THE HUMAN FACTORS OF SUSTAINABLE BUILDING DESIGN: POST OCCUPANCY EVALUATION OF THE PHILIP MERRILL ENVIRONMENTAL CENTER, ANNAPOLIS, MD

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TABLE OF CONTENTS

1. INTRODUCTION

It is widely believed that sustainable building design strategies create improved indoor environmental quality and should, thus, be associated with improved occupant comfort, satisfaction, health, and work performance relative to buildings designed around standard practices. Yet, this belief remains a hypothesis with little empirical support.

The study described in this report represents a beginning step in understanding the human factors impacts of sustainable design practices. The report summarizes the findings from a study of the Philip Merrill Environmental Center building in Annapolis, Maryland. The building, which houses the Chesapeake Bay Foundation, was the first LEED Platinum building in the United States.

The Occupant Indoor Environmental Quality Survey, a widely used building evaluation instrument developed by the Center for the Built Environment at the University of California at Berkeley, was implemented in November 2004, almost four years after the Foundation moved into the new building. In addition to the survey, a series of interviews and discussion groups were held with staff one year after the move into the new building. This report includes a detailed summary of the survey findings with additional clarification of occupant responses gathered from the interviews and discussion groups.

THE PHILIP MERRILL ENVIRONMENTAL CENTER

The Merrill Center, located in Annapolis, Maryland, houses the Chesapeake Bay Foundation, a not-for-profit conservation organization solely dedicated to restoring the Chesapeake Bay. Founded in 1967, the Foundation has 110,000 active members and a staff of about 90 in the Merrill Center building. The staff includes teachers, lawyers, researchers, executives, communication specialists, and support staff.

The Center has two major program areas: environmental education and environmental protection and restoration. The education program provides field and classroom experiences for teachers, students, and citizens. More than 35,000 students per year participate in the Center's field-oriented educational programs. The environmental protection and restoration program works with government, business, and citizen groups on policies and legislation. It also conducts its own projects with a focus on restoring vital habitats and filtering mechanisms, such as underwater grasses and oysters.

The Merrill Center building is a social experiment as well as an environmental one. The Center consolidated the entire workforce into an open plan setting, regardless of rank and position. Only the human resource personnel have enclosed offices due to their needs for confidentiality. The president of the organization as well as other key executives occupy small, open workspaces along the perimeter of the building. Their workspaces do not have doors, enabling passersby to look through the space to see the surrounding landscape from all points in the building. The majority of the staff are located in the center of the building, in shared areas with low partitions that are intended to promote interaction as well as provide equitable access to daylight and views. Higher panels run perpendicular to the windows separating work groups and providing a modest level of visual privacy.

SUSTAINABILITY FEATURES

As the first LEED Platinum building in the United States, the Merrill Center is at the leading edge in sustainability practices. As described in the Chesapeake Bay Foundation web site (www.savethebay.org), the Merrill Center building "combines space-age technology with age-old techniques."

Key sustainability features include:

- A 'socio-technical' natural ventilation system that uses environmental monitoring to decide when windows can be opened, alerting occupants by signs located in highly visible areas that it is okay to open windows.
- Open office workstations with low partitions to enhance access to daylight, views and fresh air from all areas of the building.
- Judicious use of interior hard walls to reduce materials.
- Use of rapidly renewable and natural materials, such as cork and bamboo for flooring.
- Use of water based paints and adhesives.
- Geothermal heat pumps to provide heat and cooling.
- Desiccant dehumidification system to remove moisture from the air and thereby reduce the need for mechanical air conditioning.
- Structural insulated panels in the walls and roof for increased thermal efficiency.
- Composting toilets that do not require water.
- A rainwater capture system for reuse in fire suppression, hand washing, mop sinks, the climate control system, and washing equipment.
- Restoration of the natural landscape.
- Daylight sensors and electric dimmers to control electric light when daylight levels are sufficient for work.
- Solar hot water heater.
- Photovoltaic panels.
- Use of local and recycled materials in building construction to reduce transportation costs and associated environmental impacts.
- Use of certified wood and wood from sustainably managed forests.

Photos of the building appear on the next pages.

Photo 1. Entry side of the Philip Merrill Center Building shows the rain water capture system in the round towers.

Photo 2. East side of the building with the Conference Center and outdoor deck on the far left. Shading devices on the south side of the building enclose an external walkway. Photo voltaic arrays can be seen on the sloped part of the shading device.

Photo 3

Photo 4

Photo 3 shows a second floor workspace with a view of Chesapeake Bay. As can be seen, there were no shades on the windows at the time the photo was taken and sunlight enters the workspace. Although this staff member said she liked the sun on her desk top and the open view, others found the brightness and glare difficult for working. Window shades, added subsequently, were in place when the occupant survey was administered.

Photo 4 shows the first floor workspace. Operable windows are on the right at the bottom. When conditions are appropriate, a sign indicates that the windows can be opened. The workstation panels parallel to the windows are low, allowing visual access to daylight and views.

Photo 5 shows the work area for the education group. The work surfaces are filled with artifacts used in educational programs, including a large bird nest to the left. The canoe hanging overhead displays the group's motto: "Love, Learn, Lead." The open ceiling displays the building's structural and mechanical systems.

Photo 5

2. EXECUTIVE SUMMARY OF FINDINGS

Key findings from the Occupant Indoor Environmental Quality survey, interviews and discussion groups are as follows:

- Occupants were highly satisfied with the Merrill Center building as a whole. In fact, the score for overall building satisfaction was the second highest in the entire CBE survey database.

- Satisfaction with air quality was also very positive and represents the highest level of air quality satisfaction in the CBE database.

- Close to 90% of the occupants were also satisfied with daylighting, the overall amount of light, and access to views.

- Ratings for the psychosocial outcomes were also positive, with about 80% of the occupants experiencing high levels of morale, well being and sense of belonging at work.

- Occupants have a strong sense of pride in the building, as indicted by the fact that 97% of survey respondents said they were proud to show the office to visitors.

- Acoustical conditions were the most negatively rated, primarily due to distractions from people talking and loss of speech privacy associated with the highly open environment.

Even so, the acoustics score was well above average in comparison with the CBE database.

Findings from the interviews and focus groups also provide additional insights about the psychosocial benefits of the building. Psychological benefits included sense of pride in the values conveyed by the building, a more positive overall workplace experience, and a strong connection to the natural environment. Social benefits included improved communication and sense of belonging as well as feelings of being treated in an egalitarian manner, especially regarding access to benefits of daylight and views.

Participants in the interviews and focus groups also felt that the building very strongly conveyed the mission and values of the Foundation. As one senior executive pointed out, the building's location on the edge of Chesapeake Bay allows everyone to "see what we are working *on* and what we are working *for*."

A content analysis of the interviews and discussion groups showed that 74% of the comments were of a positive nature, and 27% were about concerns or problems. The most frequently cited concerns were temperature conditions, noise distractions, insufficient meeting rooms, and glare from windows. The most frequently cited positive factors were the connection to nature and the Bay, the access to daylight and views, the openness of the space, the lunch room, and the overall aesthetics of the building.

3. RESEARCH METHODS

The research methods used in this study include a web-based survey administered by the University of California, Berkeley, and a series of interviews and discussion groups with high level executives and staff in all departments.

OCCUPANT INDOOR ENVIRONMENTAL QUALITY SURVEY

The Occupant IEQ survey, developed by the Center for the Built Environment (CBE) at UC Berkeley, includes a core section with questions on satisfaction with the workplace environment, and an additional module with questions on psychosocial experience and organizational satisfaction. The additional module was developed as part of a U.S. General Services Administration research project evaluating the links between workplace design and organizational effectiveness. The GSA WorkPlace 20·20 program currently has 16 workplace pilot projects underway across the country in which it is using the CBE survey as one of its core metrics.

The survey was administered via the Internet in November 2004. Of the 92 occupants to whom the survey was sent, 71 completed it for a response rate of 78%. The respondents represented all of the Foundation's groups.

Questions address overall satisfaction with the building and the workspace, as well as satisfaction with specific features (daylight, amount of light, views, air quality, thermal comfort, acoustics, furnishings, and layout). The psychosocial modules address the following areas: concentration and attention, information awareness and communication, interactive behaviors, acoustical functionality, sense of community, and morale and well being.
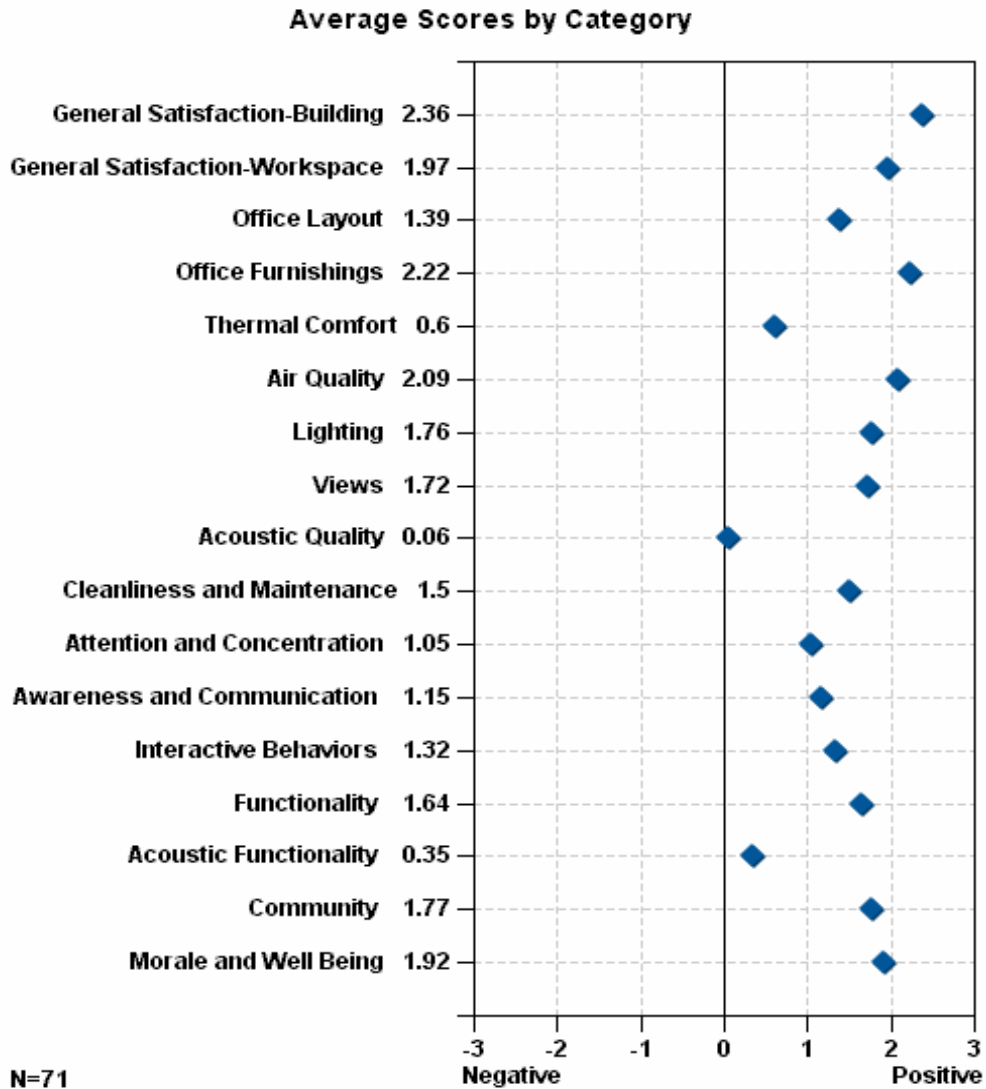
INTERVIEWS AND DISCUSSION GROUPS

In addition to the survey, a series of interviews and discussion groups were held with key executives and staff from all departments in 2002. A total of about 30 people took part. The intent of the discussion groups and interviews was to capture a full range of subjective experiences in and perceptions of the building. Each of the groups was asked the same specific questions, but the full discussion varied depending upon topics brought up by the group members. Questions asked of all groups were:

1. What were your first impressions of the building?
2. What is it like to work here compared to your previous location?
3. Have there been any impacts on your programs and work?
4. What would you change about the building?
5. How does the building relate to the Foundation?

4. SUMMARY OF RESPONSES

The graph below shows an overall summary of survey responses to the Merrill Center building. As can be seen the scores for all but acoustic quality are on the positive to highly positive side of the rating scale. The highest ratings were for the building overall, workspace, office furnishings, and air quality. The mean score on all of these categories was at or above 2.0, on a seven point scale ranging from -3 to +3. Other highly rated features were lighting and views. Of the psychosocial and organizational factors, sense of community and morale/well being had the highest mean scores.

Average Scores by Category

Category	Score
General Satisfaction-Building	2.36
General Satisfaction-Workspace	1.97
Office Layout	1.39
Office Furnishings	2.22
Thermal Comfort	0.6
Air Quality	2.09
Lighting	1.76
Views	1.72
Acoustic Quality	0.06
Cleanliness and Maintenance	1.5
Attention and Concentration	1.05
Awareness and Communication	1.15
Interactive Behaviors	1.32
Functionality	1.64
Acoustic Functionality	0.35
Community	1.77
Morale and Well Being	1.92

Scale axis: -3 -2 -1 0 1 2 3 (Negative to Positive)

N=71

Findings from the interviews and discussion groups reinforce the overall positive impressions of the building and the perceived benefits. Comments fell into three major categories – social impacts, emotional value and meaning, and functional impacts. Content analysis of the interviews also showed that there were more comments about the building in general (e.g., how it made them feel, how it looks, what it enables them to do) than about specific features and components.

Table 1. Summary of Building Benefits Identified in Discussion Groups and Interviews

Building Benefits	Percent Citing
Social Impacts Improved communication, sense of community, more egalitarian.	39%
Emotional Value and Meaning Connection to mission and values, connection to nature, reduced stress, positive experience, inspirational, great place to work.	39%
Functional Impacts Aids programmatic work, better overall support, increased work efficiency.	22%

Table 1 shows the percentage of the overall comments that fall under each category.

The interviews and discussions also revealed negative responses to the building. These were primarily related to lack of privacy, distractions, difficulty concentrating, glare from windows, and thermal discomfort. Of the total comments, 73% were of a positive nature and 27% were about concerns and problems.

In the discussion groups, participants were also asked to identify the features and attributes of the building they liked most and least. These are shown in Table 2. As can be seen, positive features include connection to nature, views, daylight, parking and aesthetics as well as overall sustainable nature of the building. Least liked aspects include ambient stressors (temperatures, glare from windows) as well as functional features such as storage and location of copiers. The reference to "move from downtown" concerned what some felt was an isolated location which made access to shops and stores for lunch and errands more difficult. The Foundation had previously been located in several buildings in downtown Annapolis.

Table 2. Most and Least Liked Features of the Building

Most Liked	Least Liked
Connection to nature and the bay	Temperature conditions
The lunch room	Things not working right
Views to the outdoors	Move from downtown
Openness of the space	Insufficient storage
Daylight	Insufficient meeting rooms
Sustainable resource use	Glare from windows
Overall aesthetics	Central vs. local copiers
Parking	
Location	

5. AMBIENT CONDITIONS

SATISFACTION WITH CONDITIONS

Figure 2 shows a summary of satisfaction with ambient conditions. As can be seen, 90% of the occupants were satisfied with daylight and close to 90% were satisfied with air quality, the amount of lighting, and access to views. Thermal and acoustic satisfaction were the lowest, with about 50% satisfied with temperatures and noise levels, and 25% satisfied with speech privacy.

Fig 2. Satisfaction With Ambient Conditions

	Satisfied	Neutral	Dissatisfied

Percent Responding
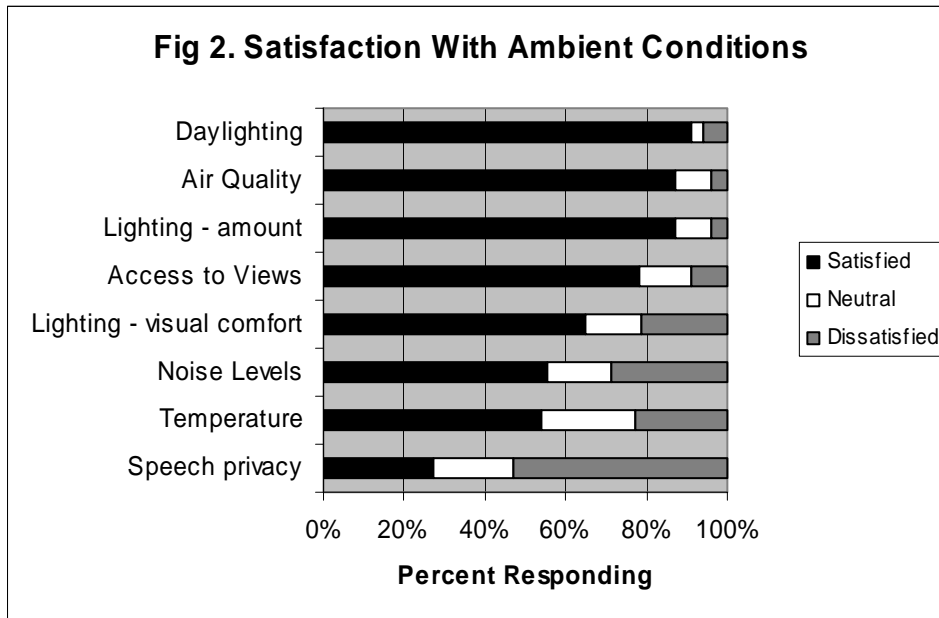
When occupants expressed dissatisfaction on a particular survey topic, a follow-up page appeared asking them to identify specific problems they experienced. Key problems with ambient conditions are shown in Table 3 on the next page. The comments are for the 20% to 30% who were dissatisfied.
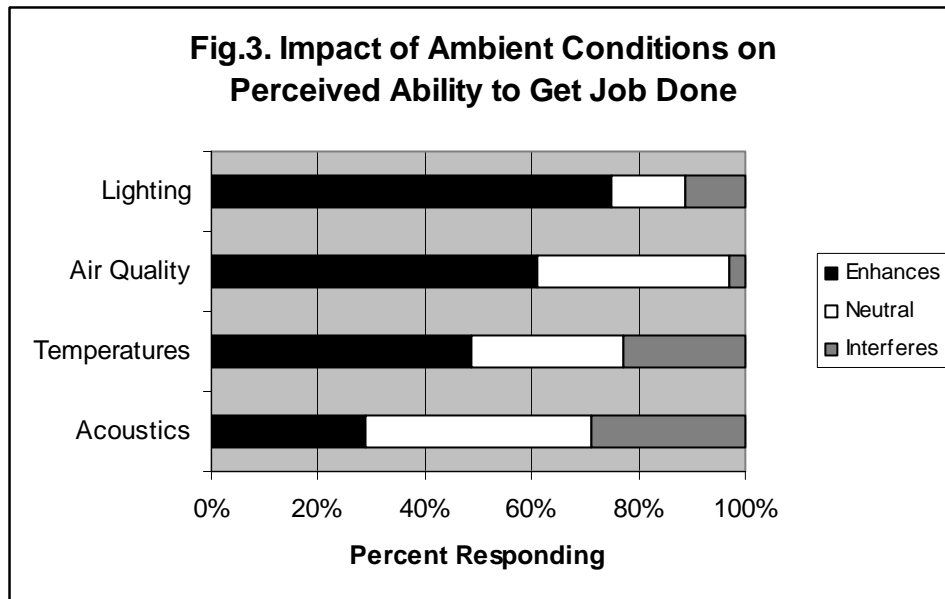
Table 3. Ambient Problems

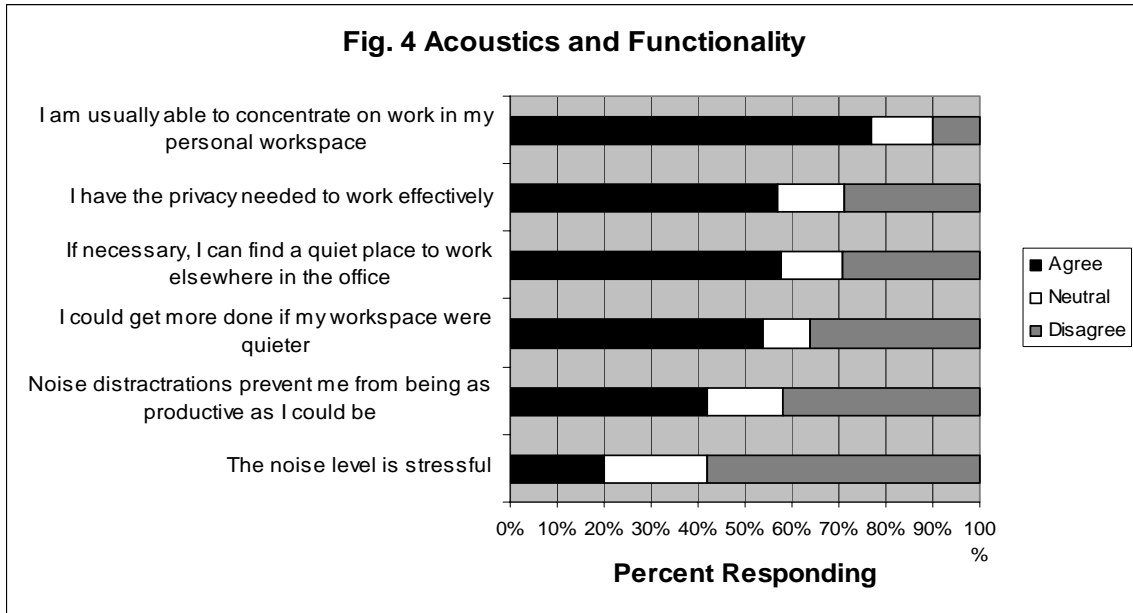| **Acoustics**	People talking nearby People talking on the phone No privacy
Thermal	Too much air movement Incoming sun Drafts from windows/vents Inaccessible thermostat Too cold in warm weather Too cold in cold weather
Visual comfort	Reflections from windows on computer screen Too much daylight

Acoustical conditions generated the most concern. The biggest problem was lack of speech privacy and distractions from other people talking either in the open areas, in workstations, or on the phone. Reflections from glare and overall brightness were still problems for some, despite window blinds that had been installed two years after occupancy to reduce these problems.

IMPACT ON PERCEIVED WORK EFFECTIVENESS

In addition to satisfaction levels, the survey also asked occupants to assess the degree to which the ambient conditions enhanced or interfered with their ability to get their job done. Figure 3 shows that acoustics and temperature conditions – the two ambient areas receiving the lowest satisfaction scores – were rated least likely to enhance ability to do work and most likely to interfere. In fact, 30% said acoustical conditions (which includes noise and speech privacy) interfered with their work, and 22% said temperature conditions interfered.

In contrast, both lighting and air quality conditions were rated as enhancing ability to work by 74% (for lighting) and 61% (for air quality). Interestingly, a relatively high percent (36%) rated themselves as "neutral" for this question. It is not clear what occupants mean when they say they are neutral. It could mean they have no opinion, or that they believe conditions have no effect on their ability to do their work.

Fig.3. Impact of Ambient Conditions on Perceived Ability to Get Job Done

Fig. 4 Acoustics and Functionality

I am usually able to concentrate on work in my personal workspace	
I have the privacy needed to work effectively	
If necessary, I can find a quiet place to work elsewhere in the office	
I could get more done if my workspace were quieter	
Noise distractrations prevent me from being as productive as I could be	
The noise level is stressful	

Legend: ■ Agree □ Neutral ■ Disagree

X-axis: 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Percent Responding

Given the high concern about acoustics and distractions (as shown earlier), the survey included additional questions on acoustical functionality (see Fig. 4).

Figure 4 shows responses to the acoustical functionality and attention/concentration questions. As can be seen, despite the previously noted high dissatisfaction with noise, loss of speech privacy, and distractions, the survey respondents appear to be able to concentrate and achieve privacy when it is important.

Nonetheless, 54% said they could get more done if their workspace were quieter, and 42% said that distractions prevented them from being as productive as they could be.

RESULTS FROM INTERVIEWS AND DISCUSSION GROUPS

Concerns expressed in the interviews and discussion groups reinforced the survey findings. Most of the discussion about work impacts centered on factors that made work difficult – such as distractions, interruptions, uncomfortable temperatures, and glare from windows. Many said they worked at home when they had important deadlines and needed to concentrate. Others tried to work in conference rooms or some other quiet space in the building. Interruptions to on-going work were particularly troublesome for those located on circulation paths. Since the partitions are low enough to see into the workstations, passersby frequently stop and chat. Many said they try harder to send signals of "unavailability" such as deliberately turning their backs to the circulation space or waving people away. However, there was concern that these behaviors would be considered rude. Behavioral protocols for dealing with the open plan environment were developed prior to the move into the space, but they were largely ignored.

6. WORKSPACE DESIGN FEATURES

Both the survey and discussion groups addressed satisfaction with features and attributes of workspaces, including amount of space, functionality and support for work tasks. Fig. 4 shows results for workspace layout satisfaction. Occupants are most satisfied with ease of interacting, and least satisfied with visual privacy.

Fig. 5 Workspace Satisfaction
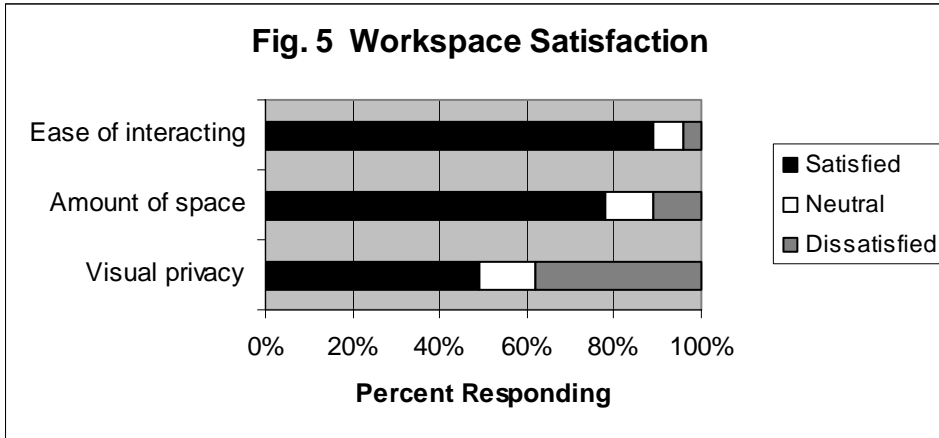
## IMPACT ON PERCEIVED WORK EFFECTIVENESS

Despite the high dissatisfaction with loss of visual privacy, 63% said the workspace layout and features enhanced their ability to do their work; 21% said the workspace layout interfered.

RESULTS FROM INTERVIEWS AND DISCUSSION GROUPS

The results of the survey were reinforced by comments made during the discussion groups. Increased potential for impromptu conversations was cited as a key benefit of the open space design. However, the distractions were also noted by many as an on-going problem, especially for reading, writing, and analysis.

7. INTERACTIVE BEHAVIORS AND COMMUNICATION

The survey also included a module with questions about interactive behaviors and communication. As can be seen in Fig. 6, occupants engage in frequent interactions in workspaces, corridors, and shared, open areas.

Fig. 6 Interactive Behaviors
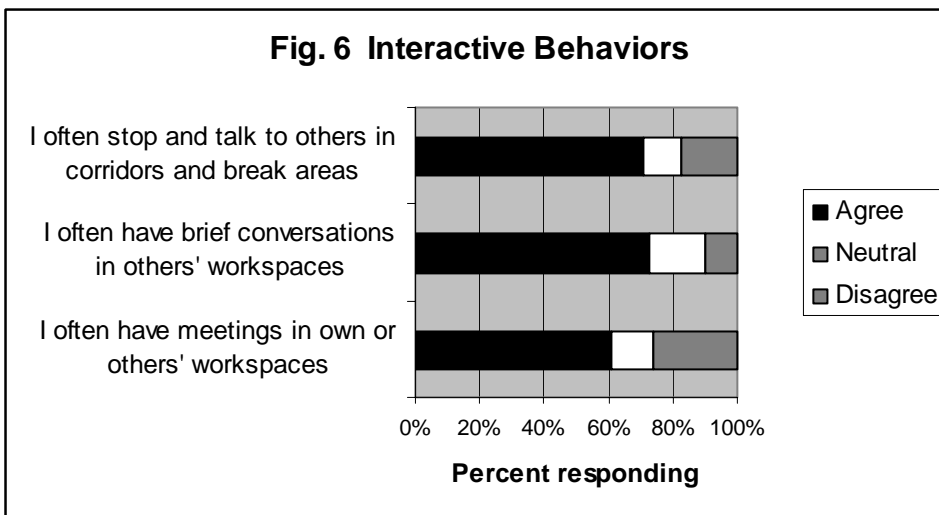
These behaviors have both costs and benefits. On the one hand, as noted previously, they make it more difficult to concentrate on individual work. On the other hand, high levels of interaction

and conversation improve overall communication, information flow and collaborative work. Figure 7 shows that survey respondents say they have high levels of awareness and access to information. A lower percent (54%) said they learned a lot about what was going on in the organization by overhearing conversations. This may indicate that many brief interactions are task specific or social in nature and may not be especially relevant to the individual who overhears the conversation.

Fig. 7 Awareness and Communication
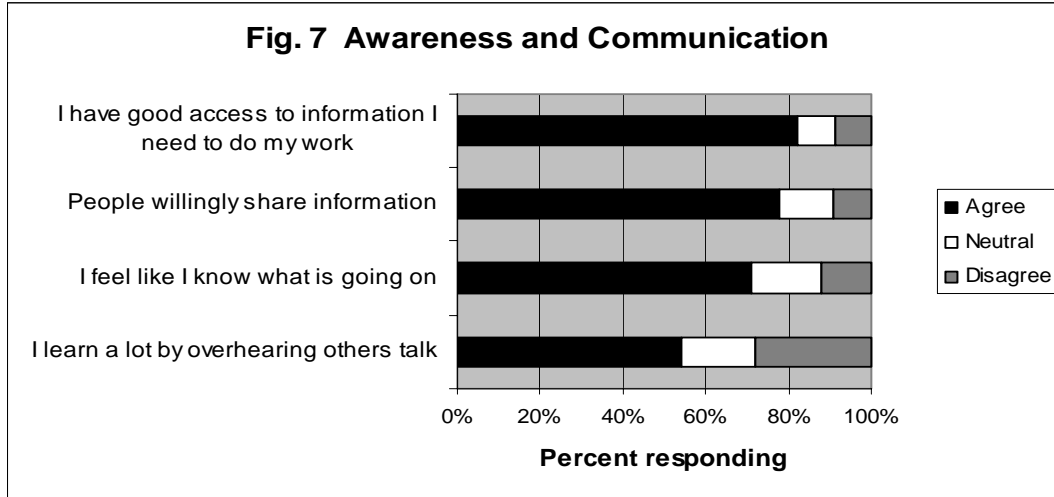
RESULTS FROM INTERVIEWS AND DISCUSSION GROUPS

Discussion group participants cited several features which they believed aided interaction and communication, including: the visual openness of the space, the wide corridors, the lunch room, the central copier, the deck and the central stairway.
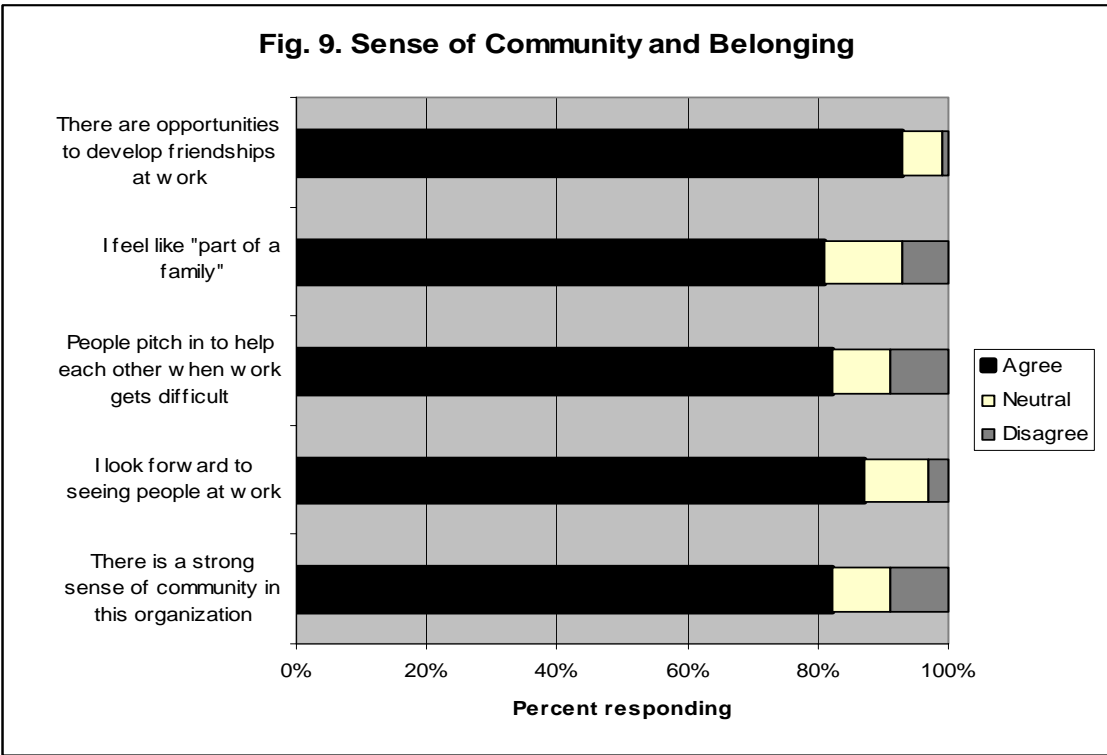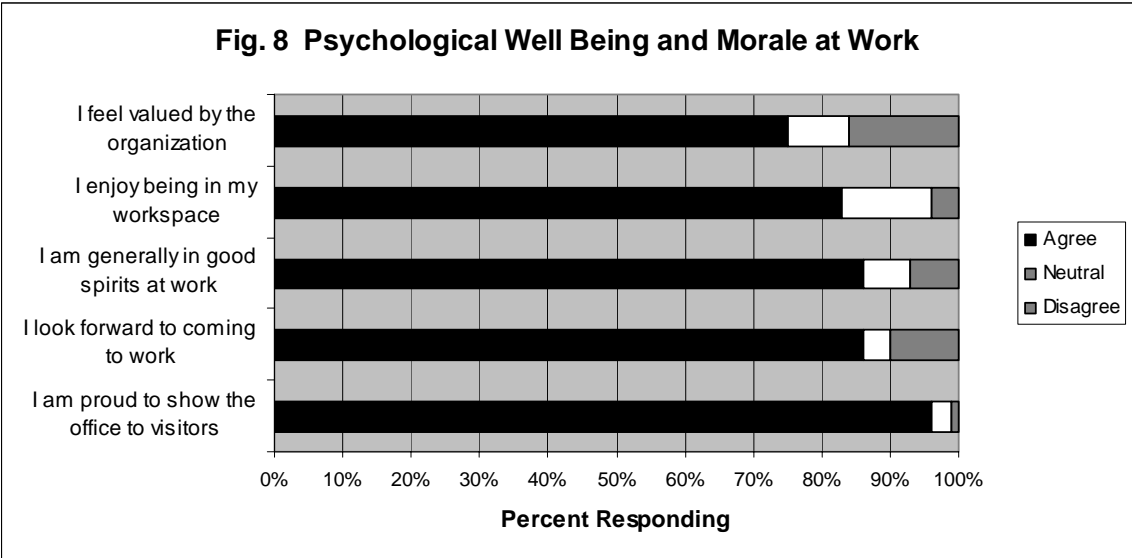
The specific communication benefits cited by participants in the discussion groups included the following:

- Ability to keep up with organizational issues
- Ability to quickly check facts and ask/answer questions
- Improved situational awareness, especially for newcomers who can quickly find out what is going on
- Getting more rapid answers to questions by interacting directly rather than by phone or e-mail
- Ability to move things forward more rapidly
- Being able to set up meetings quickly

8. WELL BEING AND COMMUNITY

A final survey module focused on well being and sense of community. Fig. 8 shows the results from the questions on psychological well being and morale. Although there is variation in responses, all outcomes are highly rated, and show that occupants experience a high sense of well being at work. Obviously, there are many factors that contribute to psychological functioning, in addition to the physical environment. The one question that is directly related to the environment is also the item which received the highest ratings – "I am proud to show the office to visitors."

Fig. 8 Psychological Well Being and Morale at Work

Legend: Agree, Neutral, Disagree

- I feel valued by the organization
- I enjoy being in my workspace
- I am generally in good spirits at work
- I look forward to coming to work
- I am proud to show the office to visitors

X-axis: Percent Responding (0% to 100%)

Fig. 9. Sense of Community and Belonging

Legend: Agree, Neutral, Disagree

- There are opportunities to develop friendships at work
- I feel like "part of a family"
- People pitch in to help each other when work gets difficult
- I look forward to seeing people at work
- There is a strong sense of community in this organization

X-axis: Percent responding (0% to 100%)

The survey also included questions about community and belonging (see Fig. 9). These questions were incorporated because there is strong evidence in the organizational science literature for the link between social experience, organizational commitment, and citizenship behaviors.

The data shows high agreement regarding the factors that contribute to a sense of community and belonging. Over 90% said there were opportunities to develop friendships at work and 87% said they look forward to seeing people at work each day. Scores for feeling like "part of a family" were somewhat lower, but still over 80%.

The sense of community came up repeatedly in the interviews and discussion groups. From a social perspective, the central connecting element – indeed, the heart of the community – is the kitchen. As one person noted, "food is a great connector." The kitchen is not only a place to eat and talk, it also symbolizes the organization's values and sense of equality. Everyone pitches in to clean up after lunch is over. This sense of community is captured by the following comment: "The cafeteria is a real community builder…There is something very nice about doing dishes with the president of the organization."

Community, as described in the discussion groups, includes a sense of fun as well as the feeling that "we are all in this together." One new staff member said that after only six months, she knew everyone, in contrast to previous environments where it was much more difficult to interact and get to know people. Another said she used to feel like she was outside the social core, but now feels more integrated and part of the organization.

There were also numerous comments about learning more about people – their families, their children, what they are working on. The discussion participants attributed the ability to learn about people to more frequent interactions and more opportunities to socialize over lunch, at organizational events, or when taking walks outdoors.
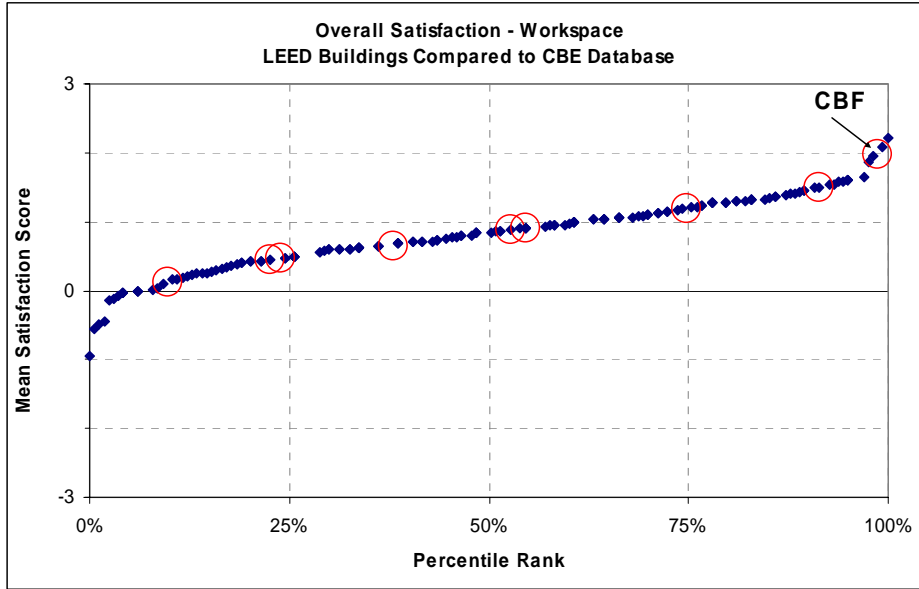
9. COMPARISON WITH OTHER LEED BUILDINGS

In this section, we compare the results of the Merrill Center building survey with survey findings from other LEED rated buildings in the database maintained by the Center for the Built Environment (CBE) at the University of California, Berkeley. The Merrill Center is referred to as CBF in the graphs (to stand for Chesapeake Bay Foundation).

CBE has surveyed approximately 170 buildings to date (represented by small blue dots), of which ten have a LEED rating (identified by large red circles). Each dot plots the average score against that score's percentile rank relative to the other buildings in the database. Although the total number of LEED buildings is small, the results show a high variability in occupant satisfaction with the LEED buildings.

As can be seen in Fig.10, the overall workspace satisfaction for the CBF building is much higher than for any of the other LEED buildings, and it is the third highest in the entire database. Similar results were found for overall building satisfaction in Fig. 11, in which the CBF building is the second highest in the database.

Fig. 10. Comparison of LEED Buildings with CBE Survey Database for Overall Workspace Satisfaction

Fig. 11. Comparison of LEED Buildings with CBE Survey Database for Overall Building Satisfaction
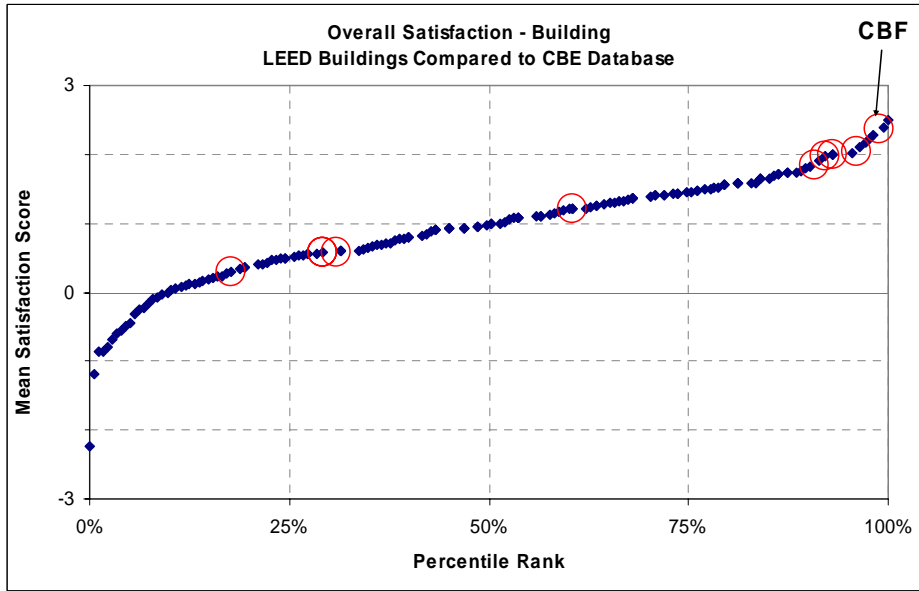
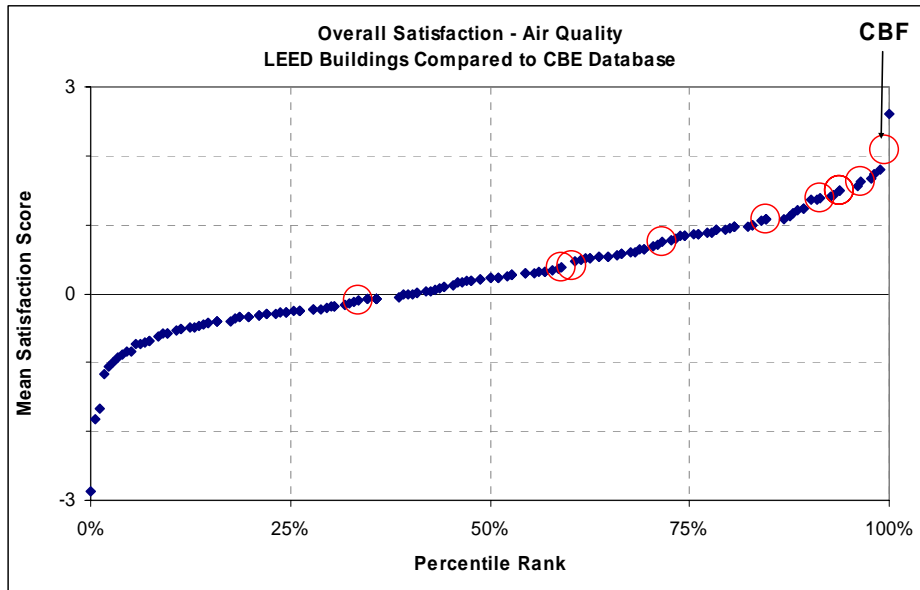**Fig. 12. Comparison of LEED Buildings with CBE Survey Database
for Air Quality**

Figure 12 shows the results for air quality. The CBF building score in this category is again rated higher than other LEED buildings, and has also achieved the second highest rating for air quality in the whole CBE building database.

Figure 13 shows the data on lighting. Overall satisfaction with lighting includes both daylight and electric light. As can be seen in the figure, the CBF building has one of the highest lighting ratings among the LEED buildings and is in the 95th percentile for the whole database.

**Fig. 13. Comparison of LEED Buildings with CBE Survey Database
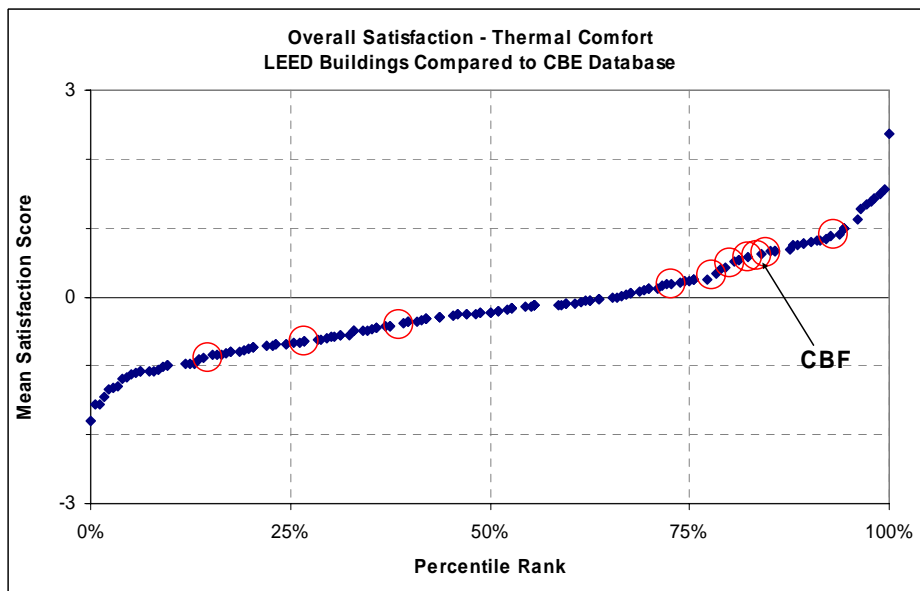for Lighting**
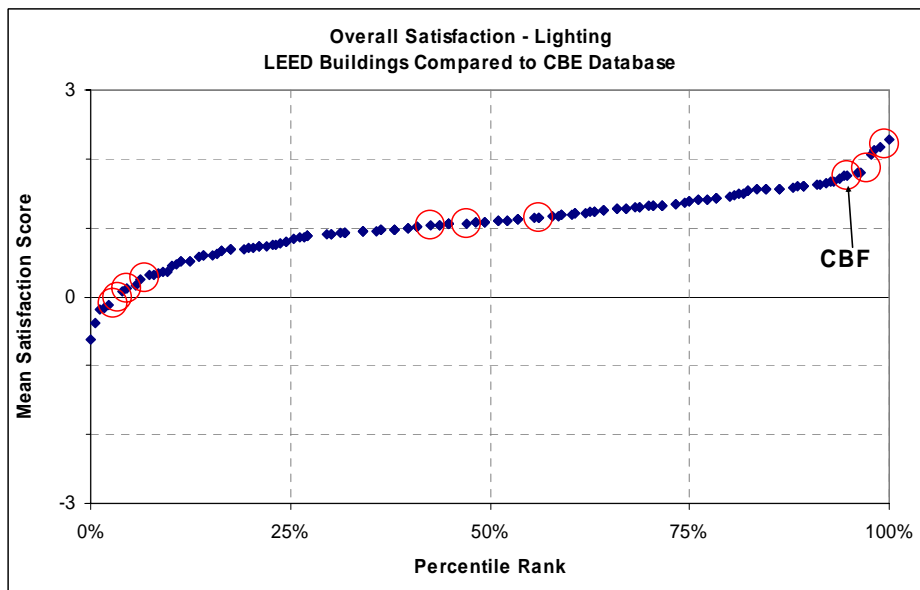
Fig. 14. Comparison of LEED Buildings with CBE Survey Database for Acoustics
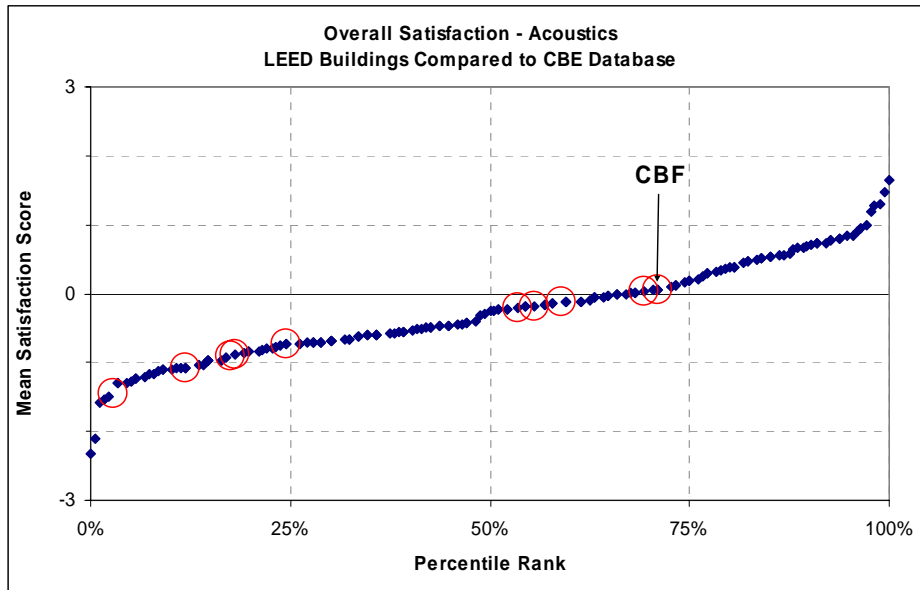
The results of comparison on acoustic satisfaction (Fig. 14) show the CBF building as rating in the 70th percentile, but still at a higher ranking than the other LEED buildings.

The final graph shows results for thermal satisfaction. In this case, there were several LEED buildings that clustered near the 80th percentile, including the CBF building.

Fig. 15. Comparison of LEED Buildings with CBE Survey Database for Thermal Comfort

The survey database shows that the Merrill Center building ratings are at or above the 95th percentile for workspace satisfaction, building satisfaction, air quality and lighting. The lowest rated factor, acoustics, was close to the 70th percentile, and thermal comfort was at the 85th percentile.

Future research will look more closely at the specific building features in the LEED buildings.

10. GENERAL DISCUSSION

To summarize the key findings from the survey, interviews and discussion groups:

1. Occupants were highly satisfied with the Merrill Center building as a whole. In fact, the score for overall building satisfaction was the second highest in the entire CBE survey database.

2. Satisfaction with air quality was also very positive and represents the highest level of air quality satisfaction in the CBE database.

3. Close to 90% of the occupants were also satisfied with daylighting, the amount of light, and access to views.

4. Ratings for the psychosocial outcomes were also very positive, but somewhat lower. About 80% of the occupants experienced high levels of morale, sense of belonging and well being at work.

5. Occupants have a strong sense of pride in the building, as indicted by the 97% of survey respondents who said they were proud to show the office to visitors.

6. Acoustical conditions were the most negatively rated, primarily due to distractions from people talking and loss of speech privacy. Still, the acoustics score was well above average in comparison with the CBE database.

THE OPEN ENVIRONMENT CONUNDRUM

Sustainable design strategies to reduce material use, enhance views and daylight, and increase air flow for natural ventilation depend to a great extent on reducing internal barriers, such as hard walls, doors and partitions. The previous sections show that this cluster of sustainable features has produced high levels of satisfaction for daylight, views, amount of lighting, and connection to nature in the Philip Merrill building.

These design features also have behavioral consequences that can be both negative (increased distractions to on going work) and positive (ease of interaction and communication) – and this is the crux of the conundrum.

THE NEGATIVE CONSEQUENCES OF OPEN ENVIRONMENTS

Research in office environments consistently shows that acoustical complaints and loss of privacy are the number one concern of occupants (Brill et al., 2001; Sundstrom et al., 1982; Heerwagen et al., 1991). These findings raise a number of questions. How much of a problem is it and for what kinds of work? How do people cope with these problems and are their coping behaviors successful?

The research on distractions from people shows that the negative effects are greatest for complex cognitive work and for sustained "cognitive flow" which is important for tasks such as writing, reading comprehension and analysis (Zijlstra et al., 1999; Jones and Morris, 1992).

Although work can continue with distractions, albeit with increased mental effort, interruptions from people stopping by to talk are detrimental because they cause work to come to a stop. Interruptions influence work process in several ways. An interruption may require a change in one's action plan or strategy for achieving an original goal, it may increase memory load, or it may increase effort to speed up performance (Zijlstra et al., 1999). Interruptions of complex work (such as difficult reading, writing or mathematical computation) as compared to more simple tasks requires a longer time to reorient to the task (Pashler et al., 2001).

Given the high level of distractions and interruptions in office environments, how do workers deal with the problems? Research by Heerwagen and Diamond (1992) shows high levels of passive coping. Passive coping is aimed at controlling emotions and perceptions, rather than actively solving the problem and is thus considered less beneficial to health than active coping strategies (Lazarus and Folkman, 1984). Across the buildings studied by Heerwagen and Diamond, 70% of the occupants said they were bothered by others' conversations. Yet, only 16% said they asked their coworkers to be quieter. Almost 60% said they tried to ignore the problem, and 40% said they "just put up with it; there is nothing I can do." Findings from the interviews and discussion groups with Merrill Center managers and staff showed that passive coping is very common. Indeed, several said that they didn't want to be considered rude by asking coworkers to be quiet.

The survey findings also showed that over 50% said they could get more work done if it were quieter, and 42% said that noise distractions prevented them from being as productive as they could be.

THE POSITIVE CONSEQUENCES OF OPEN ENVIRONMENTS

Environments with high internal visibility, open stairways, low barriers, increased density of occupants, and central circulation systems – the very features that are problematic for individual concentration – aid overall awareness, interactive behaviors and communication (Heerwagen et al., 2004; Serrato, 2002). Furthermore, there is evidence that the ability to see others improves the ability to have short side bar conversations and get answers to questions. This moves work forward more efficiently (Teasley et al., 2000; Allen and Gertsberger, 1973). High visibility also increases situation awareness and promotes the ability to come to someone's aid rapidly as problems develop (Gutwin and Greenberg, 2001).

These benefits of a high visibility environment were noted in the discussion groups with the Merrill Center staff as well as in the survey findings. In the survey segment on Workspace Layout Satisfaction, 90% of the respondents said they were satisfied with the ease of interacting. The section on interactive behaviors also showed that occupants said they engaged in frequent conversations in corridors, break areas, and workspaces. And finally, the respondents reported high levels of awareness and information sharing. Although there are no behavioral data to verify the subjective responses, the fact that the findings point in the same direction is noteworthy. Furthermore, research in other work settings shows that the features and attributes of high visibility environments are consistently associated with higher levels of interaction than environments that are more enclosed (see Heerwagen et al., 2004, for an overview of this research).

Given the high attention to improved communication and information flow in organizations, a high visibility environment is clearly advantageous. However, there is a tradeoff that needs to be carefully considered in design. The high visibility environment creates difficulties for complex cognitive tasks that characterize high value knowledge work.

Perlow (1999) sees this as a conflict between "lost collective time" and "lost individual productivity." She speculated that both can lead to decreased overall work effectiveness that can have negative organizational consequences:

> Effective time use for a group requires a sufficient number of interactive activities to achieve the group's goals, but it also requires the synchronization of these interactive activities to best insure that they occur at times that do not continuously interrupt group members' individual activities.

OVERALL RESPONSES TO THE BUILDING AND THE WORKSPACE: IS THE WHOLE GREATER THAN ITS COMPONENT PARTS?

One of the more interesting findings from the research shows that the building overall is more highly rated than any of the components. This is typical of the other buildings in the CBE survey database. This suggests that the environmental features and attributes that interest researchers may not fully capture the building experience. The data from the interviews and discussion groups support this contention. As noted in Table 1, many of the perceived benefits of the building had to do with general qualities, not specific components. Occupants discussed social and emotional value of the environment overall rather than specific elements. Only when they were asked to identify likes and dislikes did they point to specific design features.

It is also clear from the survey findings that overall workspace satisfaction was high *despite* the problems with acoustics and thermal discomfort. Similar results were found by Heerwagen et al. (1991) in a study of seven Energy Edge buildings in the Pacific Northwest. Almost 90% of the 268 occupants surveyed in the Energy Edge research said they were satisfied with their workspace, even though 40% were dissatisfied with acoustics, and 36% were dissatisfied with thermal conditions.

Clearly, these discomforts need to be addressed because they can have negative consequences for work performance. However, the fact that building ratings are higher than would be expected from examination of comfort ratings alone suggests that other factors, not normally addressed in post occupancy studies, are critical to the overall experience of a building. For sustainable design, these factors may include the values conveyed by the building, the sense of pride that occupants experience, and the psychological benefits of equitable access to views and daylight, connection to the natural environment, and the design of space to enhance social experience. Another important factor is the aesthetic pleasantness and sense of beauty conveyed through the overall design, including color, ornamentation, materials selection, and attention to detail. Aesthetic factors were clearly important in the Philip Merrill building. One senior scientist, upon entering the building for the first time, said: "I expected it to be green, but I never expected it to be beautiful."

SUSTAINABLE DESIGN AND THE IMPORTANCE OF VALUES

Participants in the Merrill Center discussion groups and interviews raised the issue of values repeatedly. Although a strong sense of values underlies sustainable design, there has been little explicit discussion regarding the connections between values, designs, and occupant or organizational well being. In *The Sustainability Advantage*, Willard (2002) argues that the values underlying sustainable development are going to increasingly play a role in organizational effectiveness. Specifically, he predicts that organizations that embrace sustainability are likely to have an advantage in recruiting and retaining young people who value the environment and whose job preferences may increasingly reflect these attitudes. Given the high concern many organizations have about attracting, retaining and motivating workers, the sustainability advantage could be significant.

The emerging field of "positive psychology" provides further support for the importance of values, not just to organizations, but to human well being. Over the past decade, numerous studies have shown that psychological well being is strongly influenced by the congruence between human values and life activities, including work that is personally fulfilling (Ryan and Deci, 2001). Psychological well being includes a positive sense of purpose, a belief in something important, a sense of pride, and feeling valued by others (Baumeister and Leary, 1991). In the discussion groups, staff members commented on the sense of pride they felt working for an organization that is committed to the environment. As one person noted, "It definitely has an impact on wanting to work here. People say, 'I want to work for a place like this.'"

Many also felt that the building very strongly conveyed the mission of the organization. As one senior executive pointed out, the building's location on the edge of Chesapeake Bay allows everyone to "see what we are working *on* and what we are working *for*." He went on to say that the siting of the building allowed the Foundation to visibly practice what it preaches by restoring the natural landscape and oyster beds in what was previously a public recreational beach. As another senior executive noted, the site also provides educational experiences for children and teachers. "When people see kids here, they better understand the mission of the organization. Most of it is invisible otherwise."

Staff members in the education and environmental protection groups also discussed the benefits of using the building and its site to train citizens on environmental restoration, to demonstrate how ecosystems work, and to train teachers on environmental issues. According to staff in environmental protection, the building is used also as part of the discussion with legislators – "It's a policy statement for us."

Not all comments were positive, however. Some staff were concerned about spending money on a new building rather than on restoring the Bay. Others felt that the image conveyed by the building may be "too grand" for a non-profit organization. This belief led several staff members to comment that the building was a "double edged sword." While it conveys the values and mission of the organization and helps in educational outreach, it also may create the feeling among potential donors that the organization is "flush" and doesn't need more money.

A FINAL THOUGHT: ARE THE MERRILL CENTER BENEFITS TRANSFERABLE?

It is difficult to know whether the positive experiences of the Merrill Center Building are easily transferable to other building types and sites. Clearly, the location of this building on the shores of the Chesapeake Bay has had much to do with the occupants' experience and positive responses to views, nature, and the expression of values. It is also evident that the organization itself has a powerful impact on the occupants, independent of the building.

Nonetheless, the findings from this research are consistent with other studies (Leaman and Bordass, 1999; Heerwagen 2000; Kaplan, 1995; Ulrich 1992). People respond positively to daylight, views, connection to nature, good ventilation, aesthetic pleasantness, and social features of the environment – all of which are readily transferable.

In the end, philosophy may also play a major role in the realization of benefits. Designs that begin with a true focus on human health and well being may, in the end, reap the biggest benefits from sustainable design. While many designs claim to do this, few actually realize the human potential of buildings. The findings from this research and other studies show that a close examination of the physical, psychological and social experiences of space may lay the foundation for the development of a positive, sustainable architecture that is as good for people as it is for the environment.

REFERENCES

Allen, T.J. and Gerstberger, P.J. 1973. A Field experiment to improve communications in a product engineering department: The non-territorial Office. *Human Factors*, 15(5): 487-498.

Baumeister, R.F.and M.R. Leary, 1995. The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, 117(3): 497-529.

Brill, M., S. Weidemann, and BOSTI Associates, 2001. *Disproving Widespread Myths about Workplace Design.* Jasper, Indiana: Kimball International.

Gutwin, L. and Greenberg, S. 2001. A descriptive framework of workspace awareness for real time groupware. CSCW'01, Kluwer Acadmeic Press.

Heerwagen, J., K. Kampschroer, K. Powell, and V. Loftness, 2004. Collaborative Knowledge Work Environments. *Building Research & Information,* 32(5): 510-528.

Heerwagen, J. 2000. Green buildings, organizational success and occupant productivity. *Building Research & Information*. 28(5/6): 353-367.

Heerwagen, J. and R.Diamond, 1992. Adaptation and Coping: Occupant Response to Discomfort in Energy Edge Buildings. Paper presented at the American Council for an Energy Efficient Environment, Asilomar, CA, August 1992.

Heerwagen, J., J. Loveland, and R. Diamond, 1991. Post Occupancy Evaluation of Energy Edge Buildings. University of Washington, Center for Planning and Design.

Jones, D.M. and N. Morris, 1992. Irrelevant speech and cognition. In D.M. Jones and A.P. Smith (Eds.) *Handbook of Human Performance,* Vol. 1, London: Academic Press.

Kaplan, S. 1995. The restorative effects of nature: toward an integrative perspective. *Journal of Environmental Psychology.* 15: 169-182.

Lazarus, R.S. and S. Folkman, 1984. *Stress, Appraisal and Coping*. New York: Springer.

Pashler, H., J.C. Johnson, and E. Ruthruff, 2001. Attention and performance. *Annual Review of Psychology,* 629-651.

Perlow, L.A. 1999. The time Famine: Toward a sociology of work time. *Administrative Science Quarterly*. 44: 57-81.

Ryan, R.M. and E.L. Deci, 2001. On happiness and human potentials: a review of research on hedonic and eudaimonic well-being. *Annual Review of Psychology,* 52:141-166.

Seratto, M.G. 2002. Building based communication research. http://www.tradelineinc.com.

Sundstrom, E., J.P. Town, D.W.Brown, A. Forman, and C. McGee, 1982. Physical enclosure, type of Job, and privacy in the Office. *Environment and Behavior*, 14(5):P 543-559.

Teasley, S., Covi, L., Krishnan, M.S., and Olson, J.S. 2000. How does radical collocation help a team succeed? CSCW '00, Dec 2-6, 2000, Philadelphia, PA.

Willard, B. 2002. *The Sustainability Advantage*. Gabriola Island, British Columbia: New Society Publishers.

Zijlstra, F.R. H., R.A. Roe, A.B. Leonora, and I. Krediet, 1999. Temporal factors in mental work: effects of interrupted activities. *Journal of Occupational and Organizational Psychology*. 72: 163-185.