a standard deviations of 1.0, then the scores are closely clustered around the mean, i.e., there is one unit of variation among all scores. If the mean was 5.0 and the SD was 3.0, there is a broader range of variation among the scores...a smaller SD means the scores are similar and the mean score is likely to be more accurate and more useful (this is better!).

Validity

The extent to which an instrument or procedure measures what it is intended to measure (internal validity). The generalizability of results to another population (external validity).