



Indoor Environment Quality + Classroom Environment Hanson Hall, Report 2

**November 2013, Minneapolis, MN
Sustainable Post-Occupancy Evaluation Survey (SPOES)
B3 Guidelines**

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

*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 Hanson Hall facility (HH) and students' satisfaction with their learning environments. Hanson Hall was designed using the B3 Guidelines (formerly known as the Minnesota Sustainability Guidelines or MSBG) and completed for occupancy in 2008. The B3 Guidelines tracks specific state-funded, B-3 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 learning environments. The Sustainable Post-Occupancy Evaluation Survey (SPOES) was developed to assess human outcomes in classrooms and workplace settings in compliance with the project tracking requirements for the B3 Guidelines goals. This is the second of two required POE surveys and represent responses at five years post-occupancy. The survey was conducted in November 2013.

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

2.0 Method

SPOES consists of a self-administered, Internet-based, questionnaire submitted to and completed by students. 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 students. Students 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 classrooms. They also rate the influence of their physical environment on their perception of their learning experience 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 Students' perceptions.

The report provides a descriptive summary of the results stated as a **mean** (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 Students' satisfaction with IEQ in their primary classrooms. This is a statistical combination of all IEQ scores, which results in a single IEQ score for all Students on all IEQ variables and is reported in an IEQ Scorecard.

2.1 Description of the Questionnaire

Students first rate their level of satisfaction with the facility and the influence of their physical environment on their perception of their learning experience and health. Then they respond to questions about their satisfaction with their primary classrooms in relation to the IEQ categories. The questionnaire uses 15 IEQ categories from the B3 Guidelines and relates each of them to Students' satisfaction with their physical environment.

Categories 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

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

3.0 Sample Description

3.1 Building Description

Within the Carlson School of Management, Hanson Hall is located on the University of Minnesota's West Bank campus at 1925 Fourth Street South, Minneapolis, MN 55455. The building (see Figure 1) was completed in 2008 and is a 130,000 square foot, four-story building comprised of nine classrooms, a business center, the Carlson School Office of Undergraduate Programs, the Department of Economics, and an economics learning lab. In addition, it houses a collaborative student learning center and recruiter and undergraduate student lounges. Classrooms are equipped with state-of-the-art audio and visual technology with wireless printing capability. In addition, breakout rooms include plasma screen televisions for student collaboration to reinforce the Carlson School of Management's commitment to building an environment that advances critical thinking and enhances the practical application of new knowledge.



Figure 1. Hanson Hall (Photo credit: <http://www1.umn.edu/twincities/maps/HMH/>)

3.2 Description of Respondents

The response rate to the questionnaire was approximately 13%. Of those responding, 36.2% were male and 63.8% were female. Relating to hours spent in HH, 4.8% of the students spend 10+ hours in their primary classroom; 1.9% spend 9-10 hours in their primary classroom; 2.2% spend 7-8 hours in their primary classroom; 6.3% spend 5-6 hours in their primary classroom, 17.8% spend 3-4 hours in their primary classroom, and 67% spend 1-2 hours in their primary classroom. The mean age of respondents was 21 years, with a range of 18 to 41 years.

4.0 Findings and Discussion

4.1 HH Facility (site, building, and interior): Overall Satisfaction, Learning experience, and Health

Students responded to questions concerning the HH facility (site, building, and interior) and their overall satisfaction with the facility, overall perceptions of their learning experience in relation to the facility, and their overall perception of their health in relation to the facility. Table 1 and Figure 2 show a summary and interpretation of their responses.

Table 1. Overall satisfaction, learning experience, and health related to the HH facility.

HH Facility (site, building, and interior)	Mean (1-7)	Standard Deviation	N	Interpretation
Overall satisfaction	6.19	.91	314	Satisfied
Overall learning experience	5.75	1.07	314	Enhances
Overall health	4.96	1.12	313	Enhances

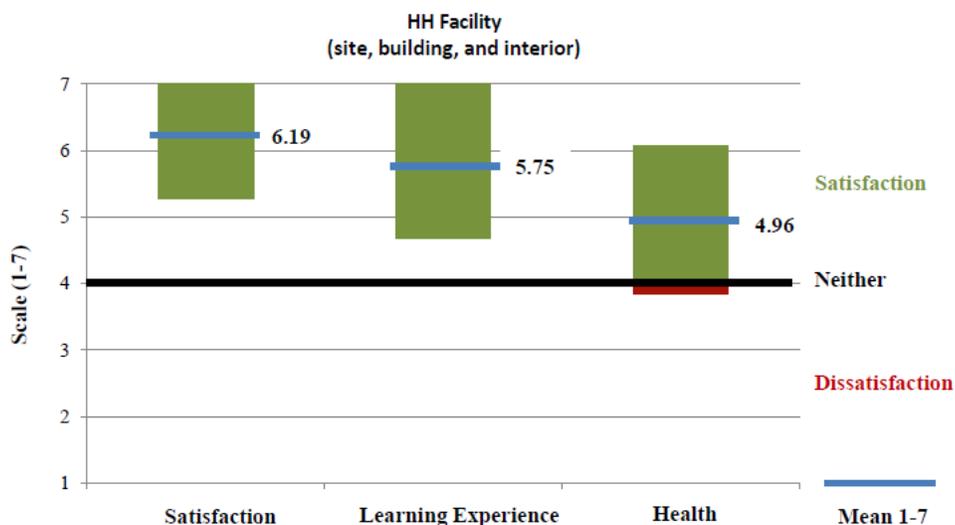


Figure 2. Overall satisfaction, learning experience, and health related to the HH facility.

Results indicated that Students were **satisfied** (Mean = 6.19) with the HH facility (building, site, and interior) and reported that their overall learning experience was **enhanced** (Mean = 5.75) by the facility. Students reported that their overall health was **moderately enhanced** (Mean = 4.96) by the facility.

**4.2 Primary Classroom:
Overall Satisfaction, Learning experience, and Health**

Students responded to questions concerning their overall satisfaction and overall perceptions of their learning experience and health as related to their primary classroom. Table 2 and Figure 3 show a summary and interpretation of their responses.

Table 2. Overall satisfaction, learning experience, and health related to primary classroom.

Primary Classroom	Mean (1-7)	Standard Deviation	N	Interpretation
Overall satisfaction	6.04	1.0	281	Satisfied
Overall learning experience	5.78	1.01	277	Enhances
Overall health	4.98	1.13	278	Enhances

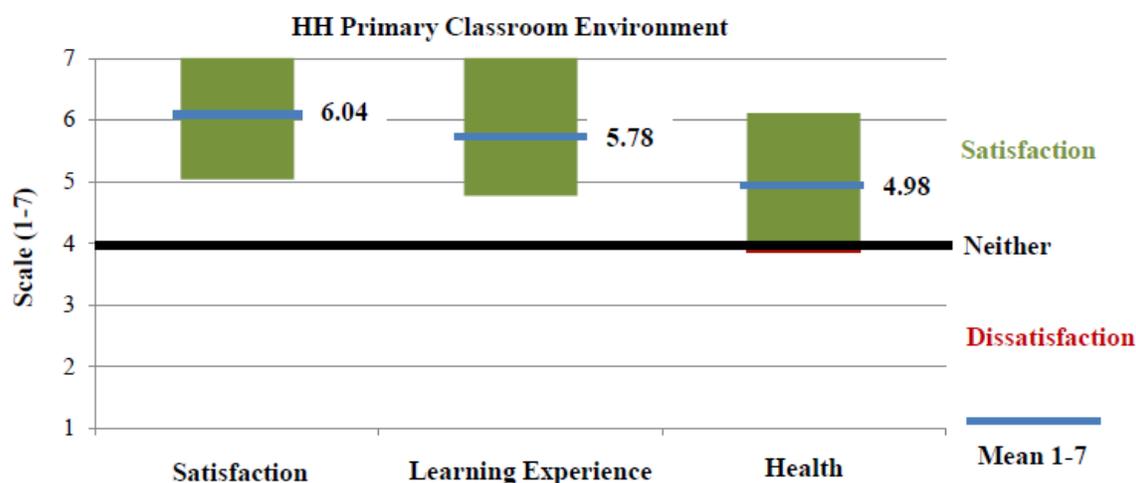


Figure 3. Overall satisfaction, learning experience and health related to primary classroom.

Results indicated that Student were **satisfied** (Mean = 6.04) with their primary classroom, their overall learning experience was **enhanced** (Mean = 5.78) by their primary classroom and their overall health was **moderately enhanced** (Mean = 4.98) by their primary classroom.

**4.3 Primary Classroom:
Satisfaction with Indoor Environment Quality (IEQ)**

Students responded to questions concerning their satisfaction with IEQ categories (thermal conditions, indoor air quality, acoustic conditions, etc.) related to their primary. Table 3 and Figure 4 show a summary of the means, the standard deviation, and interpretation of their responses.

Table 3. Satisfaction related to IEQ in primary classroom.

	Primary Classroom	Mean (1-7)	Standard Deviation	N	Interpretation
1	Cleaning and maintenance	6.37	.88	278	Satisfied
2	Ability to hear presentations	6.26	.92	280	Satisfied
3	Appearance (aesthetics)	6.24	1.0	279	Satisfied
4	Ability to understand desired sounds	6.23	.89	280	Satisfied
5	Function	6.19	.92	278	Satisfied
6	Acoustic quality	6.19	.97	280	Satisfied
7	Lighting conditions	6.14	1.07	280	Satisfied
8	Indoor air quality	6.13	1.12	279	Satisfied
9	Vibration and movement	6.09	1.01	278	Satisfied
10	Humidity	6.07	1.00	276	Satisfied
11	Technology	6.05	1.10	280	Satisfied
12	Ability to see materials presented	6.05	1.22	280	Satisfied
13	Background noise	6.04	1.09	280	Satisfied
14	Air velocity	5.96	1.10	279	Satisfied
15	Furnishings	5.96	1.25	280	Satisfied
16	Thermal conditions	5.79	1.24	280	Satisfied
17	Temperature	5.60	1.40	279	Satisfied
18	Adjustability of thermal conditions	5.12	1.50	275	Satisfied

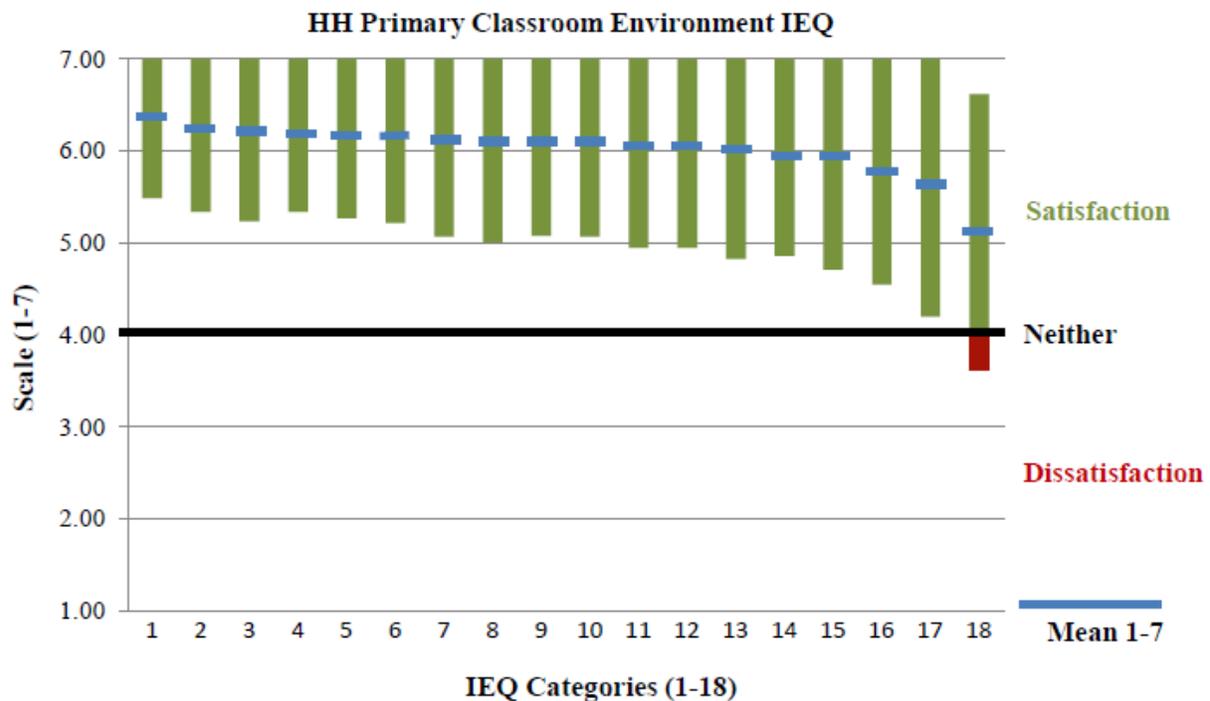


Figure 4. Satisfaction with IEQ as related to primary classroom. IEQ category means are included in Table 3 (above).

Results indicate that Students were satisfied with the following IEQ conditions in their primary classrooms:

- Cleaning and maintenance
- Ability to hear presentations
- Appearance (aesthetics)
- Ability to understand desired sounds
- Function
- Acoustic quality
- Lighting conditions
- Indoor air quality
- Vibration and movement
- Humidity
- Technology
- Ability to see materials presented
- Background noise
- Air velocity
- Furnishings
- Thermal conditions
- Temperature
- Adjustability of thermal conditions

4.4. IEQ Satisfaction Scorecard

The IEQ Satisfaction Score 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 a student to have satisfying thermal conditions than to have satisfying indoor air quality. Thus, if the student 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 HH is **6.13**.

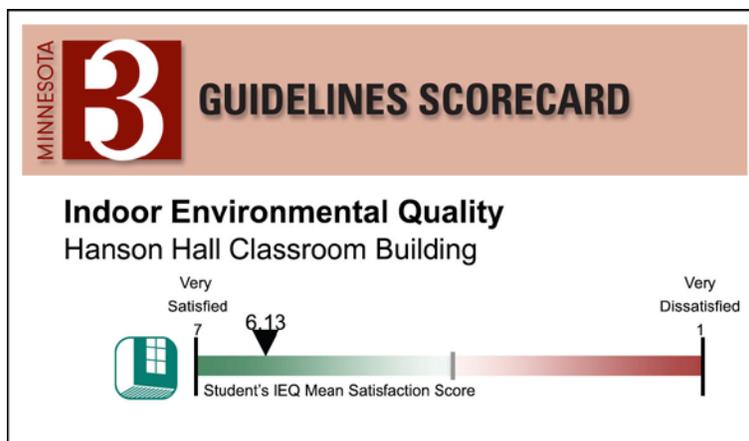


Figure 5. IEQ satisfaction score for HH Classrooms.

Overall, the occupants showed a positive response with a high level of satisfaction with IEQ as indicated by the weighted mean score of 6.13. Satisfaction with **Function** of primary classroom space was identified as the category that contributed most to the IEQ Satisfaction Score, followed by satisfaction with **Vibration and Movement**, and **Appearance** of the primary classroom. They determine IEQ satisfaction more strongly than other categories and differ slightly from the ranking of the mean scores where **Cleaning and Maintenance**, **Ability to Hear Presentations** and **Appearance (aesthetics)** were the top satisfaction scores. **Thermal Conditions** was the least contributing category to the IEQ Satisfaction Score. This concurs with the low satisfaction scores for **Temperature** and **Adjustability of Thermal Conditions**.

This score of 6.13 validates the overall satisfaction score in Table 2 (6.19). 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 classroom. The IEQ Score gives us more refined knowledge.

5.0 Physical Activity Engagement and Commuting Practices

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

5.1 Physical Activity Engagement

Providing students with opportunities for alternative paths of travel around the facility, 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 learning environment can be associated with healthier lifestyles.

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

HH facility (site, building, and interior)	Mean (1-7)	Standard Deviation	N	Interpretation
Overall physical activity (walking, stair use, etc.)	5.39	1.11	275	Enhances

Results indicated that Students felt that HH **enhanced** (Mean = 5.39) their physical activities (walking, stair use, etc.).

5.2 Commuting Practices

HH is located on the northeastern side of the East Bank of the University of Minnesota. The East Bank campus is located north of 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 HH facility.

Table 5 provides results on students' commuting mode of transportation. These results, although not related to IEQ, do offer the University insight into students' 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

Primary Mode of Transportation	Drive alone (or with children under 16)	Carpool or vanpool	Public transit	Bicycle	Walk	Telecommute	Other
Mean (1-7)	22.7 %	1.1%	19.1%	9.4%	45.5%	.4%	1.9%

The most frequent mode of transportation to HH was walking (45.5%), followed by driving alone (or with children under 16) (22.7%), public transit (19.1%), bicycle (9.4%), other (1.9%), telecommuting (.4%).

6.0 Conclusions

6.1 Summary

A post-occupancy evaluation was conducted of Students of HH at approximately 18 months after it was first occupied. About 13% of the Students responded to the survey.

The survey included questions related to students' overall satisfaction with the facility (site, building, and interior) and influence of the facility on their overall learning experience and health. Students were **satisfied** with the facility (Mean = 6.19); they found the facility **enhances** their overall learning experience (Mean = 5.75) and **enhances** their overall health (Mean = 4.96). In addition, similar results were reported when students were asked these same questions about their primary classrooms. They reported overall **satisfaction** (M = 6.04) with their primary classrooms, and that their overall learning experience (M = 5.77) and overall health (M = 4.98) was **enhanced** by their primary classroom. As the range of scores was from 1-7, scores that showed a moderate to high range of satisfaction. Most of the survey questions related to students' satisfaction with the IEQ categories in their primary classrooms. Students' responses showed they were **satisfied** with the majority of the IEQ categories. The mean satisfaction scores ranged from 5.12 (**Adjustability of thermal conditions**) to 6.37 (**Cleaning and maintenance**). Again, this shows a moderate to high level of satisfaction.

From the students' responses, an IEQ Score was developed and shows respondents' **satisfaction** with all categories and the contribution of each category to that satisfaction score. For HH, the IEQ Satisfaction Score was 6.13, with satisfaction with **Function, Vibration and Movement, and Appearance** of their classrooms as the three categories that influenced students' satisfaction level most. This score reflects the **satisfaction** level of the other categories. Finally, students reported that HH **enhances** their physical activity, which is one of the sustainable design criteria that influences occupant behavior.

6.2 Recommendations

The satisfaction scores are certainly in the positive direction, however, 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 in both overall classrooms and primary, individual classrooms. Recommendations follow:

Thermal Conditions

- Determine special thermal comfort requirements or problems that may be encountered in the building due to learning 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.
- Log complaints related to thermal conditions.

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 Students' ages, duration of task, influence of daylight quality or quantity.
- Conduct onsite measurements using Illuminating Engineering Society standards for Students' tasks.
- Log complaints related to lighting conditions.

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 building, 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 building 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.
- Log noise and other sonic environment complaints.

Privacy Conditions

- Identify Students' 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.
- Compare acoustic privacy problem areas with acoustic measurements to pinpoint specific problem areas.

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 Students about adjustability of any applicable adjustment options, e.g., furnishings, air diffusers, lighting, temperature control, etc.

The above recommendations can help address change in these categories. The focusing on areas students were least satisfied with (Thermal Conditions, Temperature, and Adjustability of Thermal Conditions) can all be addressed by the above recommendations. Exploring these areas in more detail and making adjustments may increase overall satisfaction at the primary classroom.

This study investigated students' satisfaction with the facility and primary classrooms. IEQ satisfaction is individual, but the results of the survey show a central tendency of moderate to high 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 Students and to set the benchmarks from which improvement can be measured in the future.

Appendix A. Open-Ended Responses

Students had the opportunity to raise specific concerns on the overall facility and their primary classrooms. Important information can be gleaned from the open-ended responses. HH Students raised specific concerns about the following themes: thermal conditions, cleaning and maintenance, technology, windows, building services amenities, furnishings, indoor air quality (IAQ), lighting, space organization/layout/function, and acoustics (noise). Many comments were about unsatisfactory thermal conditions the cleaning and maintenance of the rooms as well as building amenities. There were positive comments as well, which included an overall satisfaction with the building and daylighting. Though these qualitative responses overall appear as the Students are dissatisfied; they can be helpful in understanding on a deeper level areas that may need improvement. The following are qualitative responses to the above noted themes.

Daylighting

- Should have automatic sun screens and adjustable temperature that it does not have
- I love the natural light
- I wish I had a window, but I learning in the basement. So that is not a real possibility.

Space Layout

- An office with a large pillar in it is not conducive to productivity, always having to reach or go around it. That is the height of stupidity on the architect's part.
- The furnishings, floor plan, and learning plan of the offices in Hanson was abysmally poor. I honestly cannot believe the designer can hold a job in that position, or had any training or any common sense.
- Overall a badly designed building. Why are there columns in the middle of offices? As a consequence of all this I learning more at home than otherwise.

Electric Lighting

- Lighting - I had to argue for increasing #36 bulbs to #51 despite the "environmental guy" telling me #36 were bright enough - they provided little illumination and ironically the windows help very little.
- Wish there was a way to disable fluorescent lighting.
- We have some really harsh lighting which can hurt the eyes over a long period of time I wish the lights were dimmable
- The fluorescent lighting sometimes makes it difficult to focus.
- Lighting is wonderful

Temperature/Thermal conditions

- It is either too cold or hot in here (when sun goes below a highrise at 4:15pm in the winter, by 4:16 it is COLD, and fans are tamped down and heat turned down even though there are people learning here at night. We have had to call about that numerous times.
- Temp varies from too hot to too cold. Wish it were adjustable.
- It can be drafty and I can't adjust that, but overall the temperature is generally fine and I just put on layers if necessary.
- My office is way colder than others in the same floor.
- It is too cold in the summers
- According to Tim at facilities management, the recorded temp in my office (4-161 Hanson) is all over the place. After five, if it has not been sunny, I need to wear my coat. It would be great if we could keep the temp at 72 regardless of the weather.
- Temperature can often be an issue in my classroom. There are many days when cold air is blowing directly on my classroom.
- My main issue is the temp: it is too cold here!

Cleaning and maintenance

- The night janitors hardly ever vacuum or do much else. The day learners are good, but can't be expected to pick up the slack of the night guys.
- Cleaning seems limited and sporadic
- The lower level of Hanson Hall could be cleaner, I often have to clean the space because it does not get cleaned. Also I learning in the labs as well and this area does not get cleaned nearly as often as it should.
- The cleanliness of HMH 2-255 is very poor - please increase the level of attention it receives.

Furnishings

- The classroom - unmovable desks are stupid - in our former space at least we could move the desks to fit the space. These desks are fastened to the wall.

Function

- I am unable to use one desk as the heating/fan system above it rattles when the air conditioning is on and 4 years of digging in the ceiling has not even located nor solved the problem.
- The stairs are very difficult to use. There is no shower. The security and the toilets are very cheap and it makes it unattractive to use. There is no ease of moving bikes.

Indoor air quality

- Sewer gas filters up the elevator shaft, especially since Riverside Ave. was redone.
- The air quality in the lower level in my office is stale and stagnant.

Vibration and movement

- The bldg, vibrates from traffic on Riverside

Acoustics

- The stupid cross walk is always chirping WAIT WAIT (I have contacted the city about that with mixed results). To sum up, this building could have been so much better if you had a different contractor, architect, etc.

Appearance

- Oh, and the bland colors chosen to match the outdated 1997 Carlson Bldg. are depressing.

Building amenities

- The telephones on third floor Hanson Hall (at least ours) are terrible - you can't always even hear what the other person is saying.
- It is very nice. My only details are in relation to things like, the motion detector lights sometimes go out if I am typing at my computer so I have to wave my arms to get them back on.
- I also cannot shower after biking. May be an issue
- Bicycle commuting would be easier if it were possible to shower on the west bank.
- Hanson Hall should have a shower facility if the U wants people biking or walking. It does not.
- Please install water fountains that are designed for filling water bottles.

Privacy

- It's a challenge because there's no privacy nor a good place to meet with employers or colleagues with access to my office computer. And there have been temperature/draftiness issues but facilities has been very responsive.

Overall dissatisfaction

- We let architects know of our needs during the design phase but were largely ignored in the process.

Overall positive

- overall a very nice place to learning

Safety

- Ice does build up on the sidewalks in front of the building and could be a safety concern.

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 measurement 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 deviation 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).