

MINNESOTA



**POST-OCCUPANCY
EVALUATION**

**Indoor Environmental Quality + Classroom Environment
Ridgewater College Agriculture and Veterinary Sciences –
(Building C) (RCAB-C)
Willmar, 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 Ridgewater College Agriculture and Veterinary Sciences Building-C (RCAB-C) facility and occupants' satisfaction with their classroom environments located in this building. The RCAB-C facility was renovated using the B3 Guidelines (formerly known as the Minnesota Sustainable Building Guidelines or MSBG) and completed for occupancy in October 2014. 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 17 months 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 (hinders)
- 3.51 - 4.50 neither dissatisfied (hinders) nor satisfied (enhances)
- 4.51 - 7.00 satisfied (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 RCAB-C facility resides on the Willmar campus of Ridgewater College located in Willmar, Minnesota and is a member of the Minnesota State Colleges and Universities system (MnSCU). A major renovation of over 14,467 square feet of the RCAB-C facility (see Figure 1) occurred in 2013-2014 where poorly configured classrooms and labs were redesigned into six lecture, active learning, and special purpose classrooms/labs and two computer labs for the Agriculture program. The renovation provided additional educational space for the growing Agriculture student population.



Figure 1. Agriculture and Veterinary Sciences Building – (Photo credit: Ridgewater College)

3.2 Description of Respondents

The RCAB-C had approximately 182 students with classes in the renovated classrooms during the spring semester administration of the survey. The response rate to the questionnaire was approximately 10%. Of those responding, 61% were male and 39% were female. The mean age of respondents was slightly over 20 years; the range was 18 to 30+ years of age.

Students responded that 11% spend 1-2 hours per week in their primary classroom or laboratory environment, 60% spend 5-6 hours per week in their primary classroom or laboratory environment, and 29% spend more than 6 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 RCAB-C Facility (Site, Building, and Interior): Overall Satisfaction, Learning Experience, and Health

Students responded to questions concerning the RCAB-C 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. RCAB-C facility - overall satisfaction, learning experience, and health

Overall	Mean	SD	N	Interpretation
Satisfaction	5.42	0.81	24	Satisfied
Learning Experience	5.25	1.01	24	Enhanced
Health	4.88	1.05	24	Enhanced

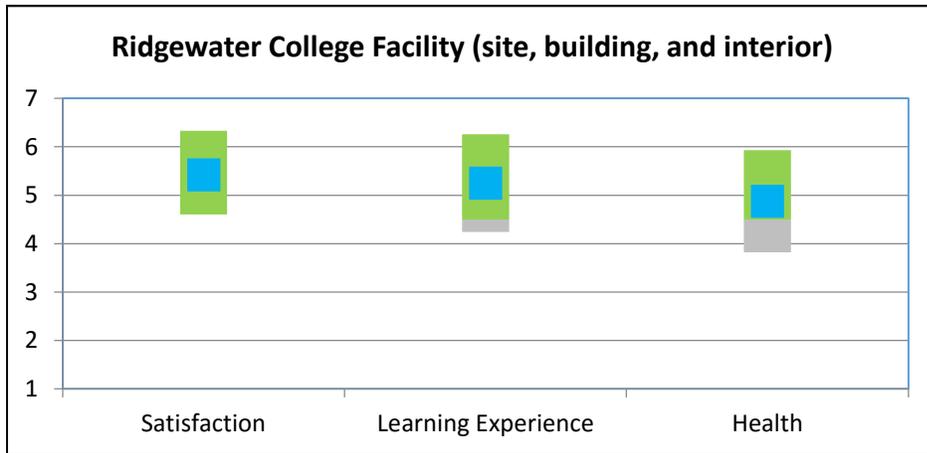


Figure 2. RCAB-C facility - overall satisfaction, learning experience, and health

Results indicate that students were **satisfied (M = 5.42)** with the RCAB-C facility (building, site, and interior) and reported that their overall learning experience was **enhanced (M = 5.25)** by the facility. Students reported that their overall health was **enhanced (M = 4.88)** 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. RCAB-C Primary classroom – overall satisfaction, learning experience, and health

Overall	Mean	SD	N	Interpretation
Satisfaction	5.53	1.04	19	Satisfied
Learning Experience	5.68	1.13	19	Enhanced
Health	5.00	1.15	18	Enhanced

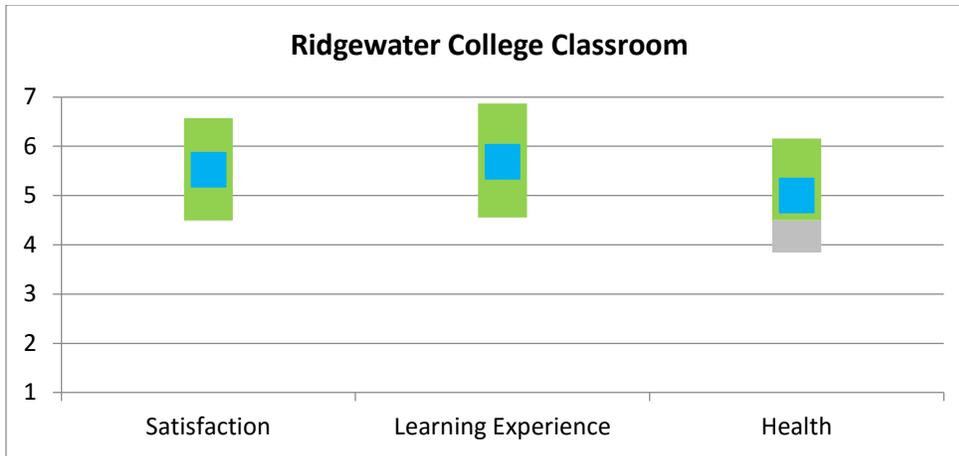


Figure 3. Primary classroom - overall satisfaction, learning experience, and health

Results indicate that students were **satisfied (M = 5.53)** with their primary classroom, their overall learning experience was **enhanced (M = 5.68)** by their primary classroom, and their overall health was **enhanced (M = 5.00)** 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 RCAB-C. Figure 4 is a visual image of the findings in Table 3.

Table 3. RCAB-C 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	5.58	1.39	19	Satisfied
2	Overall cleaning and maintenance	5.50	1.26	18	Satisfied
3	Overall electric lighting conditions	5.42	1.53	19	Satisfied
4	Overall view conditions	5.32	1.52	19	Satisfied
5	Function of furnishings	5.32	1.30	19	Satisfied
6	Ability to hear desired sounds	5.26	1.52	19	Satisfied
7	Overall vibration and movement	5.26	1.33	19	Satisfied
8	Ability to adjust electric lighting	5.16	1.31	19	Satisfied
9	Amount of daylighting	5.16	1.46	19	Satisfied
10	Overall acoustic quality	5.11	1.37	19	Satisfied
11	Overall furnishings	5.11	1.37	19	Satisfied
12	Overall indoor air quality	5.05	1.43	19	Satisfied
13	Overall daylighting	5.00	1.59	19	Satisfied
14	Overall appearance (aesthetics)	4.95	1.39	19	Satisfied

Table 3. RCAB-C primary classroom - satisfaction with IEQ criteria, continued

	IEQ Criteria (1-23) (Category level criteria are bold face)	Mean	SD	N	Interpretation (S = Satisfied) (D = Dissatisfied)
15	Adjustability of daylighting	4.89	1.83	19	Satisfied
16	Adjustability of furnishings	4.89	1.37	19	Satisfied
17	Overall technology conditions	4.84	1.72	19	Satisfied
18	Access to electric outlets	4.79	1.51	19	Satisfied
19	Air velocity (drafty or stagnant)	4.63	1.42	19	Satisfied
20	Humidity (dry or moist)	4.63	1.60	19	Satisfied
21	Overall thermal conditions	4.53	1.73	19	Satisfied
22	Adjustability of thermal conditions	4.00	1.49	19	Neither S nor D
23	Temperature (hot or cold)	3.95	1.70	19	Neither S nor D

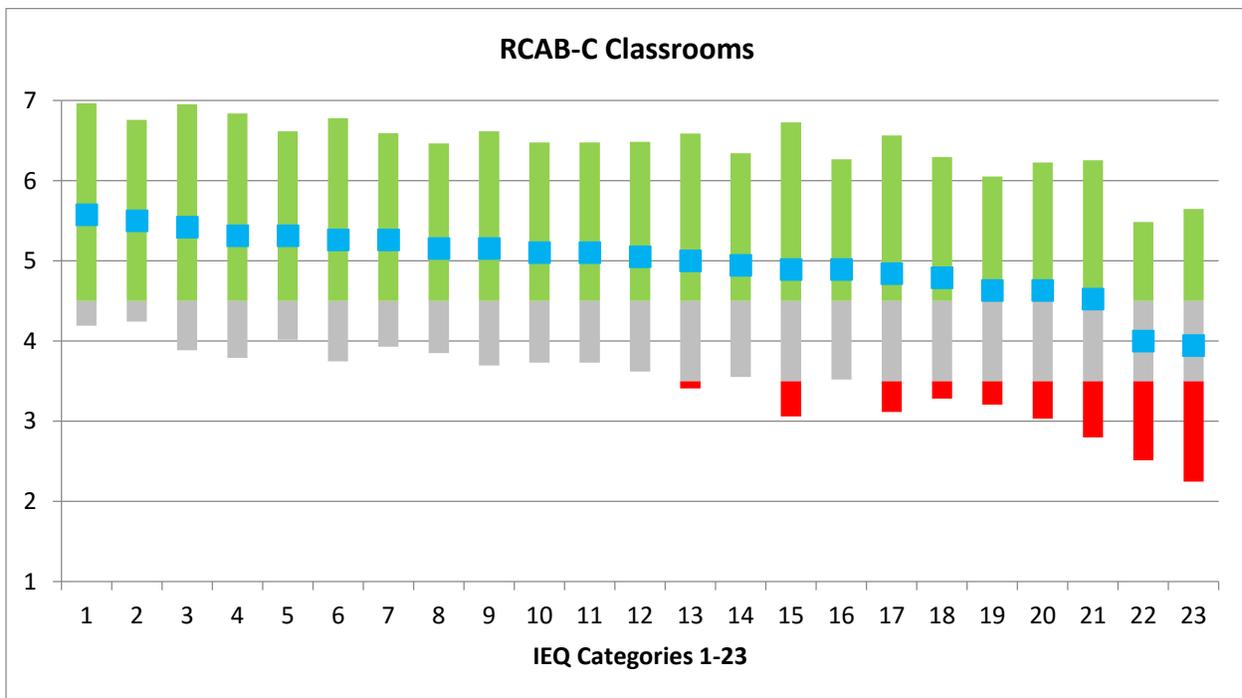


Figure 4. RCAB-C primary classroom - satisfaction with IEQ criteria (IEQ 1-23 are listed in Table 3)

Results indicate that students were satisfied with all but two of the IEQ criteria in their primary classrooms. Students were neither satisfied nor dissatisfied with adjustability of thermal conditions and temperature. As these two are closely related, this could receive close attention. Satisfaction with IEQ criteria ranged from means of 4.53 to 5.58. These findings support a **moderate 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 fair 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 RCAB-C is **5.10**.

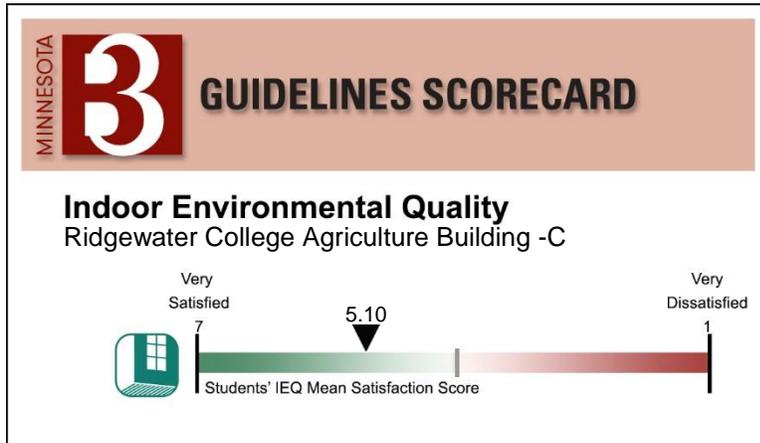


Figure 5. RCAB-C primary classroom - IEQ Satisfaction Score

Overall, the students showed a positive satisfaction level with the IEQ of RCAB-C classrooms as indicated by the mean score of **5.10**. As shown in Table 3, eight IEQ categories were at or above **5.00** 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 RCAB-C (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 RCAB-C facility

RCAB-C 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 RCAB-C **enhanced (M = 4.94)** their physical activities (walking, stair use, etc.).

5.2 Commuting Practices

RCAB-C is a facility within Ridgewater College located in Willmar, MN. RCAB-C is centrally located on the Ridgewater College campus and in close proximity to the Central Community Transit (CCT) pickup shelter. CCT provides daily service to the College between 9:00 am and 4:00 pm and on-call service. The College also provides several fee-based parking facilities throughout the campus. Sidewalks/walking

paths are available on the east and west side of campus for students who live within walking distance of the College.

Table 55 provides results on students' primary mode of transportation; Table 6 summarizes commuting distances between home and the RCAB-C 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 – RCAB-C Primary mode of transportation

Commuting Practices Home to RCAB-C (N=18)	Drive alone (or with children <16)	Walk / Combo
Students commuting mode (%)	89%	5%

Related to primary modes of transportation, 89% of students drive alone (or with children under 16) and 11% walk. This is likely due to the location of the campus.

Table 6. Commuting Practices – RCAB-C Commuting distance traveled

Miles Traveled One Way (N=18)	0-5 miles	6-15 miles	16-30 miles	31-45+ miles	46+ miles
Students commuting distance (%)	39%	17%	11%	5%	28%

Results indicate that 39% of students commute 0-5 miles one-way between home and RCAB-C, followed by 17% who commute 6-15 miles, 11% commute 16-30 miles, 5% commute 31-45 miles, and 28% who commute 46+ miles to RCAB-C. All commuting mileage is reported as one-way miles.

Table 7. Commuting practices – RCAB-C location and alternative commuting behaviors

RCAB-C Facility (Site, Building, Interior)	Mean	SD	N	Interpretation
Ability to commute in alternative ways	3.78	1.31	18	Neither Hinders or Enhances

Results indicate that the location of the RCAB-C **neither hindered nor enhanced (M = 3.78)** students' ability to commute to class in alternative ways, e.g., walk, bicycle, public transit, van or carpool, etc. However, it must be noted that this is a somewhat low positive score and is likely due, once again, to the location of the campus.

6.0 Conclusions

6.1 Summary

A post-occupancy evaluation was conducted of students of RCAB-C at approximately 17 months after its renovation in 2014. About 10% of the students who are enrolled in classes in RCAB-C 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 = 5.42**); they found the facility **enhances** their overall learning experience (**M = 5.25**) and **enhances** their overall health (**M = 4.88**). When students were asked these same questions about their primary classroom, they reported overall **satisfaction (M = 5.53)** with their primary classrooms. They also reported that their overall learning experience was **enhanced (M = 5.68)** by their

primary classrooms, and their overall health was **enhanced (M = 5.00)** by their primary classroom. As the range of scores was from 1-7, these scores indicate satisfaction is 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 21 of the IEQ criteria. The scores ranged from 4.53 (Overall thermal conditions) to 5.58 (amount of electric light). This is a low to moderate level of satisfaction. Students were **neither satisfied nor dissatisfied** with two IEQ criteria, temperature (3.95) and adjustability of thermal conditions (4.00).

From the students' responses, an IEQ Score was developed and shows their satisfaction with the IEQ of all category level criteria. For RCAB-C, the IEQ Satisfaction Score was **5.10**. This score reflects a **moderately high satisfaction** level with IEQ categories. Finally, students reported that RCAB-C **enhanced** 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 RCAB-C, 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 (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, air conditioning; HVAC) 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 RCAB-C 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. RCAB-C students raised few concerns, but those they raised related to thermal conditions and technology. Generally, the comments are shown as written.

Thermal Conditions

- The classroom is cold. Never seems to warm up.
- The room is very cold!!!! That is probably the worst part I think of the Ag Building. I'll come from the computer lab and it'll be fairly warm, then I go to the dairy room for 2 hours and I'm freezing!!

Technology

- IT system could use an entire overhaul.

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).