



# **Indoor Environment Quality + Classroom Environment Hanson Hall, Report 1**

**November 2010, 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 Hanson Hall building and students' satisfaction with their learning environments. Hanson Hall was designed using the B3 Guidelines (formerly known as the Minnesota Sustainability Guidelines or MSBG) and completed for occupancy in 2008. The B3 Guidelines 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 their work environments. 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 a report of occupants' (hereafter called students) responses at 9 months post-occupancy. The data were collected in November 2010.

This SPOES report focuses on students' satisfaction with the physical environment as related to 14 indoor environment quality (IEQ) criteria (hereafter called categories) 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 classroom experience and health are included. Finally, a brief look at students' course satisfaction and sustainability ethics were investigated. The report provides both descriptive and diagnostic 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) on overall questions on the facility, their primary classroom space, and the IEQ categories. 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 occupant 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 Score 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 14 IEQ categories from the B3 Guidelines and relates each of them to students’ satisfaction with their physical environment.

Categories include (in alphabetical order):

- |  |                          |
|--|--------------------------|
| 1. Ability to see presenter                  | 8. Furnishings           |
| 2. Ability to see presentation materials     | 9. Indoor Air Quality    |
| 3. Accessibility/accommodations for disabled | 10. Lighting Conditions  |
| 4. Acoustic Conditions                       | 11. Recycling Features   |
| 5. Aesthetics/Appearance                     | 12. Technology           |
| 6. Cleaning and Maintenance                  | 13. Thermal Conditions   |
| 7. Function                                  | 14. Vibration Conditions |

## 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

Hanson Hall is a classroom and office building that serves the Carlson School of Management. It is located on the University of Minnesota’s West Bank campus at 1925 Fourth Street South, Minneapolis, MN 55455. HH (see Figure 1) is a 124,000 square foot, four-story building comprised of nine classrooms (four 125-seat classrooms and five 75-seat classrooms), a business center, the Carlson School Office of Undergraduate Programs, the Department of Economics, and an economics learning lab. Classrooms are equipped with state-of-the-art audio and visual technology with wireless printing capability. In addition, breakout rooms include plasma screen televisions for student collaboration to reinforce the Carlson School of Management’s commitment to building an environment that advances critical thinking and enhances the practical application of new knowledge.



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

### 3.2 Description of Respondents

Students who were enrolled in any class that met in HH were sent a request to complete the SPOES questionnaire (a total of 5,490 students). The response rate was 11.5% (631 students). Of those responding, 45.9% were male and 54.1% were female. Over half of respondents (58.8%) used the 125-seat classrooms; and 41.2% used the 75-seat classrooms. Most of students (76.9%) spent 3 to 4 hours in one of the classrooms each week.

The HH classrooms used aesthetically pleasing colors and interior finishes; recycled low-emitting materials, light reflective ceiling finishes, and floor coverings that reduce unwanted noise transmissions. There were windows with blinds and occupant controlled overhead lighting. The latest presentation technology with wireless access and dual projections were installed in all classrooms. There was tiered seating with fixed bench tables and moveable chairs. The classrooms were nearly identical.

## 4.0 Findings and Discussion

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

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

Table 1 HH facility overall satisfaction, learning experience, health, and well-being

| HH Facility and Classrooms (site, building, and interior) | Mean (1-7) | SD   | N   | Interpretation |
|---|------------|------|-----|----------------|
| Overall building satisfaction                             | 6.23       | 0.90 | 629 | Satisfied      |
| Overall classroom satisfaction                            | 6.15       | 0.98 | 627 | Satisfied      |
| Overall perceptions of learning experience in classrooms  | 5.99       | 1.06 | 623 | Enhances       |
| Overall health  | 5.81       | 1.11 | 627 | Enhances       |
| Overall well-being  | 5.91       | 1.05 | 625 | Enhances       |

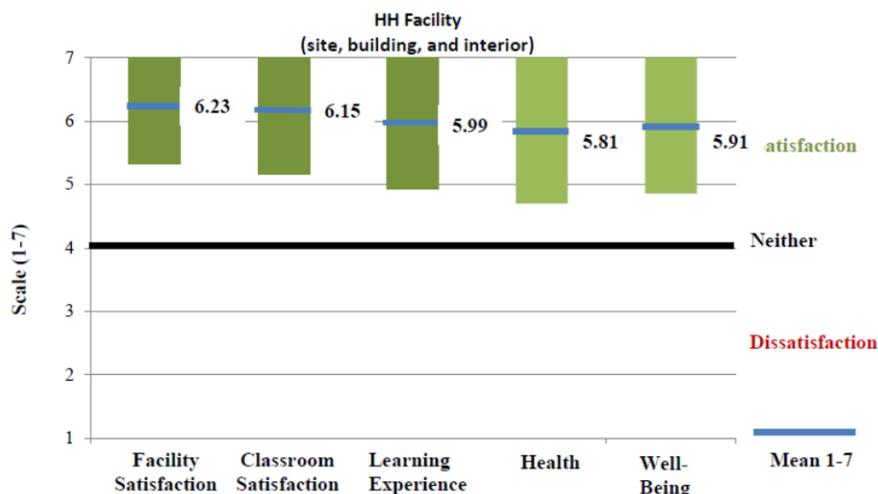


Figure 2 HH facility overall satisfaction, learning experience, health, and well-being

Results indicated that students were satisfied with the Hanson Hall facility ( $M = 6.23$ ) and also satisfied with the overall physical environment of classrooms ( $M = 6.15$ ). Students reported that their overall learning ( $M = 6.15$ ), health ( $M = 6.15$ ), and well-being ( $M = 6.15$ ) were enhanced by classrooms.

#### 4.2 Primary classrooms: Satisfaction with Indoor Environment Quality (IEQ)

Students responded to questions concerning their satisfaction with IEQ categories (thermal comfort conditions, indoor air quality, acoustic quality, etc.) related to their classrooms (e.g., 125-seat classrooms, 75-seat classrooms). Table 2 and Figure 3 show a summary of the means, the standard deviations, and interpretation of their responses.

Results indicated that students were **satisfied** with all IEQ conditions in their classrooms. IEQ categories receiving high scores for satisfaction included the following: Ability to see the presenter ( $M = 6.34$ ); Vibration conditions ( $M = 6.24$ ) and Recycling features ( $M = 6.21$ ). IEQ categories receiving the lowest levels of satisfaction included Furnishings ( $M = 5.83$ ); Aesthetics/Appearance ( $M = 5.78$ ) and Thermal conditions ( $M = 5.71$ ).

Table 2 HH primary classrooms – student satisfaction with IEQ criteria

|    | Classroom                                    | Mean (1-7) | SD   | N   | Interpretation |
|----|--|------------|------|-----|----------------|
| 1  | Ability to see the presenter                 | 6.34       | 0.88 | 629 | Satisfied      |
| 2  | Vibration conditions                         | 6.24       | 0.92 | 622 | Satisfied      |
| 3  | Recycling features                           | 6.21       | 1.00 | 620 | Satisfied      |
| 4  | Cleaning and maintenance                     | 6.19       | 1.04 | 619 | Satisfied      |
| 5  | Indoor air quality                           | 6.14       | 0.99 | 627 | Satisfied      |
| 6  | Accessibility/accommodation for the disabled | 6.12       | 1.10 | 620 | Satisfied      |
| 7  | Function                                     | 6.11       | 1.01 | 628 | Satisfied      |
| 8  | Technology provided for learning             | 6.10       | 1.12 | 621 | Satisfied      |
| 12 | The ability to hear presentations            | 6.09       | 1.06 | 629 | Satisfied      |
| 13 | The ability to understand desired sounds     | 6.07       | 0.98 | 629 | Satisfied      |
| 14 | Acoustic quality                             | 6.07       | 1.00 | 631 | Satisfied      |

|    |                                    |      |      |     |           |
|----|------------------------------------|------|------|-----|-----------|
| 15 | Lighting conditions                | 6.04 | 1.08 | 629 | Satisfied |
| 16 | Ability to see materials presented | 6.01 | 1.20 | 627 | Satisfied |
| 17 | The extent of background noise     | 5.93 | 1.16 | 629 | Satisfied |
| 19 | Furnishings                        | 5.83 | 1.22 | 625 | Satisfied |
| 20 | Aesthetics/Appearance              | 5.78 | 1.24 | 623 | Satisfied |
| 21 | Thermal conditions                 | 5.71 | 1.28 | 626 | Satisfied |

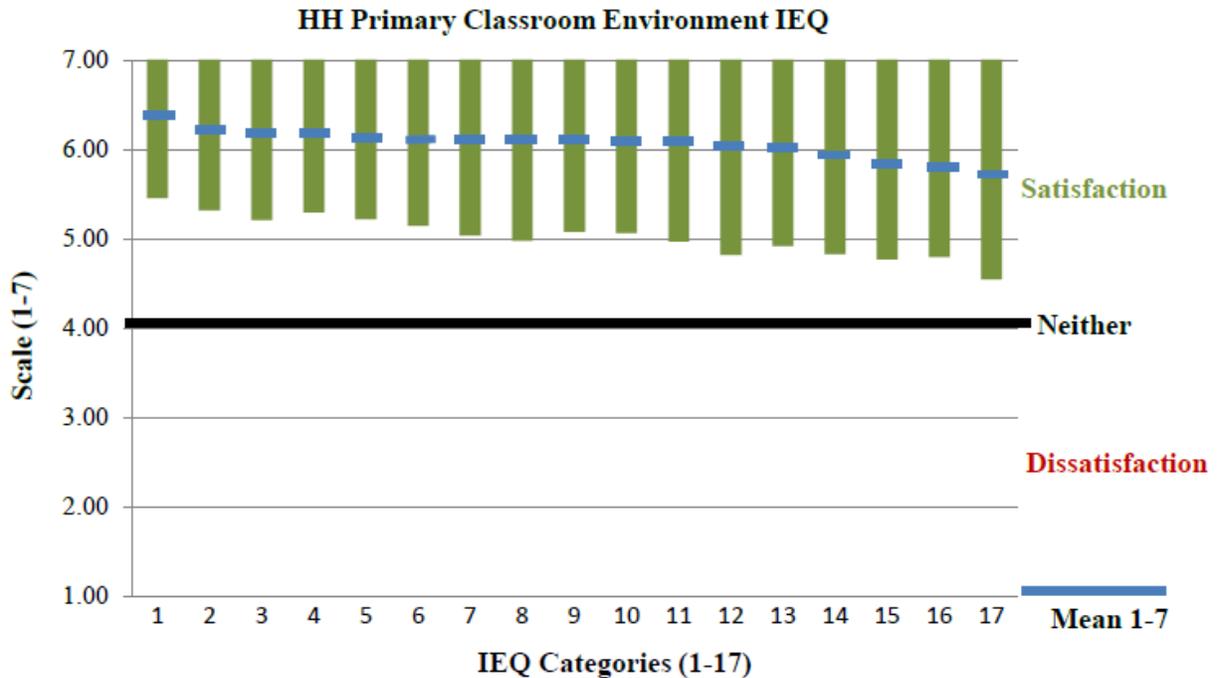


Figure 3 Satisfaction with IEQ related to primary classroom space (IEQ category means are included in Table 3 above).

### 4.3. IEQ Satisfaction Scorecard

The IEQ Satisfaction Score is determined by developing weighted factors of all categories, which is more representative of a fair overall IEQ score. For example, it might be more important for a student to have satisfying thermal conditions than to have satisfying indoor air quality. Thus, if the student gives a high thermal satisfaction score and a lower indoor air quality satisfaction score, the overall IEQ satisfaction will be scored much higher than one with the inverse statistics.

The weighted scoring system was developed by employing the following procedures:

**Factor analysis** (a multivariate statistical procedure) was conducted to determine the importance of various IEQ categories.

The factor loading of each IEQ category was regarded as the individual weight.

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 4, the **IEQ satisfaction score** for HH is **6.07**.

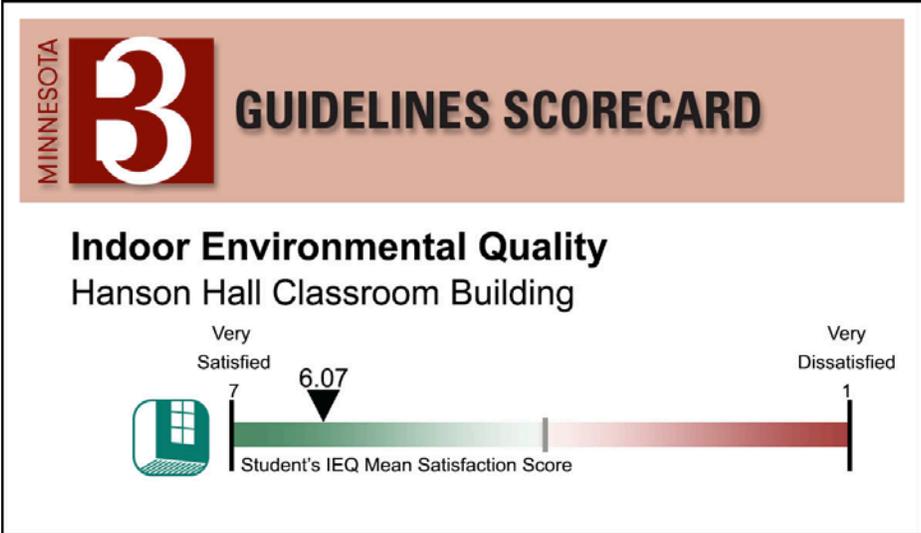


Figure 4 HH Primary classrooms IEQ Satisfaction Score

Overall, the occupants showed a positive response with a high level of **satisfaction with IEQ** as indicated by the weighted mean score of 6.07. Satisfaction with **Function** of primary classroom space was identified as the category that contributed most to the IEQ Satisfaction Score, followed by satisfaction with **Indoor Air Quality** and **the Ability to see the Presenter in the Classroom**. They determine IEQ satisfaction more strongly than other categories and differ slightly from the ranking of the mean scores where **Ability to see the Presenter in the Classroom, Vibration, and Recycling** were the top satisfaction scores. **Thermal Conditions** was the least contributing category to the IEQ Satisfaction Score, which reflect its low mean score.

This score of 6.07 validates the overall satisfaction score (6.15) in Table 1 as they both show levels of satisfaction, however the IEQ Scorecard gives more refined knowledge because it may reflect some other factors beyond IEQ such as location or size of the primary classroom space.

**5.0 Course Satisfaction and Sustainability Ethics**

**5.1 Course Satisfaction**

Students responded to questions concerning their course satisfaction. Table 4 shows a summary and interpretation of their responses.

Table 3 Course satisfaction

| Course Satisfaction                                      | Mean (1-7) | SD   | N   | Interpretation |
|--|------------|------|-----|----------------|
| I am very satisfied with this course                     | 5.68       | 1.32 | 629 | Agree          |
| I am satisfied with the kind of work I do in this course | 5.35       | 1.33 | 628 | Agree          |
| I frequently think of quitting this course               | 2.09       | 1.71 | 629 | Disagree       |

Results indicated that students agreed that they were very satisfied with the course (**M = 5.68**) and also agreed that they were generally satisfied with the kind of work they do in the course that they took (**M =**

5.35). However, students **disagreed** that they frequently thought of quitting this course ( $M = 2.09$ ), which may also be an indicator that they are **satisfied** with the course.

## 5.2 Sustainability Ethics

Students responded to questions concerning their sustainability ethics. Table 5 shows a summary and interpretation of their responses. Results indicated that sustainability is important to the students ( $M = 5.69$ ) and that the sustainable design features of this building are important to them ( $M = 5.60$ ).

Table 4 Sustainability Ethics

| Sustainability Ethics                                | Mean (1-7) | SD   | N   | Interpretation |
|--|------------|------|-----|----------------|
| How important is sustainability to you?              | 5.69       | 1.28 | 625 | Important      |
| Important of sustainable design features in building | 5.60       | 1.29 | 628 | Important      |

## 6.0 Conclusions

### 6.1 Summary

A post-occupancy evaluation was conducted of students of Hanson Hall building at approximately three years after it was first occupied. Approximately 11.5% of the students responded to the survey.

The survey included questions related to students' overall satisfaction with the physical environments of facility (site, building, and interior); overall satisfaction with the physical environments of classrooms; influence of the physical environments of classrooms on their learning, health, and well-being; and satisfaction with the classroom IEQ. Students were **satisfied** with the physical environments of facility ( $M = 6.23$ ) and classrooms ( $M = 6.15$ ); they found the physical environments of classrooms **enhance** their overall learning ( $M = 5.99$ ), health ( $M = 5.81$ ), and well-being ( $M = 5.91$ ).

Students were **satisfied** with all 14 of the IEQ categories. The mean satisfaction scores ranged from 5.71 (Thermal comfort conditions) to 6.34 (Ability to see the presenter). This shows a high level of satisfaction. They were also **satisfied** with all attributes of acoustic quality such as the ability to hear presentation ( $M = 6.09$ ), the ability to understand desired sounds ( $M = 6.07$ ), and the extent of background noise ( $M = 5.93$ ). In addition, they were **satisfied** with the course and reported that sustainability and sustainable design feature of the building are **important** to them.

From the students' responses, an IEQ Scorecard was developed and showed respondents' satisfaction with all categories and the contribution of each category to that satisfaction score. For Hanson Hall classrooms, the IEQ Satisfaction Score was 6.07, with satisfaction with functionality, indoor air quality, and the ability to see the presenter in the classroom, as main categories that influenced their satisfaction level most. This score reflects the high satisfaction level of the other categories.

### 6.2 Recommendations

The satisfaction scores are certainly in a strong positive direction, however, improvement may be possible. For IEQ categories that have physical measurement possible, e.g., thermal, acoustic, and

lighting, it is recommended that these measurements be taken in the classroom. Other recommendations for improvement follow.

- Review design standards, such as ASHRAE Standard 55-2004, *Human Factors Design Handbook*, or Illuminating Engineering Society standards that affect IEQ of classrooms.
- Conduct onsite measurements and choose appropriate daylighting and acoustics modeling software.
- Identify students' concerns via focus groups and log complaints related to specific attributes of the classroom IEQ.
- Consider the different type and arrangement of furniture with the incorporation of technology depending on nature of complaints.

Although students showed high satisfaction level with all IEQ criteria, the above recommendations can help address change in classroom physical environments based on the findings via open-end questions. The results of this study 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 classrooms. Important information can be gleaned from the open-ended responses.

### Accessibility and accommodation for the disabled

- Someone in a wheelchair had only one option for seating, which was in the back.

### Acoustic conditions

- Sometimes there is an echo when our instructor is speaking.

### Aesthetics

- Could use some more color, warmth.
- The facility is very nice but could use some more aesthetically pleasing art or decorations.

### Furnishings

- Some of the chairs in the classrooms are broken.
- The chairs are really uncomfortable.
- The seating fabric is slippery, if I shift my weight backward, I slide forward in the seat.

### Lighting Conditions

- I had a difficult time viewing the videos and PowerPoint presentations due to the limited ability to control light in the classroom. We could not make the room dark enough to see the screens.
- The lighting is really poor in the evening. Maybe it's better during the day, but there is a sort of glare off the lights that strains your eyes.
- The lights always seem too dim for me.
- Could use more natural sunlight.
- When the instructor presented a video it was very hard to see because even though we were able to turn off most of the lights in the classroom, the ones that really mattered were the ones at the front. Those lights did not turn off, and they provided a glare on the screen that made it hard to see what was going on.

### Overall facility

- Need more break-out/meeting rooms available to students.
- The only thing that I noticed in the building that did not particularly like were the chairs in the breakout rooms. They recline too easily and too far with no obvious adjustment.
- For a building built for undergraduate business students, there is very limited seating and tables.
- Bathrooms are generally not clean and out of paper towels, soap and toilet paper even though I see facilities workers wandering around all of the time.
- I would suggest a bigger Starbucks and more study lounges with comfortable chairs; the benches in the lobby aren't very comfortable to study in while waiting for class.
- Not enough tables to work at outside classroom between classes, a few benches, but they are not always a sufficient amount due to the numbers of people in the building at the time.

### **Recycling features**

- The order of the trash/recycling containers should be rearranged. The trash sides are closer to the door and the main hallway, making it the easier to reach while quickly passing by. The slight change in position of having the recycling closer would increase recycling rates.

### **Technology**

- The wireless internet capabilities of the Hanson Hall classrooms are severely lacking. Connections are very slow, and often completely unavailable.
- As for technology, there should be more plug ins for notebook computers and computer lab facilities for graduate students.
- The double screens in the classrooms actually make it more difficult to see. Often distracting and headache-causing.
- I wish there were power outlets in all seating tiers.
- A lot of the desk sockets don't work.
- Not enough electronic outlets for back side of desk.
- The technology is too hard for the teachers to use.
- Poor wireless connection.

### **Thermal comfort conditions**

- The room is freezing.
- My only issues are that the temperature seems cold sometimes.
- It tends to get stuffy since the air doesn't flow through very much.
- The classroom was uncomfortably hot in the fall - to the point where it was distracting to me, the professor, and other students.
- Hanson Hall, in general is very hot in the summer. I know that is not the question you are asking here, but my classes this summer had very poor temperature control.

### **The ability to see the presenter and materials presented**

- Slight glare off of white board made it hard to see writing on white board sometimes.
- The projection screen is much higher than most of the seats and makes it uncomfortable to look at the screen. When designing classrooms I think it is preferable for the students to have the projection at eye level.
- The class sizes / depth of the classroom is too large. It can be hard to read what is printed on the board from the mid-back to back section of the room.
- Front row is too close, if you are stuck in a front side seat, very hard to see the projection. Minor gripes - overall a great environment and facility to learn.
- Really hard to see white board from the far angle to the opposite side of the board.

## 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).