

MINNESOTA



POST-OCCUPANCY EVALUATION

Indoor Environmental Quality + Classroom Environment

East Campus Classroom Building-Century College (ECCB-CC)

White Bear Lake, MN

March 2016, 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 East Campus Classroom Building-Century College (ECCB-CC) facility and occupants' satisfaction with their classroom environments located in this building. The ECCB-CC facility was renovated using the B3 Guidelines (formerly known as the Minnesota Sustainable Building Guidelines or MSBG) and completed for occupancy in August 2013. 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 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 2.5 years post-occupancy. The survey was conducted in February/March 2016.

This SPOES report focuses on students' satisfaction with the physical environment as related to 23 indoor environmental 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 academic performance 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 academic performance and health on a scale from 1 (hinders) to 7 (enhances).

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 - 3.50 dissatisfied (or hinders)
- 3.51 - 4.50 neither dissatisfied (or hinders) nor satisfied (or enhances)
- 4.51 - 7.00 satisfied (or enhances)

An IEQ Score is also calculated for students' satisfaction with IEQ in their primary classrooms. This is a statistical combination of category-level IEQ scores, which results in a single IEQ score for all respondents 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 academic performance and health. Then they respond to questions about their satisfaction with their primary classrooms in relation to IEQ criteria from the B3 Guidelines. Additionally, students' physical activities and commuting practices are investigated.

In the SPOES questionnaire, the 23 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 an attribute of students' ability to hear desired sounds. There are 11 category-level and 12 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 statistical combination of the 11 category-level criteria only and results in a single, mean IEQ Satisfaction Score for 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 (lecture, video, discussions, etc.)

Overall Appearance (aesthetics)

Overall Cleaning and Maintenance

Overall Daylighting Conditions

- Ability to adjust daylighting
- Amount of daylighting

Overall Electric Lighting Conditions

- Ability to adjust electric lighting
- Amount of electric lighting

Overall Furnishings

- Ability to adjust furnishings

- Function of furnishings

Overall Indoor Air Quality

Overall Technology (presentation, laptop support, etc.)

- Access to electric outlets

Overall Thermal Conditions

- Ability to adjust thermal conditions
- Air velocity (drafty/stagnant)
- Humidity (dry or moist)
- Temperature (hot or cold)

Overall Vibration and Movement

Overall View Conditions (ability to see instructor, screens, etc.)

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. The classrooms are shown as a congregate measure, not analyzed individually. This study is limited to students' perceptions.

3.0 Sample Description

3.1 Description of Building

The ECCB-CC facility resides on the campus of Century College, a part of the Minnesota State Colleges and Universities system (MnSCU), and is located at 3300 Century Ave., North, White Bear Lake, MN 55110. The ECCB-CC facility (see Figure 1) had five new classrooms constructed in 2012-13 including classrooms E2780, E2782, E2784, E2786, and E2788. These areas are distributed across one floor of the facility and amounts to 8,290 square feet.



Figure 1. East Campus Classroom Building-Century College (Photo credit: Century College)

3.2 Description of Respondents

The ECCB-CC had approximately 690 students with classes in the renovated classrooms during the spring semester administration of the survey. The response rate to the questionnaire was approximately 4%. Of those responding, 67% were female, 30% were male, and 4% were 'other.' The mean age of respondents was slightly over 27 years; the range was 18 to 52 years.

Students responded that in their primary classroom or laboratory environment, 11% spend 1-2 hours per week in their primary classroom or laboratory environment, 22% spend 3-4 hours, and 67% spend 5+ hours per week in their primary classroom or laboratory environment. This indicates how much they are exposed to the classrooms' IEQ.

4.0 Findings and Discussion

4.1 ECCB-CC Facility (Site, Building, and Interior): Overall Satisfaction, Learning Experience, and Health

Students responded to questions concerning the ECCB-CC 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 represented by a green/red, vertical bar with green representing satisfied (or enhanced) and red representing dissatisfaction (or hindered). Gray represents the 'neither/nor' range of responses. In cases where there were no dissatisfied responses, the bar will be all grey and green. This graph is simply a visual image of the findings from Table 1.

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

Overall	Mean	SD	N	Interpretation
Satisfaction	5.73	1.32	44	Satisfied
Learning Experience	4.98	1.54	44	Enhanced
Health	4.89	1.17	44	Enhanced

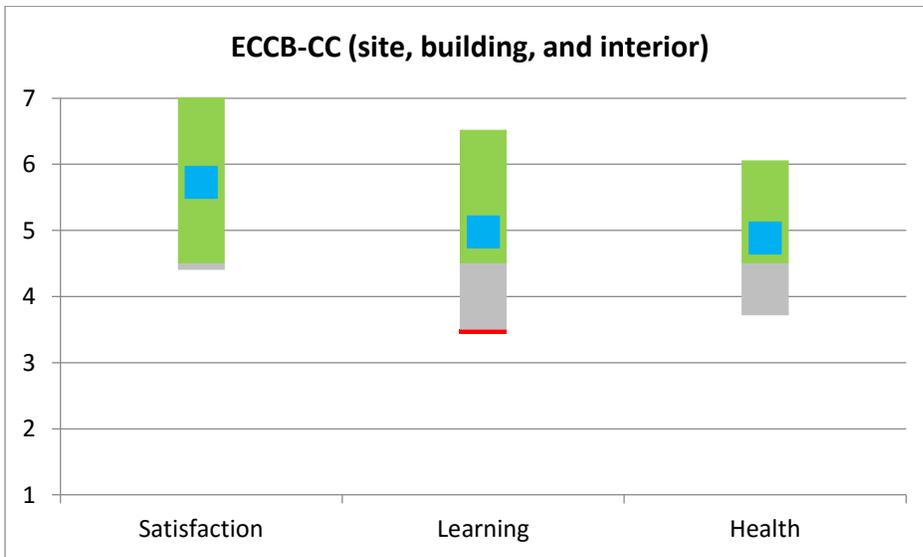


Figure 2. ECCB-CC facility - overall satisfaction, learning experience, and health

Results indicate that students were **satisfied (M = 5.73)** with the ECCB-CC facility (building, site, and interior) and reported that their overall learning experience was **enhanced (M = 4.98)** by the facility. Students reported that their overall health was **enhanced (M = 4.89)** 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.

Table 2. ECCB-CC primary classroom – overall satisfaction, learning experience, and health

Overall	Mean	SD	N	Interpretation
Satisfaction	5.08	2.02	27	Satisfied
Learning Experience	5.08	1.86	27	Enhanced
Health	4.62	1.44	27	Enhanced

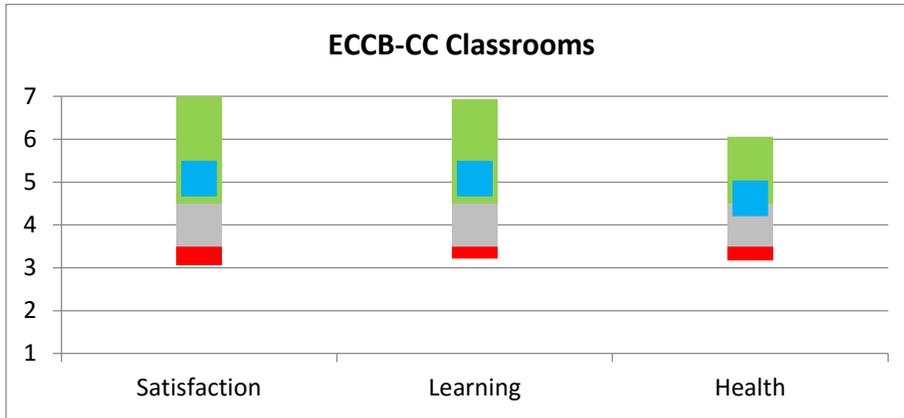


Figure 3. ECCB-CC primary classroom - overall satisfaction, learning experience, and health

Results indicate that students were **satisfied (M = 5.08)** with their primary classroom, their overall learning experience was **enhanced (M = 5.08)** by their primary classroom, and their overall health was **enhanced (M = 4.62)** by their primary classroom.

4.3 Primary Classroom: Satisfaction with Indoor Environmental Quality (IEQ)

Students responded to questions concerning their satisfaction with IEQ criteria (thermal conditions, indoor air quality, acoustic conditions, etc.) related to their primary classroom. Table 3 shows the means and standard deviations of their responses in order from highest to lowest mean, 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 ECCB-CC. Figure 4 is a visual image of the findings in Table 3.

Table 3. ECCB-CC primary classroom - satisfaction with IEQ criteria

#	IEQ Criteria (1-23) (Category level criteria are bold face)	Mean	SD	N	Interpretation (S = Satisfied) (D = Dissatisfied)
1	Amount of electric light	5.96	1.02	26	Satisfied
2	Overall indoor air quality	5.88	1.05	26	Satisfied
3	Overall electric lighting conditions	5.85	1.13	26	Satisfied
4	Overall appearance (aesthetics)	5.85	1.06	26	Satisfied
5	Air velocity (drafty or stagnant)	5.65	1.07	26	Satisfied
6	Overall acoustic quality	5.65	1.07	26	Satisfied
7	Overall cleaning and maintenance	5.65	1.27	26	Satisfied
8	Overall daylighting	5.58	1.18	26	Satisfied
9	Overall thermal conditions	5.54	1.47	26	Satisfied
10	Ability to hear desired sounds	5.50	1.55	26	Satisfied
11	Humidity (dry or moist)	5.46	1.22	26	Satisfied
12	Amount of daylighting	5.46	1.34	26	Satisfied
13	Access to electric outlets	5.46	1.42	26	Satisfied
14	Ability to adjust electric lighting	5.27	1.56	26	Satisfied
15	Overall vibration and movement	5.24	1.56	25	Satisfied
16	Overall technology conditions	5.12	1.93	26	Satisfied
17	Overall furnishings	5.04	2.07	26	Satisfied
18	Function of furnishings	5.04	2.14	26	Satisfied
19	Overall view conditions	5.00	2.15	26	Satisfied
20	Adjustability of furnishings	4.96	2.07	26	Satisfied
21	Temperature (hot or cold)	4.92	1.49	26	Satisfied
22	Adjustability of daylighting	4.92	1.32	25	Satisfied
23	Adjustability of thermal conditions	4.81	1.44	26	Satisfied

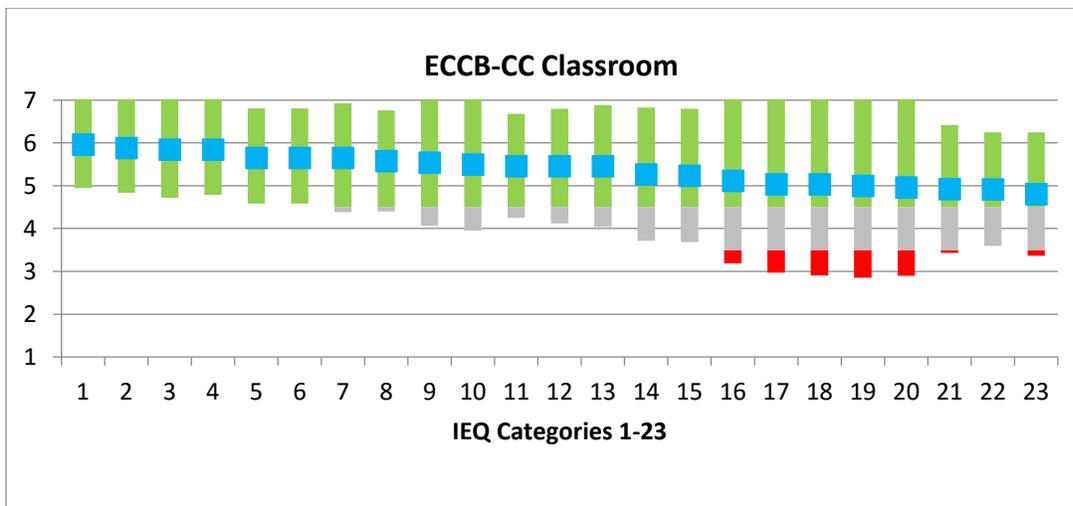


Figure 4. ECCB-CC primary classroom - satisfaction with IEQ criteria (IEQ 1-23 are listed in Table 3)

Results indicate that students were satisfied with all of the IEQ criteria in their primary classrooms. Means ranged from **4.81** (adjustability of thermal conditions) to **5.96** (amount of electric light). These findings support a **consistently positive 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 11 category level IEQ criteria. At this time, all criteria are weighted equally in this calculation as little evidence exists that provides rationale for weighting some criteria heavier than others. The IEQ mean is representative of a moderately high overall IEQ score and can serve as a benchmark of students' satisfaction with the physical environment of their primary classroom. As shown in Figure 5, the **IEQ Satisfaction Score** for ECCB-CC is **5.50**.

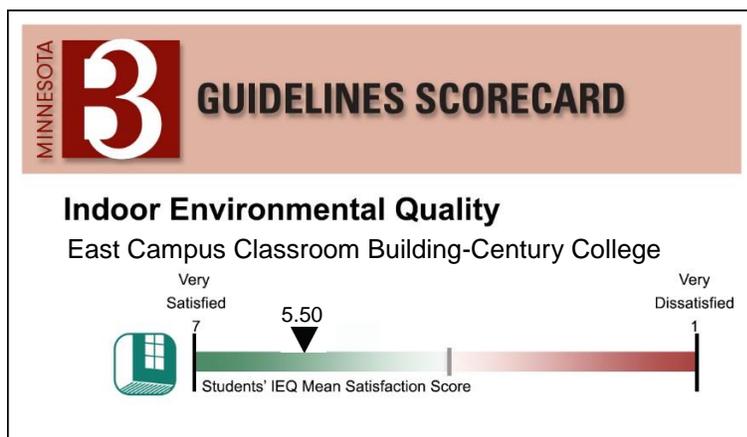


Figure 5. ECCB-CC primary Classroom - IEQ Satisfaction Score

Overall, the students showed a positive satisfaction level with the IEQ of ECCB-CC classrooms as indicated by the mean score of **5.50**. As shown in Table 3, all IEQ categories were at or above **5.00**; seven categories were above **5.50** and helped to increase the IEQ Score. 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 IEQ score sets a positive 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 ECCB-CC (site, building, and interior) and their commuting practices.

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 ECCB-CC facility

ECCB-CC Facility (Site, Building, and Interior)	Mean	SD	N	Interpretation
Overall physical activity (walking, stair use, etc.)	4.94	1.35	18	Enhanced

Results indicate that students felt that ECCB-CC **enhanced (M = 4.94)** their physical activities (walking, stair use, etc.).

5.2 Commuting Practices

ECCB-CC is a facility within Century College in White Bear Lake, MN. ECCB-CC is located on the east side of the campus. The College provides a free parking facility adjacent to the building. There is a covered skywalk over Hwy 120 that serves students who use the west campus parking area.

Table 55 provides results on students' primary mode of transportation; Table 6 summarizes commuting distances between home and the ECCB-CC 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 College 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 – ECCB-CC primary mode of transportation

Commuting Practices Home to ECCB-CC (N=27)	Drive alone (or with children <16)	Car or Van Pool	Public Transit
Students commuting mode (%)	85%	11%	4%

Related to primary modes of transportation, 85% of students drive alone (or with children under 16), 11% participate in a car or van pool, and 4% take public transit.

Table 6. Commuting practices – ECCB-CC commuting distance traveled

Miles Traveled One Way (N=27)	0-5 miles	6-15 miles	16-30 miles	31-45+ miles	46-60 miles	76+ miles
Students commuting distance (%)	11%	33%	37%	11%	4%	4%

Results indicate that 11% of students commute 0-5 miles one-way between home and ECCB-CC, followed by 33% who commute 6-15 miles, 37% commute 16-30 miles, 11% commute 31-45 miles, and 8% who commute 46+ miles to ECCB-CC. All commuting mileage is reported as one-way miles.

Table 7. Commuting practices – ECCB-CC location and alternative commuting behaviors

ECCB-CC Facility (Site, Building, Interior) (N=27)	Mean	SD	N	Interpretation
Ability to commute in alternative ways	4.41	1.47	27	Neither Hindered nor Enhanced

Results indicate that the location of the ECCB-CC **neither hindered nor enhanced (M = 4.41)** students' ability to commute to class in alternative ways, e.g., walk, bicycle, public transit, van or carpool, etc.

6.0 Conclusions

6.1 Summary

A post-occupancy evaluation was conducted of students of ECCB-CC at approximately 2.5 years after its renovation in 2013. About 4% of the students who are enrolled in classes in ECCB-CC 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 = 5.73**); they found the facility **enhances** their overall learning experience (**M = 4.98**) and **enhances** their overall health (**M = 4.89**). When students were asked these same questions about their primary classroom, they reported overall **satisfaction (M = 5.08)** with their primary classrooms. They also reported that their overall learning experience was **enhanced (M = 5.08)** by their primary classrooms, and their overall health was **enhanced (M = 4.62)** by their primary classroom. As the range of scores was from 1-7, these scores indicate satisfaction is moderately low to moderately high.

Most of the survey questions related to students' satisfaction with the IEQ criteria in their primary classrooms. Students' responses showed they were **satisfied** with all 23 of the IEQ criteria. The scores ranged from **4.81** (adjustability of thermal conditions) to **5.96** (amount of electric light). This is a low to moderately high level of satisfaction. However, the consistently positive satisfaction scores are admirable.

From the students' responses, an IEQ Score was developed and shows their satisfaction with the IEQ of all category level criteria. For ECCB-CC, the IEQ Satisfaction Score was **5.50**. This score reflects a **moderately high satisfaction** level with IEQ categories. Finally, students reported that ECCB-CC **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 continuously work on IEQ criteria before there is dissatisfaction. Specifically, for the ECCB-CC, a closer look at thermal conditions seems necessary. For example, for IEQ categories that have physical measurement possible, e.g., thermal, acoustic, and lighting, it is recommended that these measurements be taken in classrooms. Other recommendations follow that could help the College keep occupants' satisfaction positive.

Acoustic Conditions

- Identify acoustic criteria for overall requirements.
- Determine if any task areas differ now from their original spatial layout/use (e.g., classrooms adjacent to noisy spaces).
- Develop specialized acoustical performance requirements to support functional programming occupants' tasks (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). Identify and apply appropriate acoustics modeling software for the project.
- Measure acoustic performance onsite with full building systems (heating, ventilation, and air conditioning) running.
- Identify occupants' privacy concerns via focus groups and/or log complaints relative to acoustical conditions for further evaluation.
- Consider occupants' tasks within shared spaces to determine if spatial layout changes can be made for increased acoustic control.

Lighting Conditions

- Identify occupants' lighting performance criteria that are to be met to achieve goals by conducting onsite measurements of existing illumination and compare them to standards for occupants' tasks as

identified by the Illuminating Engineering Society (IES).

- Determine if any task areas differ now from original intent to be sure illumination quantity and quality are not impeded by physical changes to the space (i.e., walls, ceilings, furnishings, fixtures, or equipment).
- Develop additional quality lighting criteria as needed for special facility (e.g., influence of daylight quality or quantity) or occupant (e.g., age, task duration) issues.
- Log complaints related to lighting conditions for further evaluation.
- Identify poor lighting conditions caused by a lack of control over daylighting, which can cause glare and eyestrain.

Personal Adjustability

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

Privacy Conditions

- Identify occupants' privacy concerns via focus groups or log complaints relative to privacy to determine if visual or audio privacy is most affected.
- Determine if any task areas or responsibilities differ from original intent and develop alternatives or modifications.
- Consider adding noise masking equipment and/or visual screening depending on the nature of the complaints.
- Document and compare acoustic privacy problem areas with acoustic measurements to pinpoint specific problem areas.

Thermal Conditions

- Measure thermal performance conditions on site.
- Log complaints related to thermal conditions for further evaluation.
- Determine special thermal comfort requirements or problems that may be encountered in the building due to physicality of work activities, duration of sitting, or design/layout considerations. Focus groups can be useful in identifying problem locations.
- Determine if any occupants' task areas differ now from original layout to determine if air flow is meeting systems design intent.
- Review conditions that affect thermal comfort using ASHRAE Standard 55-2004 or *Human Factors Design Handbook* (see B3 Guidelines).

This study investigated students' satisfaction with the ECCB-CC facility and primary classrooms. IEQ satisfaction is individual, but the results of the survey show a central tendency of low to moderately high satisfaction with the facility and most 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 survey responses. ECCB-CC students raised few concerns, but those they raised related to furnishings and classroom spatial layout. Generally, the comments are shown as written.

Furnishings

- Not everyone is the same height. This should be taken into consideration when classroom furniture is selected. Being a tall adult & having to sit on a chair that is the size of a primary school student's chair is ridiculous. The chairs & tables were TOO HIGH & uncomfortable. The chairs were adjustable, but the tables were not. The chairs are too short for anyone over 5 feet 8 inches tall. I felt very cramped.
- High chairs and tables are worthless
- The chairs are terribly uncomfortable for those with short legs. The foot rest is unreachable and if I can reach my legs are bent backwards putting stress on my low back and knees.
- In some classrooms, there is not enough room to write or take notes.
- HATE the high-top tables and chairs, legs get extremely tired, ankles throb and it is very distracting. Sitting through a 2 hour lecture is difficult, and I feel my grade is reflecting that.

Spatial Layout

- Space is limited
- The layout of this room turns your attention towards the walls (to see TV screens or computer monitors) all the while the instructor is in the middle of the room. Very difficult to take notes and see the instructor at the same time. This room is awful!
- Very difficult to learn if your prof lectures because there are students on all sides, so there's always at least one side that can't hear.
- Also depending on what side of the table you are sitting on, it is close to impossible to see the instructor and take notes at the same time. For me, looking at my instructor and seeing them talk makes it easier to learn, understand, and hear what they are saying.
- The room is not very functional when it comes to viewing professors' PowerPoint lectures. Too many TV screens. Get rid of the TVs and put in a projector and whiteboard. Teacher's station (computer) is in middle of the class causing some students to be looking at his/her back.

Thermal Conditions

- Lab is always freezing.

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).