



Indoor Environment Quality + Classroom Environment Normandale Partnership Center (Report 1)

**April 2014, Bloomington, 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 Normandale Partnership Center (NPC) and students' satisfaction with their classroom environment. The NPC facility was designed using the B3 Guidelines (formerly known as the Minnesota Sustainability Guidelines or MSBG) and completed for occupancy in January 2013. The B3 Guidelines track specific state-funded 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 the physical environment. The Sustainable Post-Occupancy Evaluation Survey (SPOES) was developed to assess human outcomes in classroom and workplace settings in compliance with the project tracking requirements for the B3 Guidelines goals. This is the first of two required POE surveys and represents responses obtained at 14 months post-occupancy. The survey was conducted in April, 2014.

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 acoustics conditions in their primary classroom spaces, i.e., offices. Students' satisfaction with the facility (site, building, and interior) and the effect of the facility's physical environment on their perceptions of their classroom experience and health are included. Finally, a brief look at students' commuting and physical activities within the building are included. The report provides descriptive information about students' perceptions of the IEQ of their classroom environment. 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) scale from 1 (very dissatisfied) to 7 (very satisfied) with IEQ of the facility and their primary classroom space. 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. Higher or lower 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 neither satisfied (enhances) or dissatisfied (hinders)
- 4-4.49 neither satisfied (enhances) or dissatisfied (hinders)
- 4.5-7 satisfied (enhances)

An IEQ Scorecard is also calculated for students' satisfaction with IEQ in their primary classroom spaces. 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 classroom space 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; some categories have additional attributes added.

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

Student 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

Normandale Community College is a part of the Minnesota State Colleges and Universities system located at 9700 France Avenue South in Bloomington, MN. There are currently over 14,500 students in attendance, 43% full-time and 56% part-time. Of this student population, 55% are male, 44% are female, and 30% are students of color. The NCP is a recently constructed facility located on the Normandale College campus. The building (see Figure 1) is comprised of 27 classrooms, laboratories, faculty offices, and student common areas. These areas are distributed across three floors and 76,000 square feet. The facility provides spaces for business, accounting, hospitality, continuing education, and customized training programs.



Figure 1 Normandale Partnership Center (Photo credit: Normandale Community College)

3.2 Description of Respondents

The response rate to the questionnaire was approximately 4%, which is quite low. It's common to have a low response rate among subjects who are not directly involved in the issue. Of those responding, 33% were male and 67% were female. Relating to hours spent in NPC classrooms, 20.3% of the students spend 5+ hours in their primary classroom space; 59.4% spend 3-4 hours in their primary classroom space; and 20.3% spend 1-2 hours in their primary classroom space. When not in their classrooms, 64.4% (the majority) of students spend 1-2 hours a week in other spaces. The mean age of respondents was 25 years, with a range of 18 to 55 years.

4.0 Findings and Discussion

4.1 NPC Facility (Site, Building, and Interior):

Overall Satisfaction, Work Performance, and Health

Students responded to questions concerning the NPC 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 NPC facility (site, building, and interior) overall satisfaction, learning experience, and health

NPC Facility (site, building, and interior)	Mean (1-7)	SD	N	Interpretation
Overall satisfaction	6.46	.7	61	Satisfied
Overall learning experience	5.59	1.32	61	Enhances
Overall health	4.98	1.28	61	Enhances

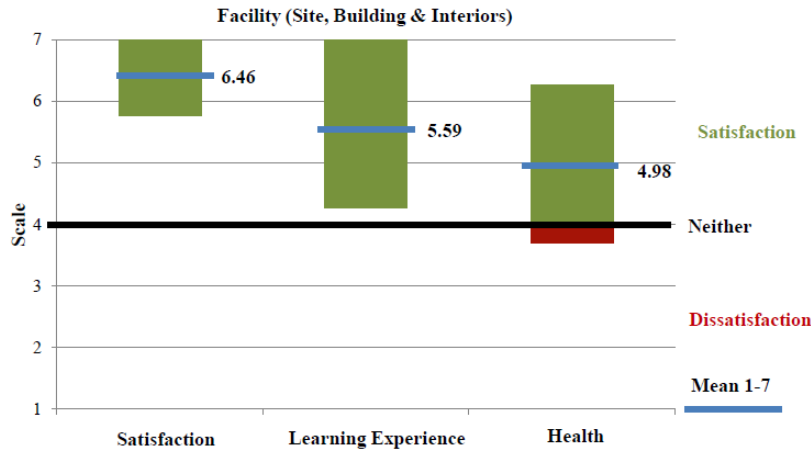


Figure 2 NPC facility (site, building, and interior) overall satisfaction, learning experience, and health

Results indicated that students were satisfied ($M = 6.46$) with the NPC facility (building, site and interior) and reported that their overall learning experience was enhanced ($M = 5.59$) by the facility. Students reported that their overall health was enhanced ($M = 4.98$) by the facility. Results indicated 71.2% of respondents were satisfied with the classroom in which they were taking a course. Results also indicated 86.4% of respondents believe that environmental sustainability is important.

4.2 Primary Classroom: Overall Satisfaction, Work Performance, and Health

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

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

Primary Classroom Space	Mean (1-7)	SD	N	Interpretation
Overall satisfaction	6.02	1.21	60	Satisfied
Overall learning experience	5.65	1.18	60	Enhances
Overall health	5.08	1.20	60	Enhances

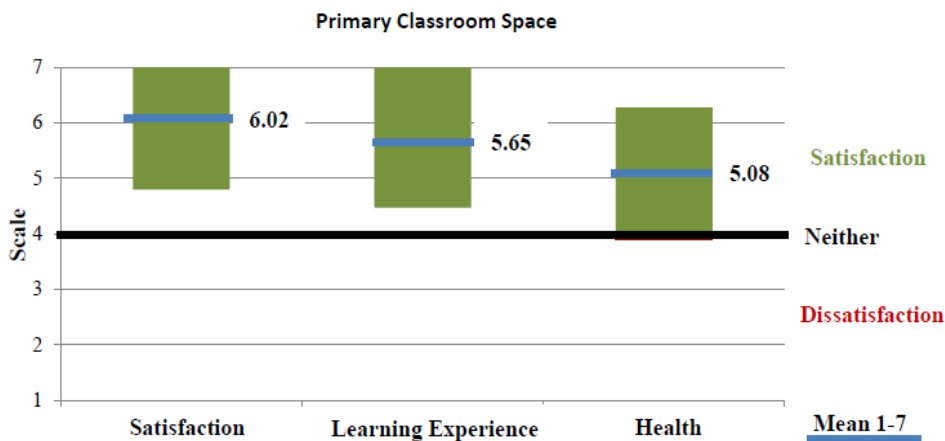


Figure 3 Overall satisfaction, learning experience, and health related to primary classroom

Results indicated that student were satisfied ($M = 5.65$) with their primary classroom space, their overall learning experience was enhanced ($M = 4.98$) by their primary classroom space, and their overall health was enhanced ($M = 5.65$) by their primary classroom space.

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 space. Table 3 and Figure 4 show a summary of the means, the standard deviations, and interpretation of their responses.

Table 3 Satisfaction with IEQ related to primary classroom

	Primary classroom space	Mean (1-7)	SD	N	Interpretation
1	Cleaning and maintenance	6.34	1.24	59	Satisfied
2	Lighting conditions	6.33	0.93	60	Satisfied
3	Appearance (aesthetics)	6.15	1.03	59	Satisfied
4	Ability to see teaching materials	6.14	1.32	59	Satisfied
5	Vibration and movement	6.13	1.18	58	Satisfied
6	Function	6.07	1.22	60	Satisfied
7	Acoustics	6.05	1.26	59	Satisfied
8	Indoor air quality	6.05	1.29	59	Satisfied
9	Humidity	5.95	1.21	60	Satisfied
10	Ability to hear presentations	5.93	1.50	60	Satisfied
11	Technology	5.91	1.44	60	Satisfied
12	Ability to understand desired sounds	5.90	1.37	60	Satisfied
13	Temperature	5.87	1.21	60	Satisfied
14	Thermal conditions	5.82	1.38	60	Satisfied
15	Air velocity	5.82	1.43	60	Satisfied
16	Furnishings	5.78	1.64	60	Satisfied
17	Background noise	5.61	1.39	60	Satisfied
18	Adjustability of thermal conditions	5.21	1.60	57	Satisfied

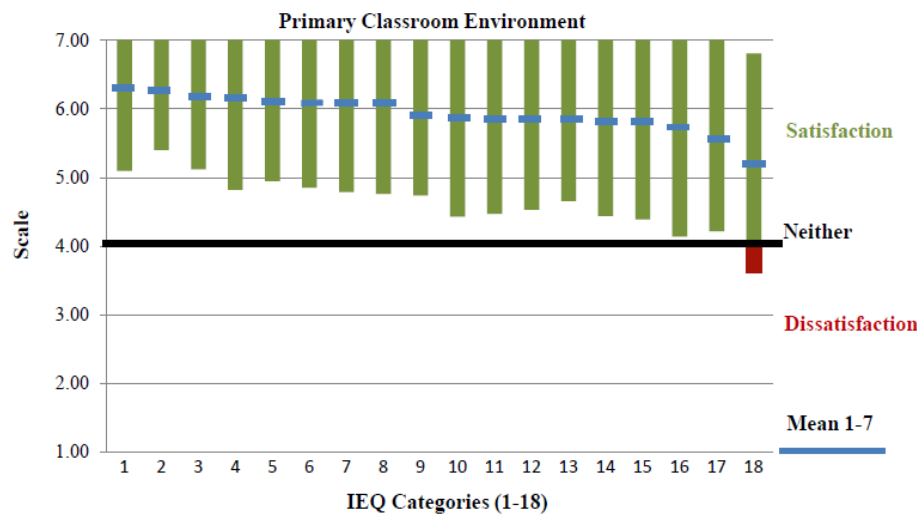


Figure 4 Satisfaction with IEQ as related to primary classroom space

The results indicate that students were satisfied with all of the IEQ conditions in their primary classroom spaces with the highest satisfaction level shown first. There were no scores indicating dissatisfaction with any of the IEQ criteria.

4.4 Primary Classroom: IEQ Satisfaction Score

The IEQ Satisfaction Scorecard 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 low 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 NPC is **6.14**.

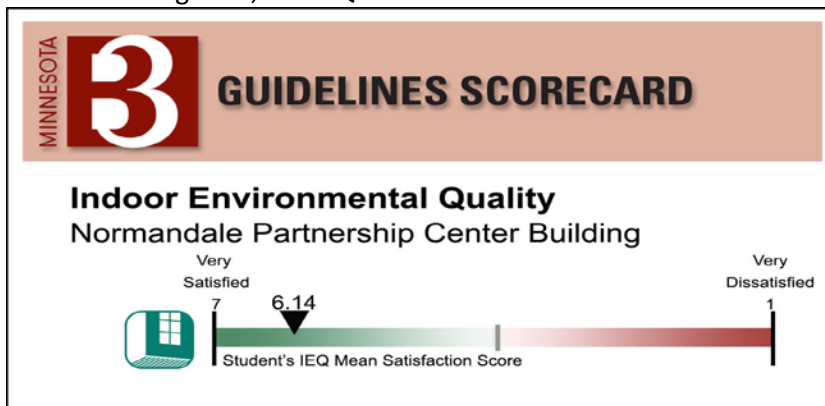


Figure 5 IEQ Satisfaction Score for NPC classroom environment

Overall, the students showed a positive response with a high level of satisfaction with IEQ as indicated by the weighted mean score of 6.14. Satisfaction with **Function** of primary classroom space was identified as the category that contributed the most to the IEQ Satisfaction Score, followed by satisfaction with **Indoor air quality** of the primary classroom space. They determine IEQ satisfaction more strongly than other categories and differ from the ranking of the mean scores where **Cleaning and maintenance, Lighting conditions, and Appearance (aesthetics)** were the top satisfaction scores. **Acoustic quality** was the least contributing category to the IEQ Satisfaction Score.

This score of 6.14 validates the overall satisfaction score in Table 2 (5.65). They both show high satisfaction with classrooms, but the IEQ Score is higher because it may reflect some other factors beyond IEQ such as location or size of the primary classroom space.

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 NPC (site, building, and interior) and their commuting practices.

5.1 Physical Activity Engagement

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

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

NPC facility (site, building, and interior)	Mean (1-7)	Standard Deviation	N	Interpretation
Overall physical activity (walking, stair use, etc.)	5.7	1.11	60	Enhances

Results indicated that students felt that NPC enhanced ($M = 5.7$) their physical activities (walking, stair use, etc.). Further, of the 60 respondents to this set of questions: 81.7% said they were **satisfied** with the facility's influence on their overall physical activity; 18.3% said they were **neither dissatisfied nor satisfied**, and none were dissatisfied.

5.2 Commuting Practices

NPC is a facility within Normandale Community College located on 98th and France Avenue South in Bloomington, MN. The institution resides on a 90-acre wooded lot 1.5 miles south of a major highway that runs through the Minneapolis/St. Paul Metro area. The campus is convenient to public transportation and bicycle trails.

Table 5 provides results on students' mode of transportation and use of alternative modes of commuting. 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 Primary mode of transportation to NPC facility

Daily Commuting Practices	Drive alone (or with children<16)	Carpool or vanpool	Public transit	Dropped off
Primary mode of transportation	78.3 %	11.7%	6.7%	3.3%

The most frequent mode of transportation to NPC was driving alone (or with children under 16) (78.3%), followed by carpool or vanpool (11.7%), public transit (6.7%), and being dropped off (3.3%). There were no students who walked, drove a motorcycle / moped, or rode a bike to the NPC facility.

Table 6 Commuting Practices – Distance traveled to NPC facility one way

Commuting distance (miles)	0-5 miles	6-15 miles	16-30 miles	31-45 miles	61-75 miles
Home-to-NPC	10%	48%	35%	5%	2%

Results indicated that 10% of the students commuted 0-5 miles one-way between home and the NPC facility, followed by 48% who commuted 6-15 miles, 35% who commuted 16-30 miles, 5% who commuted between 31-16 miles, and 2% who commuted between 61-75 miles to the NPC facility. There were no students who commuted between 45- 60 miles one-way to the NPC facility.

Table 7 Commuting practices – NPC location and alternative commuting behaviors

Alternative commuting practices	Mean (1-7)	SD	N	Interpretation
Ability to commute in an alternative way	4.38	1.78	60	Neither Satisfied or Dissatisfied

Results indicated that students were neither satisfied or dissatisfied (**M = 4.38**) with the location of the NPC and their ability to commute to school in alternative ways, e.g., walk, bicycle, public transit, van or carpool, etc. Further, of the 60 respondents to this set of questions, **18%** said the location hindered their commuting options, **42%** indicated the location neither hindered or enhanced their ability for alternative commuting, and **40%** indicated the location enhanced their ability to commute in alternative ways.

6.0 Conclusions

6.1 Summary

A post-occupancy evaluation was conducted of students of Normandale Partnership Center at approximately 14 months after it was first occupied. Approximately 4% 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 **highly satisfied** with the facility (**M = 6.46**); they found the facility **enhances** their overall learning experience (**M = 5.59**) and **enhances** their overall health (**M= 4.98**). In addition, similar results were reported when students were asked these same questions about their primary classroom spaces. They reported overall **satisfaction** (**M = 5.65**) with their primary classroom spaces, and that their overall learning experience (**M = 4.98**) and their overall health was **enhanced** (**M = 5.65**) by their primary classroom space. As the range of scores was from 1-7, this is a positive level of satisfaction.

Most of the survey questions related to students' satisfaction with the IEQ categories in their primary classroom spaces. Students were **satisfied** with all of the IEQ categories. The mean satisfaction scores ranged from 5.21 (Adjustability of thermal conditions) to 6.34 (Cleaning and Maintenance). Again, this shows a positive level of satisfaction. None of the categories received **neither dissatisfied nor satisfied** scores, and no categories received **dissatisfied** scores. These scores conclude that there is a high level of satisfaction among students with this facility.

From the students' responses, an IEQ Scorecard was developed and shows respondents' satisfaction with all categories and the contribution of each category to that satisfaction score. For NPC, the IEQ Satisfaction Score was 6.13, with satisfaction with **Function** and **Indoor air quality** of their classrooms as the two categories that influenced their satisfaction level most. This score reflects the high satisfaction level of the other categories. Finally, students reported that NPC **enhances** their physical activity, which is one of the sustainable design criteria that influence 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 may be taken in both the overall facility and classroom spaces. 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.

Determine if any area usage differs 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.
- Measure acoustic performance onsite with full systems running.
- Log noise and other sonic environment complaints.
- 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.
- Develop any additional special acoustical performance requirements to support functional programming of building (e.g., sources of recurrent noise that needs to be controlled, special user populations that may have distinct auditory performance limitations, multiple uses of building spaces that may have different acoustic criteria. Investigate and choose appropriate acoustics modeling software for the project.

Technology

- Consider using focus groups and observation to understand specific technological concerns.
- Create a process that tracks technological concerns and addresses them in a timely manner.
- Based on specific technology concerns, re-evaluate products and their future use.

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.

Addressing the categories that fell on the lower end of satisfaction may be beneficial. In addition, reviewing qualitative responses will offer a deeper and more specific insight into concerns by students. Making improvements by addressing these responses when applicable may prove to be beneficial.

This study investigated students' satisfaction with the facility and primary classroom spaces. IEQ satisfaction is individual, but the results of the survey show a central tendency of moderate to high satisfaction with the facility and all 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 classroom space. Important information can be gleaned from the open-ended responses. Students made the most remarks about liking the facility and technology. Below are the responses in detail that will offer greater insight into the physical environment of the NPC. As you may notice, some of the comments here are reflective of the responses we have seen above such as concerns about technology and acoustics, however there continues to be a positive sense of satisfaction overall with the facility and classrooms.

Acoustics

- Speaker's volume not very clear and thus limits the clarity on video and audio presentations.
- Professor should use mic, as I can hardly hear him.

Building Services

- One centrally located elevator is not enough. The elevator is also extremely slow resulting in long wait times. Reaching the 3rd level (floor 2) is much more difficult than going from the ground floor to level 1
- Not many elevators near where I need to go.
- I HATE the half-step stairs.
- Should have more spread out bathrooms, instead of only one on each floor.
- The unlock scheduling needs to be more cohesive for student study sessions

Cleaning and Maintenance

- Desks are not clean

Furnishings

- Chair should have adjustment for height and back support.
- Circular tables: good for group work if there is less than three people (because the tables are so small), but horrible for lecture/note taking because only one person at the table gets a good angle.
- Tables in the classroom - the angle of the setup of the legs and wheels is really annoying because people hit it all the time.
- The tables are very narrow and the legs are angled so they get in the way.
- If we are watching a long film, the chairs can sometimes get uncomfortable. It doesn't usually bother me though.
- My legs hit against the table legs because they are pressed in like / \ instead of | |. It is very distracting and annoying during class

IAQ

- Air circulation in classroom was non-existing!
- Students smoke right outside the end entrance so it smells like smoke sometimes.

Layout

- A very long building, takes a while to get to a class on the end. I do not like that it comes to a dead-end and cuts you off, you have to walk back the way to came to go around the other side
- There are too many tables in the classroom

- This classroom is actually a lot smaller than the classrooms I've had in previous semesters and I greatly preferred the larger classrooms.
- The space between the person next to me [at the tables] makes it hard to write, we keep bumping elbows awkwardly every class period.

Lighting

- Lighting technology is confusing for teachers. It is not always apparent which buttons do what.

Technology

- The projector display screen covers the middle portion of the whiteboard where professor is supposed to write notes. Hence, professor writes notes on the remaining portion of the whiteboard, i.e., left or right. If you are sitting on the first or second row, it's very hard to see either left or right portion. I would suggest that the projector screen get locked above the whiteboard and professor should use laser if he wants to show any part on the screen.
- Not all of the outlets work so I am not able to charge my computer or phone.
- Many of the electrical outlets do not work
- Projector screen should get locked above the whiteboard.
- Sometimes our projector has problems.
- The outlets for computers are far away so everyone's cords are stung around the room making for a hazard.
- There have been multiple accounts of projector or audio not working properly.

Thermal Conditions

- I always feel like it's really cold in my classes. The other day I wore my winter jacket almost the whole class period.
- We've never had to adjust the thermal conditions.

Window Control Devices

- It would be nice when its sunny out to have some sort of shades on the window because it gets hot sitting near the windows

Overall Positive

- Very nice! Lots of seating and plug-in options.
- The building is very nice. It's beautiful, modern, it smells nice, looks nice, and has lots of nice little nooks and crannies that are great areas for studying. Also, many comfy chairs.
- It's very nice! I have three out of my five classes in the Partnership Center this semester, and I hate having to go to the old buildings for my other classes.
- I like the modernity and cleanliness of the Partnership Center. The larger class room sizes are nice, too.
- I love the building! It is very nice and comforting!
- Nice building.
- The place is always quiet and peaceful. Like to work on my homework.
- It's beautiful and the classrooms have the best chairs!
- It is the nicest part of the school.
- It's a nice building. I like the colors and the floor.
- The Partnership Center has amazing classrooms with great technology. The design of the Center is appealing and feels much more updated than the rest of the school. It was very beautifully designed.

- I really like the classrooms, the study rooms and the computer labs. There is nothing not to love about the partnership center. It's very clean as well
- Generally good.
- Has a modern feel to it which makes it look nice.
- Love how the classrooms have the white boards all around it helps me learn with the lessons wrapping around the classroom!
- Love it! Thank you for the nice classroom.
- No concerns.
- Love the room, wish every classroom would be like this
- I just really like the Partnership Center. It's a great building and a great place. I like hanging out there a lot when I'm at school.
- Love it!
- I love the space.
- It was a great add-on to the school. Fantastic!
- Keep up the good work!

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).