



Indoor Environment Quality + Classroom Environment Folwell Hall (FH), University of Minnesota Minneapolis, MN Report 1

**February 2015, Minneapolis, MN
Sustainable Post-Occupancy Evaluation Survey (SPOES)
B3 Guidelines**

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1.0 Overview

The purpose of this report is to examine the connection between sustainable design criteria used in the design of the Folwell Hall facility (FH) and occupants' satisfaction with their work environments located in the FH. The FH facility was designed using the B3 Guidelines (formerly known as the Minnesota Sustainability Guidelines or MSBG) and completed for occupancy in 2011. The B3 Guidelines track specific state-funded, B3 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 workplace, classroom, and residence hall settings in compliance with the B3 Guidelines project tracking requirements. This is a report of occupants' (hereafter called students) responses at 3.5 years post-occupancy. The survey was conducted in February 2015 and is the first of two required survey events for this building.

This SPOES report focuses on students' satisfaction with the physical environment as related to 18 indoor environment quality (IEQ) criteria such as lighting, thermal, and acoustic conditions in their primary classrooms. Students' satisfaction with the facility (site, building, and interior) and the effect of the facility's physical environment on their perceptions of their learning experience and health also are included. Finally, a brief look at students' commuting and physical activities within the building are reported. The report provides descriptive information about students' perceptions of the IEQ of their classroom 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). 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 each question 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:

- 1.00 - 3.5 dissatisfied (hinders)
- 3.51 - 4.5 neither satisfied (enhances) nor dissatisfied (hinders)
- 4.51 - 7.0 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 (site, building, and interior) and the influence of their physical environment on their perception of their learning experience and health. Then they responded to questions about their satisfaction with their primary classrooms in relation to IEQ criteria from the B3 Guidelines.

In the SPOES questionnaire, the 18 IEQ criteria listed below are evaluated. There are two levels of criteria, categories and attributes. As shown in the list, the 'overall' criteria are boldfaced and called 'categories' or 'category level' criteria. A category is broader or more general such as Overall View Conditions or Overall Indoor Air Quality. Some categories have 'attributes' or 'attribute level' criteria and provide greater detail about the category. For example, Overall Thermal Conditions is a category level question, and there are four attribute level questions related to thermal conditions such as adjustability, air velocity (draft), humidity, and temperature. Overall Acoustic Conditions is a category with attributes of students' ability to hear desired sounds and their ability to limit undesired sounds. There are 10 category-level and 8 attribute level questions. Means are calculated and reported for all category and attribute-level criteria.

An IEQ Satisfaction Score is also calculated for students' satisfaction with IEQ in their primary classrooms. This is a weighted mean statistical combination of the 10 category-level criteria only and results in a single, mean IEQ Satisfaction Score for all students' satisfaction with the physical conditions of their primary classrooms. Attribute-level criteria are not included in the IEQ Score because unequal weight would be given to criteria that have both category and attribute-level questions.

In the following list, **category (boldface)** criteria are listed in alphabetical order. If a category has attributes, they are listed with the category.

Overall Acoustic Quality

- Ability to hear desired sounds
- Ability to understand presentations
- Extent of background noise

Overall Appearance (aesthetics)

Overall Cleaning and Maintenance

Overall Lighting Conditions

Overall Furnishings

- Function of furnishings

Overall Indoor Air Quality

Overall Technology

Overall Thermal Conditions

- Adjustability of thermal conditions
- Air velocity (drafty/stagnant)
- Humidity (dry or moist)
- Temperature (hot or cold)

Overall Vibration and Movement

Overall View Conditions (materials)

Additionally, students' physical activities, commuting practices, and recycling behaviors within the building were investigated.

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 Description of Building

Folwell Hall is located at 9 Pleasant St. on the East Bank campus of the University of Minnesota at the intersection of University Avenue SE and Pleasant Street SE in Minneapolis, MN. It is in a walkable community that is in close proximity to other campus buildings, open green space, public transportation, restaurants, student housing, and grocery and retail stores. In 1907 Folwell Hall was constructed to replace the Old Main Hall building that was destroyed by fire. It is 111,500 square feet over five floors. It houses the College of Liberal Arts language departments and includes office spaces, classrooms, and other supporting work spaces for students, faculty, and staff. It underwent a major renovation in 2011. The building is on the Minnesota Historic Register (see Figure 1).



Figure 1. Folwell Hall (Courtesy of University of Minnesota)

3.2 Description of Respondents

The FH had approximately 4,100 students were taking classes in the facility during the spring semester period and administration of the survey event. The response rate to the questionnaire was approximately 10%. Of those responding, 32% were male and 68% were female. The median age of respondents was 20.5 years; the mode was age 19, with a range of 18 to 70 years.

The renovation and expansion were completed by Fall 2011. Students responded that 75% of them spend up to 4 hours a week in their primary classroom (the one they related all responses to); 22% spend more than 5 hours per week in their primary classroom. Additionally, 83% of students spend 1-4 hours per week in other parts of FH; 9% spend more than 5 hours per week in parts of FH other than their primary classroom. Next, 82% of respondents rated their satisfaction with their course(s) at 5.0 or higher (31% were at 7.0). Eighty-four percent of the respondents also indicated a high level of satisfaction with how much they have learned from the course(s) in which they are enrolled in FH.

4.0 Findings and Discussion

4.1 FH Facility (Site, Building, and Interior): Overall Satisfaction, Learning experience, and Health

Students responded to questions concerning the FH 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 shows the means and standard deviations of their responses as well as how the responses are interpreted. Figure 2 is a graph that shows the mean for each question with a blue mark. The standard deviation is shown by the green/red, vertical bar with green representing satisfied (or enhanced) and red representing dissatisfaction (or hindered). Gray represents the ‘neither/nor’ range of responses. This graph is simply a visual image of the findings from Table 1.

Table 1. FH facility - overall satisfaction, learning experience, and health

FH Facility (site, building, and interior)	Mean (1-7)	SD	N	Interpretation
Overall satisfaction	5.91	1.01	422	Satisfied
Overall learning experience	5.43	1.08	426	Enhances
Overall health	4.83	1.14	424	Enhances

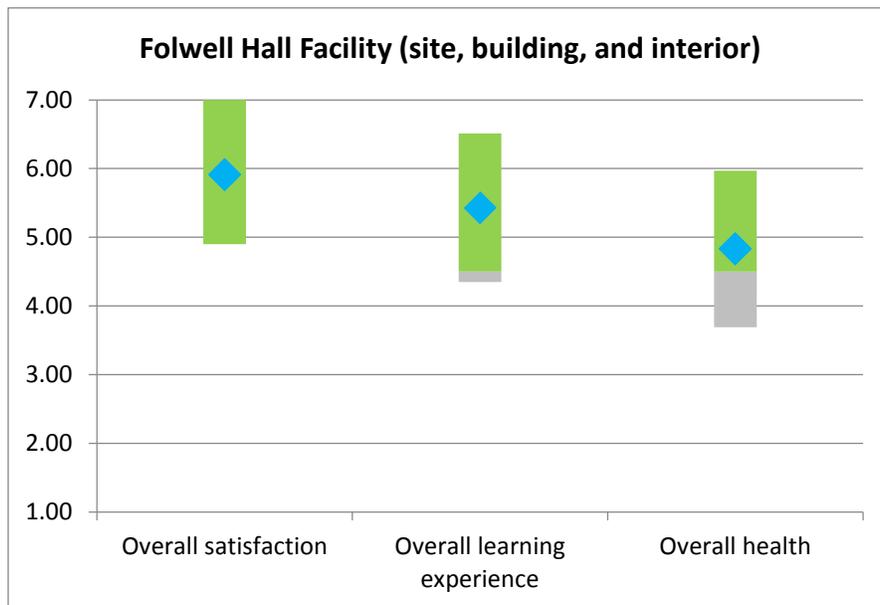


Figure 2. FH facility - overall satisfaction, learning experience, and health

Results indicated that students were **satisfied (M = 5.91)** with the FH facility (building, site, and interior) and reported that their overall learning experience was **enhanced (M = 5.43)** by the facility. Students reported that their overall health was **enhanced (M = 4.83)** 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 shows the means and standard deviations of their responses as well as how the responses are interpreted. Figure 3 is a visual image of the findings from Table 2; an explanation of the graphic was given for Figure 2.

Table 2. Primary classroom – overall satisfaction, learning experience, and health

Primary Classroom	Mean (1-7)	SD	N	Interpretation
Overall satisfaction	5.55	1.26	422	Satisfied
Overall learning experience	5.36	1.18	424	Enhances
Overall health	4.92	1.10	425	Enhances

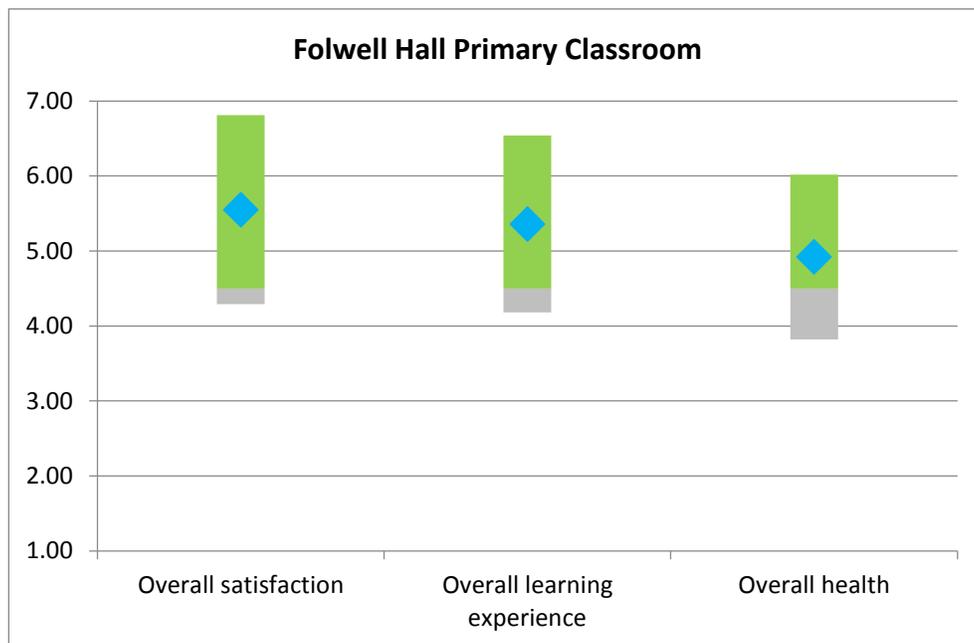


Figure 3. Primary classroom - overall satisfaction, learning experience, and health

Results indicated that employee were **satisfied (M = 5.55)** with their primary classroom, their overall learning experience was **enhanced (M = 5.36)** by their primary classroom, and their overall health was **enhanced (M = 4.92)** 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 classroom. Table 3 shows the means and standard deviations of their responses as well as how the responses are interpreted. It must be noted that all responses, regardless of the classroom, were combined so these are composite means of all classrooms in FH. Figure 4 is a visual image of the findings in Table 3; an explanation of the graphic was given for Figure 2.

Table 3. Primary classroom - satisfaction with IEQ conditions

FH Primary Classroom					
IEQ Criteria (1-18) Category Level Criteria are Boldface)		Mean	SD	N	Interpretation (D = Dissatisfied) (S = Satisfied)
1	Overall cleaning and maintenance	6.05	1.06	424	Satisfied
2	Overall vibration and movement	5.96	1.03	423	Satisfied
3	Ability to hear presentations	5.96	1.08	427	Satisfied
4	Ability to understand desired sounds	5.91	1.05	425	Satisfied
5	Overall view conditions (see materials)	5.88	1.15	423	Satisfied
6	Function of furnishings	5.84	1.16	425	Satisfied
7	Overall acoustic quality	5.82	1.13	426	Satisfied
8	Humidity (dry or moist)	5.78	1.16	426	Satisfied
9	Overall lighting conditions	5.76	1.25	427	Satisfied
10	Overall indoor air quality	5.75	1.29	424	Satisfied
11	Overall technology	5.71	1.26	425	Satisfied
12	Air velocity (drafty or stagnant)	5.71	1.20	426	Satisfied
13	Overall appearance (aesthetics)	5.69	1.33	426	Satisfied
14	Extend of background noise	5.67	1.30	424	Satisfied
15	Overall thermal conditions	5.59	1.28	427	Satisfied
16	Temperature (hot or cold)	5.45	1.43	426	Satisfied
17	Overall furnishings	5.40	1.62	427	Satisfied
18	Adjustability of thermal conditions	5.07	1.45	419	Satisfied

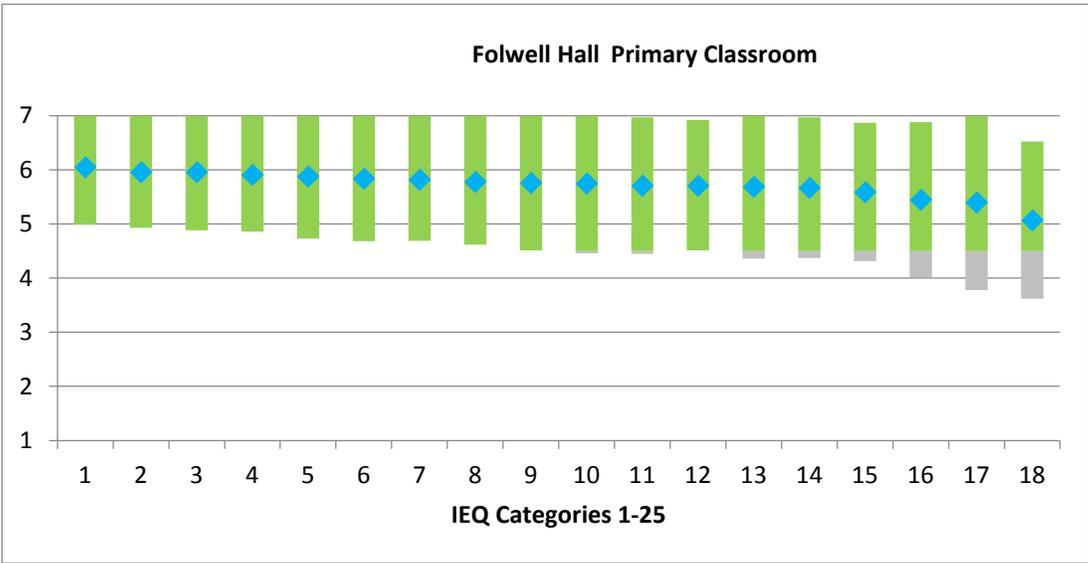


Figure 4. Primary classroom - satisfaction with IEQ criteria (IEQ 1-18 are listed in Table 3 above)

Results indicate that students were satisfied with all of the IEQ criteria in their primary classrooms; none fell below a mean of 5.07. These findings support the **moderate to high level of student satisfaction** with the IEQ of their classrooms. Further information about their perceptions can be found in Appendix A.

Open-Ended Responses.

4.4 IEQ Satisfaction Scorecard

The IEQ Satisfaction Score is determined by calculating a mean of all overall category level IEQ criteria. At this time, all variables are weighted equally in this calculation as little evidence exists that provides rationale for weighting some variables heavier than others. The IEQ mean is representative of a fair overall IEQ score and can serve as a benchmark of students' satisfaction with the physical environment of their primary workspace. As shown in Figure 5, the **IEQ Satisfaction Score** for FH is **5.76**.

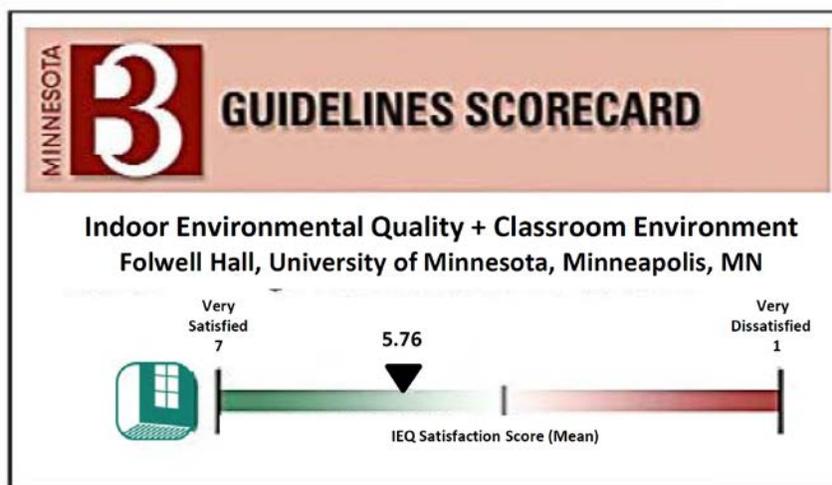


Figure 5. Primary Classroom - IEQ Satisfaction Score

Overall, the students showed a highly positive satisfaction level with the IEQ of Folwell Hall classrooms as indicated by the weighted mean score of **5.76**. As shown in Table 3, all IEQ criteria were above 5.01 with Overall cleaning and maintenance showing the highest at 6.05. Please note that the IEQ Satisfaction Score only uses the category level criteria (those labeled 'Overall'; see section 2.1, paragraph 3 for explanation). This sets a high benchmark for continued assessment of students' satisfaction.

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 FH (site, building, and interior), their commuting practices, and their learning experience.

5.1 Physical Activity Engagement

Providing students with opportunities for alternative paths of travel around the classroom building, 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 FH facility

FH facility (site, building, and interior)	Mean (1-7)	SD	N	Interpretation
Overall physical activity (walking, stair use, etc.)	5.36	1.11	416	Enhances

Results indicated that students felt that FH **enhanced** ($M = 5.36$) their physical activities (walking, stair use, etc.). Further, of the 416 respondents to this question, 98% said they were **satisfied** with the facility's influence on their overall physical activity.

5.2 Commuting Practices

FH is located on 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 FH facility.

Table 5 provides results on students' primary mode of transportation; Table 6 summarizes commuting distances between home and the FH facility; and Table 7 summarizes students' ability to commute using alternative choices (walk, public transit, bike, van, or carpool, etc.). 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. Commuting Practices – FH Primary mode of transportation

FH – Primary Mode of Transportation					
Drive alone (or w/children <16)	Carpool	Public Transit	Bicycle	Walk	Other
11%	2%	27%	7%	51%	2%

Related to primary modes of transportation, 11% of students drive alone (or with children under 16), 27% use public transit, 7% use a bicycle, 51% walk, 2% carpool, and 2% use a combination of commuting options (e.g., driving and biking).

Table 6. Commuting Practices – FH Commuting distance traveled

Commuting Distance – Home to FH – One Way					
Miles Travelled	0-5	6-15	16-30	31-45	46+
	73%	13%	9%	3%	2%

Results indicated that the large majority of students (73%) commuted 0-5 miles one-way between home and FH, followed by 13% who commute 6-15 miles, 9% commute between 16-30 miles, 3% commute between 31-45 miles, and 2% commute over 46 miles. All of these are one-way miles. As this is a metro area and many students live on campus or in near-by apartments, the commute is short.

Table 7. Commuting practices – FH location and alternative commuting behaviors

FH – Ability to commute in alternative ways				
F (SBI) Location	Mean	SD	N	Interpretation
Alternative commuting options	5.20	1.50	419	Enhanced

Results indicated that the location of the FH **enhanced** (M = 5.20) students' ability to commute to class in alternative ways, e.g., walk, bicycle, public transit, van or carpool, etc. Further, of the 419 respondents to this question, 91% said the location **enhanced** their commuting options.

6.0 Conclusions

6.1 Summary

A post-occupancy evaluation was conducted of students of FH at approximately three and a half years after its renovation in 2011. About 10% of the students who are enrolled in classes in FH 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 (M = 5.91); they found the facility **enhances** their overall learning experience (M = 5.43) and **enhances** their overall health (M = 4.83). When students were asked these same questions about their primary classroom, they reported overall **satisfaction** (M = 5.55) with their primary classrooms. They also reported that their overall learning experience was **enhanced** (M = 5.36) by their primary classrooms, and their overall health was **enhanced** (M = 4.92) by their primary classroom. As the range of scores was from 1-7, scores that showed satisfaction are in a low – to high satisfaction range.

Most of the survey questions related to students' satisfaction with the IEQ criteria in their primary classrooms. Students' responses showed they were **satisfied** with the all of the IEQ criteria. There were no mean satisfaction scores below 5.07 (Adjustability of thermal conditions), and the highest was 6.07 (Overall cleaning and maintenance). This is a moderate level of satisfaction for several IEQ criteria and moderately high satisfaction for most of them.

From the students' responses, an IEQ Score was developed and shows respondents' satisfaction with the IEQ of all category level criteria. For FH, the IEQ Satisfaction Score was **5.67**. This score reflects a moderately high satisfaction level with IEQ categories. Finally, students reported that FH **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, it is important to maintain a high level of satisfaction as the building continues to age. It is appropriate to consider a continuing assessment, and recommendations below can assist in this plan. For IEQ categories that have physical measurement possible, e.g., thermal, acoustic, and lighting, it is recommended that these measurements be taken in all classrooms. Recommendations follow:

Thermal Conditions

- Determine special thermal comfort requirements or problems that may be encountered in the building due to work activities or sitting or design considerations. Focus groups can be useful in identifying problem locations.
- Determine if any classroom areas differ now from original intent to be sure air flow is the same as

originally designed.

- 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

- Determine if any classroom areas differ now from original intent to be sure light patterns, quantity, and quality are not impeded by changing walls, ceilings, or fixtures.
- Develop additional quality lighting criteria as needed for special facility issues such as students' ages, culture, duration of tasks, or influence of daylight quality or quantity.
- Conduct onsite measurements using Illuminating Engineering Society standards for students' tasks.
- Log complaints related to lighting conditions.
- Identify problem locations that may be affected most by lack of control over daylighting, which can cause glare and eyestrain.

Acoustic Conditions

- Identify acoustic criteria for overall requirements.
- Determine if any classroom areas or activities differ now from original intent including collaborative teaching spaces now being located adjacent to focus teaching areas (individual workstations).
- Develop any additional special acoustical performance requirements to support functional programming of learning, 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.
- Identify students' privacy concerns via focus groups or log complaints.
- Consider students' tasks within shared spaces, i.e., outside of the classroom, to determine if change can be made for increased acoustic control.

Privacy Conditions

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

This study investigated students' satisfaction with the facility and primary classrooms of Folwell Hall. IEQ satisfaction is individual, but the results of the survey show a central tendency of moderate to high satisfaction with the facility and all IEQ criteria. 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. FH students raised specific concerns about thermal conditions, IAQ, furnishings, and technology. It should be noted that these responses may be helpful in pinpointing both positive and negative aspects of the facility or classroom, it does not mean they represent the overall sentiment from students. Following is a quantitative summary of the qualitative responses to the criteria, with descriptions drawn from each.

Overall Facility (site, building, and interior)

- There were 55 positive responses to the overall FH facility. Common phrases were “it’s a beautiful building and interior; it’s my favorite building on campus.” However, it should be noted there were four negative comments about the **slippery floors**, and six respondents noted the need for **more study rooms** as the current ones were great, but crowded.
- There seems to be a need for more **trash cans**, i.e., one in each room (16 respondents); the need for more **drinking fountains** especially those where one can fill a water bottle (14 respondents); and even the need for **pencil sharpeners** (6 respondents) as much language work is done in pencil.
- There were 10 respondents who commented that several rooms were **too small** for the class scheduled in it, and they were **crowded** with too many chairs/tables.

Thermal Conditions

- Most comments (16) related to how **cold** it was in FH; only two reflected that it was too hot.

IAQ

- Respondents (15) reported **bad odors** in FH. Many talked about a moldy aroma; all said they were concerned about the influence on their health.

Furnishings

- Furnishings seemed to be ‘liked’ (9)... “love the chairs and tables” or highly disliked by 46 respondents. The very high number of negative responses related to “tables are **too small** for both laptops and books/papers to be used at the same time; **difficult to move** around; many classes require team work and can’t move the tables/chairs; placement of tables/chairs in rooms make it so you **can’t see** other students; chairs are not **comfortable**.” Comments (7) also related to how ‘**messy**’ the classrooms were because the furnishings were never put back in order.
- Ten respondents suggested **adding benches** to the halls for seating as they wait for classrooms to clear.

Technology

- 21 responses referred to classroom technology **not working and lack of access** to outlets.

Acoustics

- Seven respondents commented on the **noise** that filtered into classrooms from across the street, i.e., from the fraternity houses and from street traffic.

Lighting

- Daylighting control was an issue for five respondents; **glare** in the classroom caused difficulty in seeing the screens.
- Electric lighting (8) was seen as **cool and insufficient**; there are also **too many switches** in a single room so it's difficult to find the right switch.

Cleaning and Maintenance

- Five respondents commented that the classrooms were **not tidy**; often cups, papers, and other trash were left in the rooms.

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.

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, or a single question, 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).