



B3 Buildings



B3 Buildings: Post-Occupancy Evaluation(POE) Findings Inform Future Design Outcomes for Building Occupants

Presented for the
Center for Sustainable Building Research (CSBR)
Caren S. Martin, PhD, CID, Associate Professor Emeritus,
College of Design and
Principal, Martin & Guerin Design Research, LLC
December 9, 2020

Learning Objectives



1. Understand the role and benefit of POEs within the suite of Minnesota B3 programs and tools.
2. Explore the linkage between design, sustainability, and occupants' health, work performance/learning, and satisfaction.
3. Examine the value post-occupancy evaluations (POEs) have for building owners, occupants, and design teams in identifying critical issues that impact IEQ and how to apply the findings to inform future design decisions.
4. Understand the process required to successfully implement the POE survey and B3 tools available for continuous learning.

Agenda



- Introduction to POES and their value
- Development of the B3 POE as a component of the B3 programs and tools
- Review of POE outcomes relative to design, sustainability, and building occupants' satisfaction, performance/learning, and health
- Diagnostic benefits of POEs for building owners, occupants, and design teams; what we learn from POE findings
- Comparative Case Study of IEQ across 30 workplace buildings
- B3 process contribution to successful POEs and continuous learning

What is a POE?



- POEs have been used to study user satisfaction with the built environment.
- POEs have been recognized for documenting occupants' well-being and responses to indoor environmental quality (IEQ), such as thermal, lighting, and acoustic conditions (Guerin et al., 2011).
- POEs are recognized as a key element of an evidence-based design approach, preferably combined with pre-design occupant surveys (Hamilton & Watkins, 2009)

What is a POE?



- Evaluation of occupants' (employees, students, consumers, family, etc.) perceptions of the physical environment after they have occupied it for several months. Here are some examples:
 - Satisfaction with a public library study area
 - Performance enhanced/hindered by workspace design
 - Health is enhanced/hindered by the residence hall
 - Learning is enhanced/hindered by the classroom environment
 - Safety is enhanced/hindered by security measures
 - Healing is enhanced/hindered by the hospital environment

Why Conduct a POE?



- Determine success/failure of a design solution as part of an evidence-based design (EBD) approach
- Apply lessons learned to the next design...client...renovation
- Determine the value of the design to the client
 - Is there a return on investment (ROI) for the client/business owner?
 - Have decisions advanced 'best practices' through evaluation of previous benchmarks?
 - Do industry standards, codes, guidelines, or recommendations need to be updated to meet shifting human needs? In what way?

Why Conduct a POE?



- Did the design actually *improve* employee performance, health, or satisfaction?
- Was there evidence of dissatisfaction?
 - What is the root cause?
- How to separate overall outcomes/success versus 'a few loud complainers'?
 - When the 'squeaky wheel' is right!

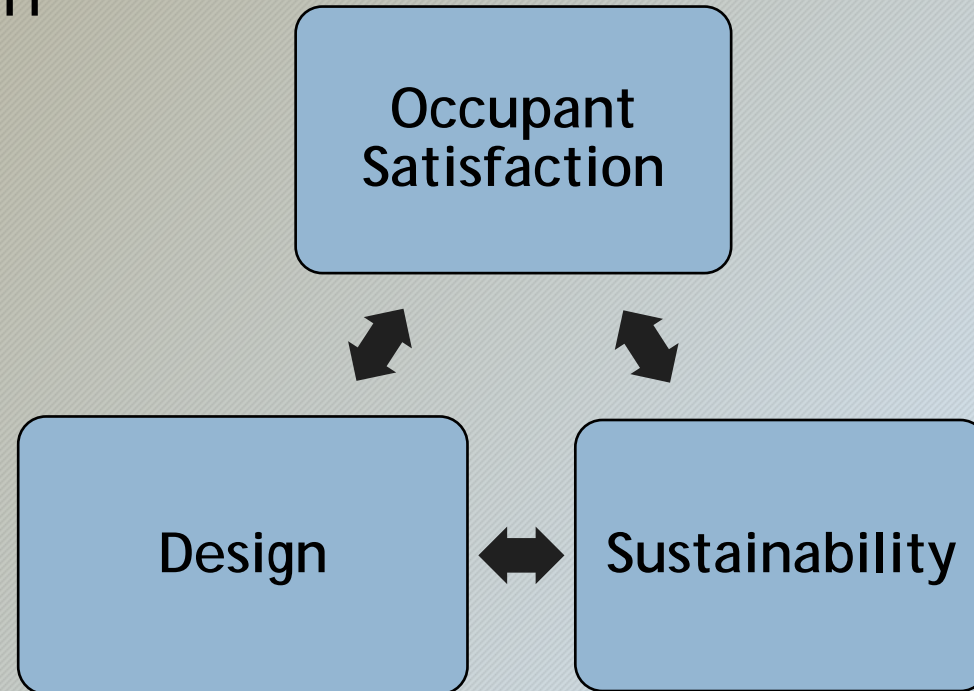
Remember that after the building cost, employees are the greatest operating expense of a business—no matter the type.

Interaction of the Factors



Successful outcomes depend on strength *in all factors*

- 80% of employees must be satisfied with workplace temperature (ASHRAE).
- A sustainable building that no one 'likes' is underutilized.
- A well-designed space that hides its stairwell reduces occupants' physical activity.

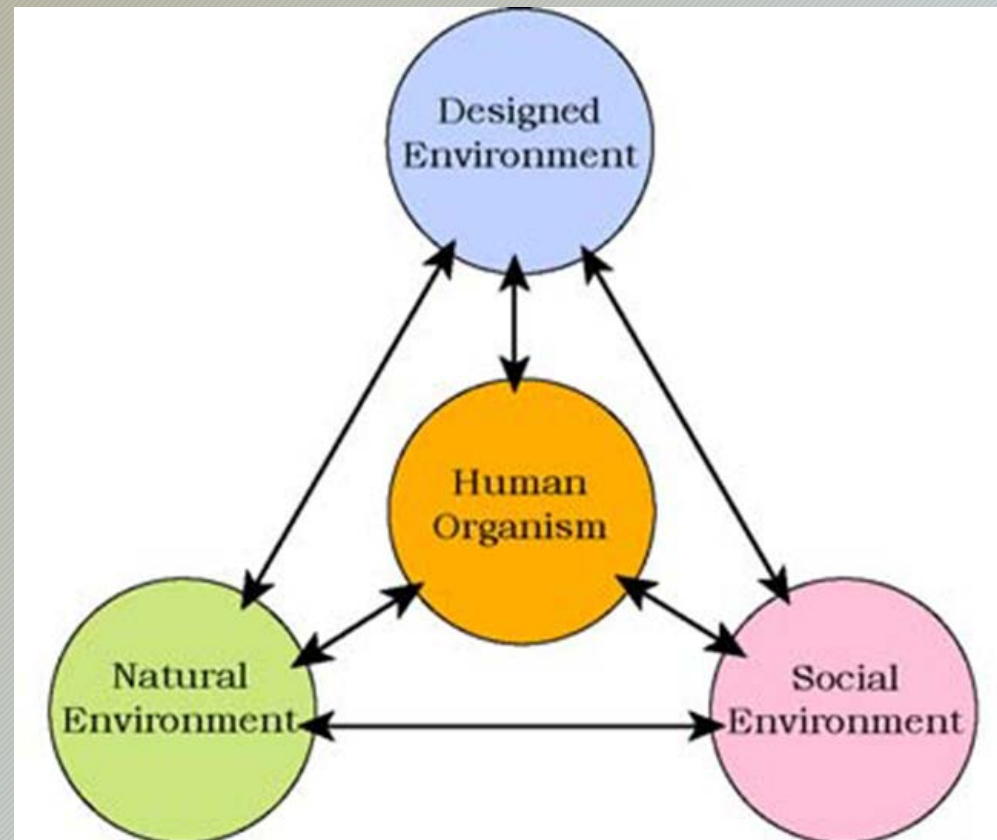


Theoretical Foundation for Conducting a POE

Human Ecosystem Theory

Other theories:

- Person-Environmental Fit
- Meaning of Place
- Environmental Press
- Prospect and Refuge



POE: A Survey Method



POEs are generally:

- An interview, conducted in person or over the phone
- A questionnaire, mailed or online
- Benefits of an online questionnaire
 - Numerical statistics result from the survey that can be analyzed and examined across a database of findings
 - Reduced cost and effort
 - Anonymous and objective
- Challenge: response rate

B3 POE within the B3 Programs and Tools



Design of New Buildings and Renovations

- *Guidelines*
- *SB 2030 Energy Standard*

Operation of Existing Buildings

- *Benchmarking*
- *Energy Efficient Operations*
- *Post-Occupancy Evaluation (POE)*

For more information, go to <https://www.b3mn.org/>

Development of the B3 POE Instrument



- The B3 POE reflects the B3 (Buildings, Benchmarks, and Beyond) Sustainable Design Guidelines developed by CSBR.
- B3 Guidelines and the B3 POE are required to be used by any state-funded project in Minnesota, with some exemptions.
- Focus of the B3 POEs are the Indoor Environmental Quality (IEQ) Guidelines, intended to measure:
 - Satisfaction, performance/learning, health, and sustainability ethic
 - Buildings: workplaces, classrooms, residence halls, *and public libraries*
 - Validity and reliability are essential

Development of the B3 POE Instrument



- *Before the B3 POE...*
 - No questionnaire existed that was specific to the occupant's environment
 - Individual data were not collected, meaning only descriptive not inferential analysis were possible
 - Measurement of employee satisfaction and performance in relation to sustainable design criteria was inadequate
 - Poorly constructed questions

B3 Guidelines Context



B3 Guidelines for New Buildings and Major Renovations (Version 3.2, 12/2019) include requirements in the following Sustainable Criteria Categories:

- Performance Management (P.1-P.2)
- Energy and Atmosphere (E.1-E.5)
- **Indoor Environmental Quality (IEQ) (I.1-I.9)**
- Site and Water (S.1-S.5)
- Material and Waste (M.1-M.4)

B3 Guidelines: IEQ Overview



The goal of the guidelines is to provide high quality indoor environmental conditions to promote occupant health, well-being, and productivity. This is achieved through both the reduction of the conditions that contribute to negative outcomes, and support for the conditions associated with increased health, comfort, and productivity. IEQ Guidelines (required vs recommended varies):

- I.1 Low-Emitting Materials
- I.2 Moisture and Water Control
- I.3 Ventilation

B3 Guidelines: IEQ Overview



IEQ Guidelines (continued):

- I.4 Thermal Comfort
- I.5 Lighting and Daylighting
- I.6 Effective Acoustics
- I.7 View Space and Window Access
- I.8 Ergonomics and Physical Activity
- I.9 Wayfinding and Universal Access

Current WP IEQ Criteria (Categories and Attributes)



- **Overall Acoustic Quality**
 - Ability to hear desired sounds
 - Ability to limit undesired sounds
- **Overall Appearance (aesthetics)**
- **Overall Cleaning and Maintenance**
- **Overall Daylighting Conditions**
 - Amount of daylighting
 - Adjustability of daylighting
- **Overall Electric Lighting Conditions**
 - Amount of electric lighting
 - Adjustability of electric lighting
 - Adjustability of task lighting conditions
- **Overall Furnishings**
 - Function of furnishings
 - Adjustability of furnishings

Current WP IEQ Criteria (Categories and Attributes)

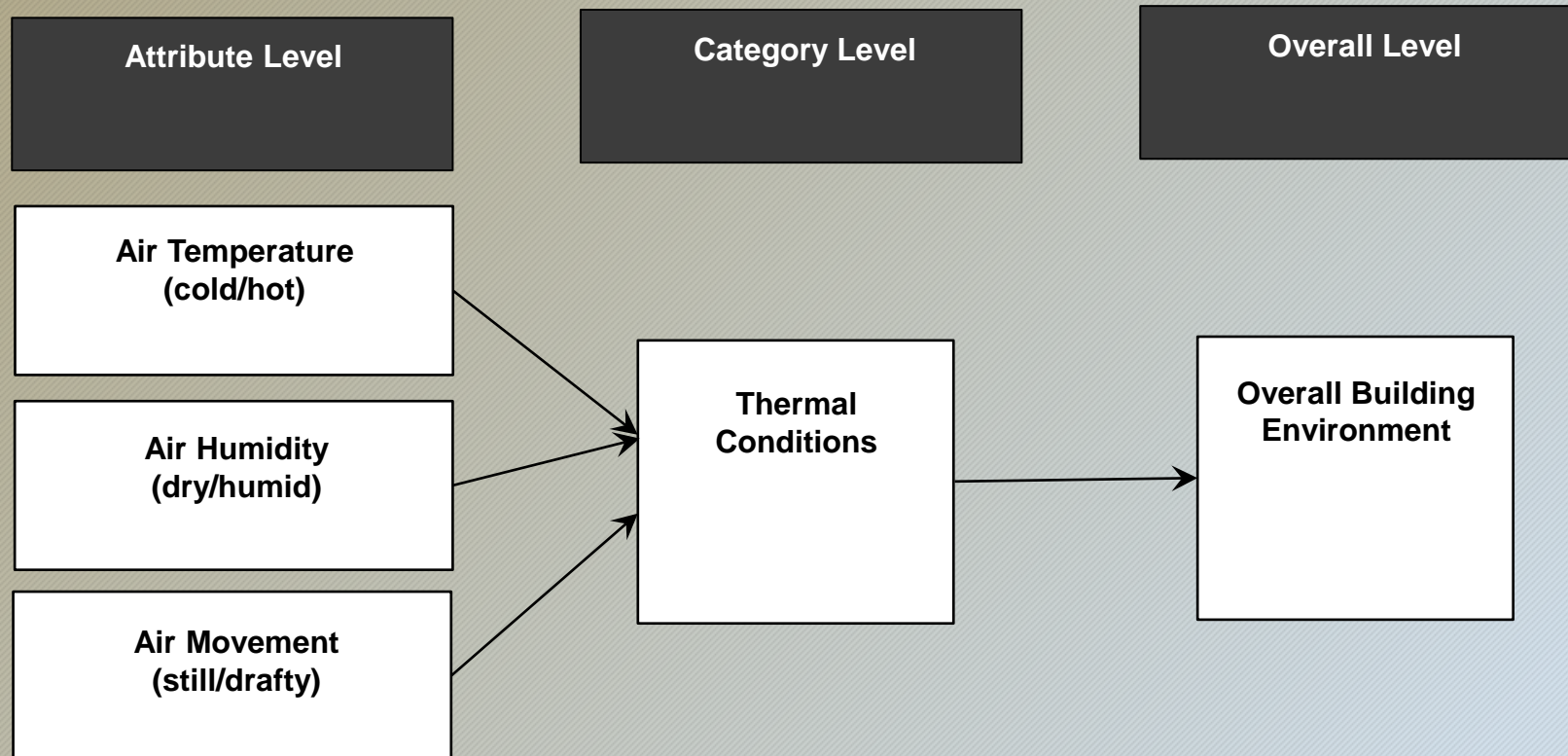


- **Overall Indoor Air Quality**
- **Overall Privacy**
- **Overall Technology**
 - Access to electric outlets
- **Overall Thermal Conditions**
 - Adjustability of thermal conditions
 - Air velocity (drafty/stagnant)
- **Overall Thermal Conditions (cont.)**
 - Humidity (dry or moist)
 - Temperature (hot or cold)
- **Overall Vibration and Movement**
- **Overall View Conditions**

B3 POE Conceptual Framework: Instrument



Each question is linked to sustainable design criteria.



Updated WP IEQ Criteria: Overall Building (Categories and Attributes)



- **Overall Appearance (aesthetics)**
- **Overall Cleaning and Maintenance**
 - Cleaning of the building
 - Maintenance of the building
- **Overall Universal Design**
 - People with diverse abilities are supported
 - Hazards/accidents are minimized
 - Low physical effort is required
 - Appropriate size and space
- **Overall Wayfinding**
 - Entrance clearly visible
 - Circulation routes understood
 - Space/features help navigation
 - Signs located where info needed
 - Signs understandable
 - Directory/map helped find the destination

Updated WP IEQ Criteria: Primary Workspace (Categories and Attributes)



- **Overall Acoustic Quality**

- Mechanical systems noise
- Background noise from people
- Background noise from music, tools, equipment, etc.
- Absence of noise (nearly silent)
- Use of sound masking, 'white' noise
- Noise from outside the building

- **Overall Appearance (aesthetics)**

- **Overall Daylighting Conditions**

- Amount of daylighting
- Adjustability of daylighting
- Visual comfort (absence of glare)

- **Overall Electric Lighting Conditions**

- Quality of electric light
- Amount of electric light
- Adjustability of electric light
- Effectiveness of automatic lighting sensors

Updated WP IEQ Criteria: Primary Workspace (Categories and Attributes)



- **Overall Electric Lighting Conditions (cont.)**

- Quality of task lighting
- Adjustability of task lighting
- Visual comfort
- Amount of noise produced by electric light fixtures

- **Overall Furnishings Comfort**

- Comfortable, supportive posture
- Support of your chair
- Worksurface height

- Work items within accessible reach
- Computer placement
- Monitor(s) placement for viewing
- Absence of visible glare
- Leg clearance under worksurface

- **Overall Indoor Air Quality (IAQ)**

- Air freshness
- No odors from cleaning products/chemicals
- No odors from unknown source

Updated WP IEQ Criteria: Primary Workspace (Categories and Attributes)



- **Overall Indoor Air Quality (cont.)**

- Absence of dampness or water
- Absence of mold or mildew

- **Overall Privacy Conditions**

- Ability to have a one-on-one conversation without being overheard
- Ability to control noise
- Amount/extent of visual privacy
- Ability to limit visual distractions

- **Overall Technology**

- Access to electrical outlets
- Internet/network speed and reliability
- Technology systems/equipment provided by the facility

- **Overall Thermal Conditions**

- Consistent temperature
- Air temperature
- Air humidity
- Air movement

Updated WP IEQ Criteria: Primary Workspace (Categories and Attributes)



- **Overall Thermal Conditions (cont.)**
 - Temperature control
 - Air flow control
- **Overall Vibration and Movement**
- **Overall View Conditions**
 - Visual connection to nature or the outdoor environment
 - Visual connection to an interior point of interest

B3 POE IEQ Survey Instrument Criteria



Building Typology	Through 2019 B3 Design Guidelines		January 2020 B3 Design Guidelines	
	Category Level IEQ Criteria	Attribute Level IEQ Criteria	Category Level IEQ Criteria	Attribute Level IEQ Criteria
Workplace (WP)	12 (PWS) N/A (Bldg.)	14 (PWS) N/A (Bldg.)	11 (PWS) 4 (Bldg.)	46 (PWS) 12 (Bldg.)
Classroom/Lab (CR)	11 (PCR) N/A (Bldg.)	12 (PCR) N/A (Bldg.)	TBD (PCR) TBD (Bldg.)	TBD (PCR) TBD (Bldg.)
Residence Hall (RH)	12 (PLS) N/A (Bldg.)	11 (PLS) N/A (Bldg.)	TBD (PLS) TBD (Bldg.)	TBD (PLS) TBD (Bldg.)
Public Library (PLIB)	N/A	N/A	15 (Bldg.)	33 (Bldg.)

Primary Workspace (PWS); Primary Classroom (PCR); Primary Living Space (PLS)

B3 POE Instrument Composition



- For buildings that used the Design Guidelines through December 2019, the Scan V4 instrument (refined in 2015) is being used.
- For buildings designed using the Version 3.2 Design Guidelines, new instruments are being implemented.
- Questions:
 - Likert-type scale (category and attribute level)
 - Open-ended (overall facility, primary space)
 - Demographics
- Duration: 10-15 minutes
- Consent: voluntary (addressed in the introduction screen)

B3 POE Survey Instrument Characteristics



Occupants use a **Likert-type scale** to respond to questions:

- Satisfaction: from 1 (very dissatisfied) to 7 (very satisfied).
- Work performance: from 1 (hinders) to 7 (enhances).
- Health: from 1 (hinders) to 7 (enhances).

Occupants rate the **influence** of the physical environment:

- Overall: site, building, and interior
- Primary space: workspace, classroom, or living space

Public library (PLIB) survey: in addition to IEQ Criteria, occupants will rate the influence of the library's physical environment regarding:

- Value (community, personally)
- Meaning of place

B3 POE Typical Question Format



Regarding your primary workspace (the one where you spend most time in your office building), on a scale of 1-7 (very dissatisfied = 1 to very satisfied = 7), how satisfied are you with:

- the temperature in your primary workspace

Very Dissatisfied

1

2

3

4

5

6

7

Very Satisfied

- the humidity in your primary workspace

Very Dissatisfied

1

2

3

4

5

6

7

Very Satisfied

Publication of POE Outcomes



Reports Published on the B3 Web site include:

- Building Description, Design Team/Building Owner
- Method and Sample Description
- **Findings and Discussion** (narrative, tables, and figures)
 - Overall satisfaction, work performance, and health (facility and primary space)
 - IEQ satisfaction (all category and attribute criteria)
 - Physical activity engagement and commuting practices (movement within the building, commuting habits)
 - Demographics (age, gender, etc.)

Publication of POE Outcomes (cont.)



- **Conclusions** that review and qualify highlights of the findings
- **Recommendations** for IEQ Categories that are typically most problematic (based on previous studies)
- **Appendix A. Open-Ended Responses:** captures perspectives of occupants regarding the facility as a whole and specific spaces they utilize, captured verbatim and categorized by theme (acoustics, daylighting, etc.)
- **Appendix B. Glossary:** definition of key terms used in the report

POE Outcomes: IEQ Criteria Primary Workspace

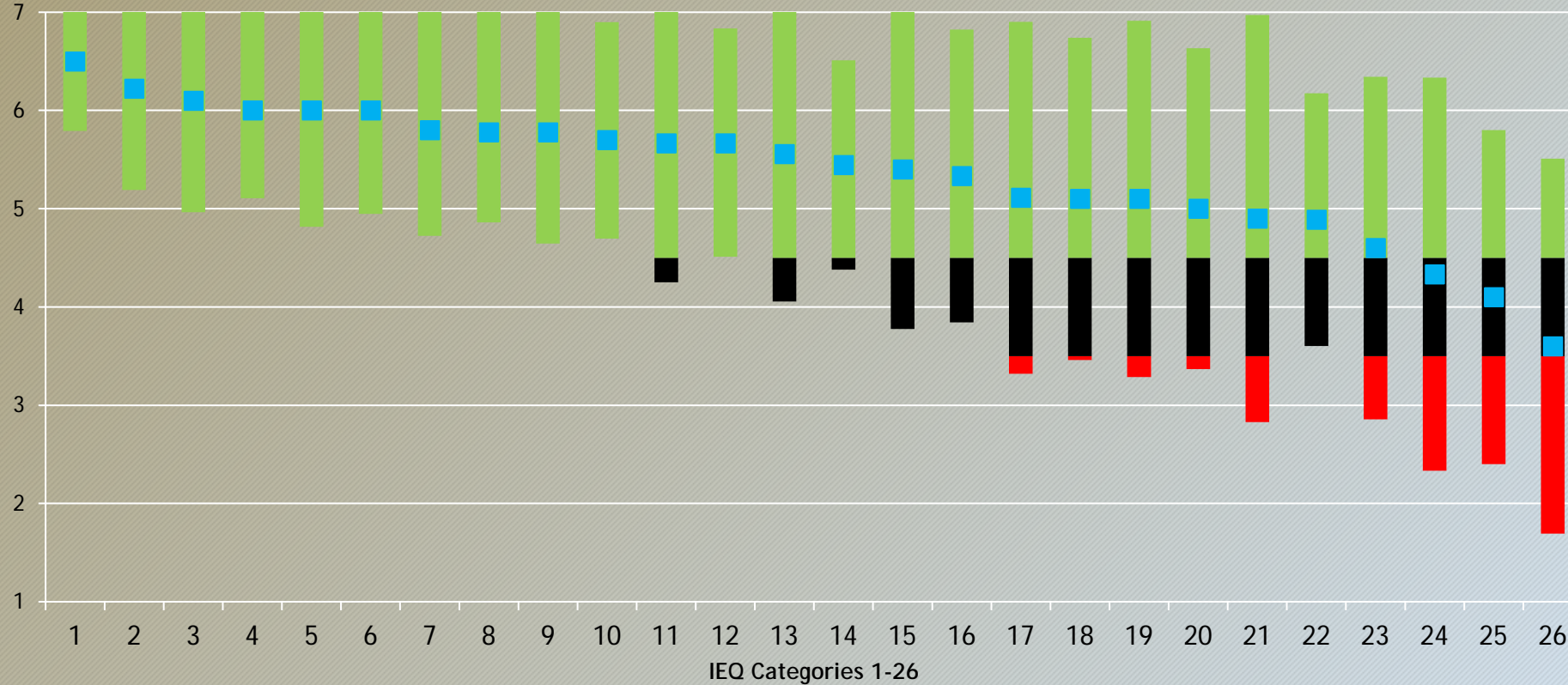


#	IEQ Criteria (1-26) (Category level criteria are bold face)	Mean	SD	N	Interpretation (D = Dissatisfied) S = Satisfied)
19	Overall acoustic quality	5.10	1.81	44	Satisfied
20	Adjustability of task lighting	5.00	1.63	46	Satisfied
21	Adjustability of daylighting	4.90	2.07	44	Satisfied
22	Adjustability of furnishings	4.89	1.29	45	Satisfied
23	Temperature (hot or cold)	4.60	1.74	43	Satisfied
24	Overall privacy (sound and visual privacy)	4.33	2.00	46	Neither S or D
25	Ability to limit undesired sounds	4.10	1.70	44	Neither S or D
26	Adjustability of thermal conditions	3.60	1.91	46	Neither S or D

POE Outcomes: IEQ Criteria Primary Workspace



XXXX Primary Workspace IEQ Scores



POE Outcomes: IEQ Satisfaction Scorecard



A composite score that is an average of all IEQ Category Criteria:



Published POE Outcomes: B3 POE Library



B3 POE Reports to date: 60

- Workplace: 42
- Classrooms/Training Centers: 15
- Residence Halls: 3

For more information, please visit the B3 POE Library page:

<http://www.b3mn.org/poe/library/>

What More Can We Learn from a POE?



Project Level

- Feedback to project owners, managers, and the design team
- Evaluation of success towards pre-identified goals
- Constructive diagnostic information by topic and location

B3 Program Level

- Track progress toward intended human outcomes
- Feedback to inform evolution of IEQ Guidelines relative to criteria

Research and Outreach Level

- Increased understanding of human-environment interactions
- Development of evidenced-based design criteria

Learning About Specific Issues: Balance



Additional data gathered from responses to open-ended questions

"...the physical environment of *your space*" (workspace, classroom, or living environment)

"...the physical environment of *the facility* (site, facility, interior)

Data are organized by theme

- Comments are provided verbatim within Appendix A of the POE report
 - Issues relative to specific people, facility policies or operations, or other matters are provided to the facility, but are not included in the POE report.

Learning About Specific Issues



MUST pay attention to the issues that are addressed by the building occupants:

- Information can be used to make additional inquiries through **focus groups** to identify resolution to issues.
- Many negative **issues can be rectified** improving occupants' satisfaction, performance, and health
- Lessons learned can be **applied to the next** renovation and/or new building project

The Good, the Bad, the Ugly



Much to learn from open-ended question responses:

- **Positive comments** tend to be more general and commonly reflect appreciation for the new and/or renovated facility:
 - “It’s a privilege to work here in such a beautiful building!”
 - “I really do think the building is a beautiful space. It is new, clean, and efficient.”
 - “A great place to study and learn in!”
 - “It is a very bright, inviting space.”
 - “I love the improvements!”
 - “Everything is new and stylish!”

The Good, the Bad, the Ugly



Negative responses tend to be very specific, primarily regarding:

- Thermal Comfort (adjustability, air velocity, humidity, and temperature)
- Overall Acoustic Quality (ability to hear desired sounds and limit undesired sounds)
- Overall Daylighting (amount and adjustability)
- Overall Electric Lighting Conditions (amount, adjustability of general lighting and task lighting)

The Good, the Bad, the Ugly: Thermal Comfort



"My office is sweltering hot at all times with no way to control the temperature."

"Very cold, noisy fans blowing all the time for any heat."

"I'm freezing cold all of the time—we all are."

"The science building is always too cold, even summertime."

"Conference rooms lack temperature control—a problem."

"I would like to be able to open a window, but that is not an option."

"Super humid in some areas, too dry in others."

"Our heater wouldn't work on one of the coldest nights of the year."

The Good, the Bad, the Ugly: Acoustics



"I can't hear myself think!"

"Walls too thin, I hear everything—some of which I shouldn't hear."

"Very, very noisy place to work. There is absolutely no way to get around this as we are surrounded by offices and people standing and talking in the hallway two feet away from me. Obviously, our needs were not too important."

"The walls and ceilings are so thin you can hear your neighbors all times of the day. Corridor doors are too high off the floor allowing sound to enter our room when we are trying to study."

"I can hear my neighbors when they are whispering to each other!"

The Good, the Bad, the Ugly: Daylighting and Electric Lighting



“Lack of windows is a bit depressing.”

“The large, ample windows are lovely...until those times when I need to darken the room. I wish there were shades.”

“The generous amount of natural light we receive is a great improvement.”

“The electrical lights on the ceiling flickers on and off during class.”

“Our ability to control the lighting is limited—sometimes there is too much, other times not enough.”

The Good, the Bad, the Ugly: Other Categories



- Most buildings have provided adequate **technology** features and are appreciated, but sometimes are not conveniently located or easily controlled. Internet access is a common problem for some buildings.
- Some buildings might meet functional requirements, but in terms of **appearance (aesthetics)** they are “cold,” “have no soul,” “impersonal,” and are “uninviting.” Lack of art/artwork is often mentioned.
- Most buildings are complimented on **cleaning and maintenance**, though a few are criticized, citing dust, unemptied trash bins, and seldom vacuumed floors.

The Good, the Bad, the Ugly: Other Categories



Privacy

"There is no privacy (when counseling students) in this shared office, which is probably a real concern given today's privacy laws."

"I can hear multiple conversations all the time. It is having a negative effect on my productivity. It makes me want to work at home."

Wayfinding

"This building was designed to encourage use of the stairs, but between floors there is no continuous staircase. Many people get lost and ask staff where they need to go. This wastes out time."

The Good, the Bad, the Ugly: Other Categories



Spatial Layout

- “Some of the lab spaces, specifically the chemistry labs, feel too small for the class size. More equipment and lab space would be nice so that crowding, waiting for instruments, and bumping into people wouldn't be an issue.”
- “Your neck gets really stiff from looking at the whiteboard on the side of the classroom instead of in front of you.”

Controls

- “Need controls to lower and raise the window blinds in the building accessible to students after professors leave so that we can block excessive light from the sun when using the study rooms.”

The Good, the Bad, the Ugly: Other Categories



Indoor Air Quality

"My primary workspace this semester is at home, online. The XXXX building made me sick every time I was in it—I can't teach there. After more than a year, I continue to have headaches, dizziness, and nausea if I go there."

"On days where there are a lot of people in the building it is humid and smelly."

Furnishings

"Chairs are hard to sit in for most of the day. They are very uncomfortable, making it hard for me to concentrate."

"Seating cannot be used well with the worksurfaces—they bang."

"More stacked, moveable white boards needed in the math classrooms."

Analysis of POE Outcomes (2017-2020): Scientific Journals and Refereed Presentations



Journals:

- *Building Research & Information* (3)
- *Journal of Organizational Psychology*
- *LEUKOS: The Journal of the Illuminating Engineering Society*

Presentations:

- American Institute of Architects (AIA Minnesota)
- Environmental Design Research Association (EDRA; multiple)
- Illuminating Engineering Society (IES)
- Interior Design Educators Council (IDEC; multiple)
- Minnesota State (aka MnSCU)
- University of Minnesota

Case Study Example: Analysis of POE Outcomes



The Impact of Proximity to Window on Satisfaction with Indoor Environmental Quality

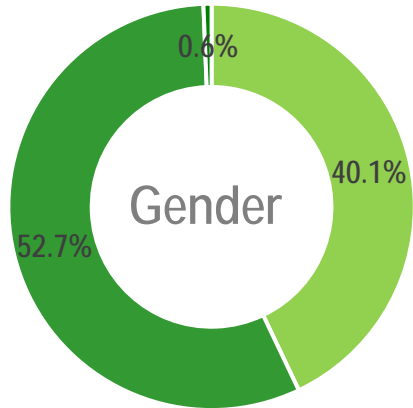
Suyeon Bae PhD, Abimbola Asojo PhD, and Caren Martin PhD
University of Minnesota

EDRA 2019
Brooklyn, New York
May 24, 2019

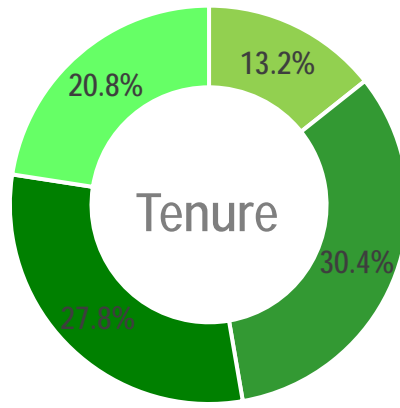
METHODOLOGY

Building and Respondents

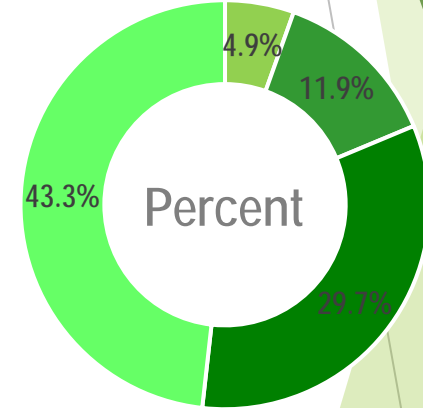
- From 2009 to 2017, the data was collected from 30 different workplace B3 buildings in Minnesota
- A total of 2,275 building occupants participated.



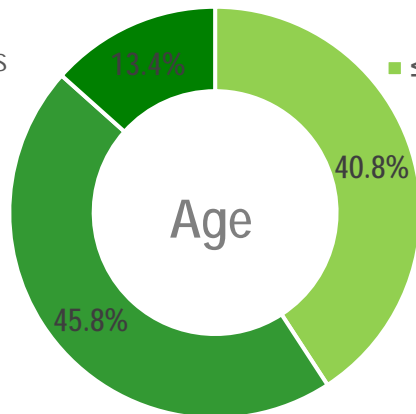
■ Male ■ Female ■ Others



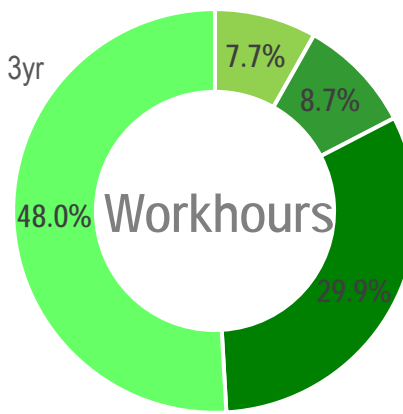
■ ≤ 1yr ■ 1-2yr ■ 2-3yr ■ ≥ 3yr



■ ≤ 25% ■ 25-50% ■ 50-75% ■ ≥ 75%



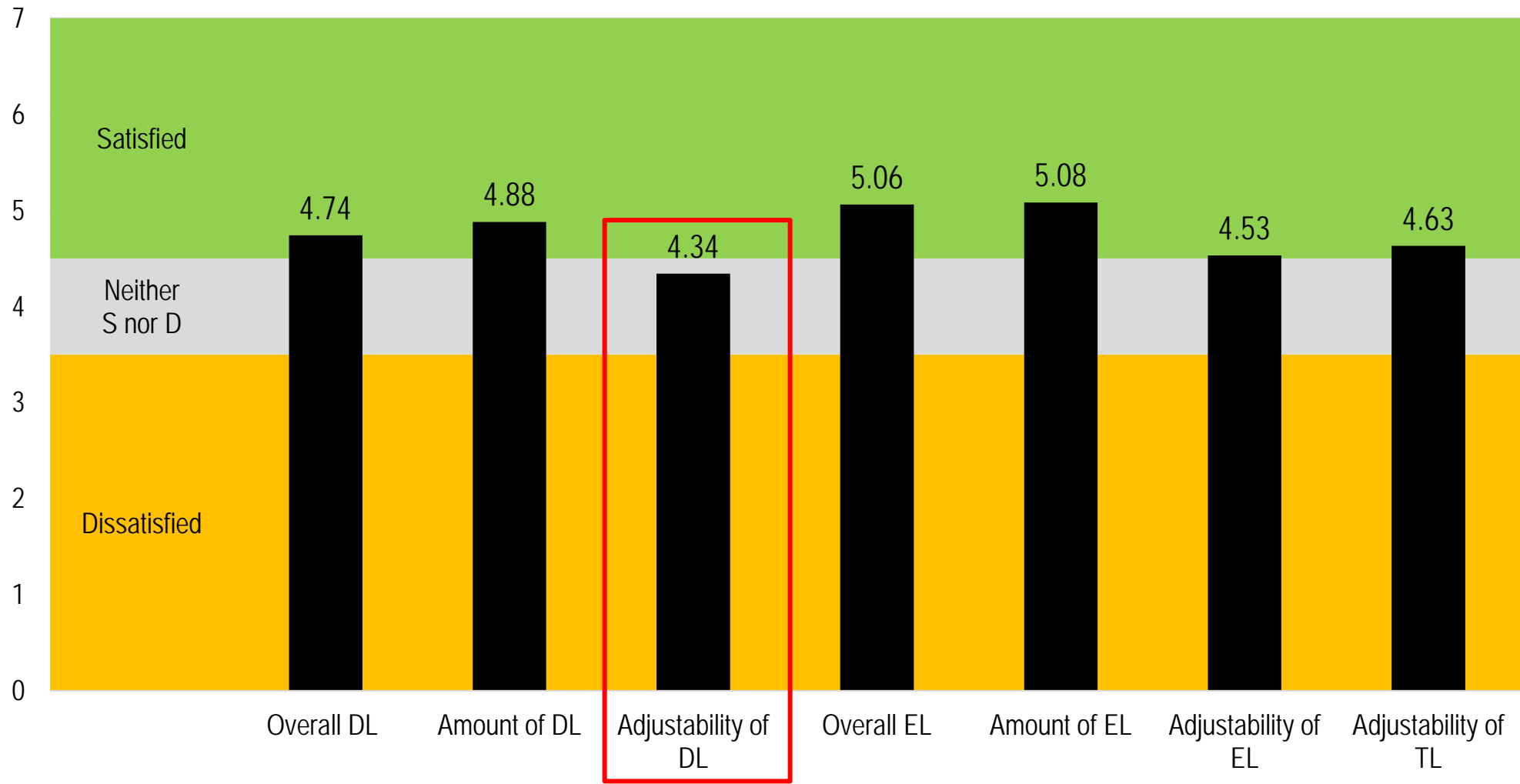
■ 18-34yr ■ 35-54yr ■ ≥ 55yr



■ ≤ 20hr ■ 20-29hr ■ 30-39hr ■ ≥ 40hr

RESULT

IEQ Satisfaction



RESULT

Lighting Correlation

- The correlations between DL and EL categories and their attributes

DL	Overall	Amount	Adjustability	
Overall DL	-	-	-	-
Amount of DL	.750 ***	-	-	-
Adjustability DL	.650 ***	.745 ***	-	-
EL	Overall	Amount	Adjustability EL	Adjustability TL
Overall EL	-	-	-	-
Amount of EL	.710 ***	-	-	-
Adjustability EL	.736 ***	.732 ***	-	-
Adjustability TL	.481 ***	.614 ***	.624 ***	-

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Note. DL – Daylighting, EL – Electric lighting, TL – Task Lighting. N=2,202

- All the relationships are **strong, positive, and statistically significant** ($0.481 \leq r \leq 0.750$)

RESULT

Lighting Association

- Overall DL was significantly predicted by both the **amount of DL** and **adjustability of DL** with 58% of variance explanation ($R^2 = .58$, $F(2,1920)=1350.07$, $p \leq 0.001$)
- **Amount of DL** ($\beta = .61$, $p \leq 0.001$) had stronger association with overall DL, compared to adjustability of DL ($\beta = .19$, $p \leq 0.001$)
- Overall EL was significantly predicted by **all three attributes of EL** (amount of EL, adjustability of EL and TL) with 81% of variance explanation ($R^2 = .81$, $F(3,1115)=1636.00$, $p \leq 0.001$).
- The strongest association with **overall EL** was found with **amount of EL** ($\beta = .79$, $p \leq 0.001$) than adjustability of EL ($\beta = .20$, $p \leq 0.001$) and TL ($\beta = -.04$, $p \leq 0.001$)

DL	β	SE B	t	VIF
Amount of DL	.611 ***	0.022	27.202	2.287
Adjustability DL	.194 ***	0.022	8.871	2.287
Constant	.969 ***	0.078	12.494	
F			1350.07	
Adjusted R ²			.584 ***	

EL	β	SE B	t	VIF
Amount of EL	.788 ***	0.021	3.329	2.363
Adjustability EL	.195 ***	0.019	10.373	2.723
Adjustability TL	-.035 ***	0.017	-2.024	2.137
Constant	.246 ***	0.074	3.329	
F			1636.00	
Adjusted R ²			.814 ***	

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Note. DL – Daylighting, EL – Electric lighting, TL – Task Lighting. N=2,202

RESULT

Satisfaction

- The results indicated that occupants with primary workspace within 15 feet of a window space were statistically more satisfied with both **daylighting** ($\Delta M=1.69$, $p \leq 0.001$) and **electric lighting** ($\Delta M=.41$, $p \leq 0.001$). Likewise, occupants with their primary workspace within 15 feet of a window perceived that both daylighting and electric lighting enhanced their work performance and health.
- However, **larger differences in satisfaction and perception regarding daylighting** may imply that proximity to a window impacts daylighting satisfaction and the perceived positive impacts on workplace performance of daylighting more than electric lighting satisfaction and the perceived positive impacts on work performance by electric lighting.

Table 1. Independent sample t-test between a primary workspace near a window or not near a window (i.e., non-window) on daylighting and electric lighting

		Window		Non-window		ΔM	t
		M	SD	M	SD		
Daylighting	Satisfaction	5.60	1.53	3.79	2.07	1.81	13.40 ***
	Perceived impact on WP	5.58	1.39	4.25	1.80	1.33	11.17 ***
	Perceived impact on health	5.58	1.31	4.16	1.81	1.42	11.98 ***
Electric Lighting	Satisfaction	5.31	1.61	4.83	1.76	0.49	4.05 ***
	Perceived impact on WP	5.18	1.32	4.76	1.50	0.42	4.07 ***
	Perceived impact on health	4.99	1.23	4.52	1.37	0.47	5.07 ***

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Note. M: Mean, SD: Standard Deviation, WP: Work Performance, ΔM : Difference in mean value

RESULT

Likelihood

- Occupants within 15 feet of a window perceived **9.58 times more that daylighting enhanced their health** (OR=9.58, $p < 0.001$) and **8 times more likely to be satisfied with the amount of daylighting** (OR=8.01, $p < 0.001$) than occupants who do not have window within 15 feet.
- Proximity to a window statistically influence occupants' satisfaction with daylighting as well as their positive perceptions of daylighting on work performance and health.
- The results imply that the workstation having a window nearby may lead to a high likelihood of satisfaction with IEQ and workstation.

Table 2. The likelihood of the occupants within 15 feet of a window being satisfied with the IEQ satisfaction and perception compared to occupants without proximity to a window

	Odds Ratios
Perceived impact of daylighting on health	9.58 *** [5.91; 15.49]
Amount of daylighting	8.01 *** [5.61; 11.45]
Daylighting – satisfaction	6.50 *** [4.54; 9.31]
Perceived impact of daylighting on WP	6.07 *** [3.97; 9.26]
Adjustability of daylighting	5.87 *** [4.26; 8.08]
View conditions – satisfaction	4.63 *** [2.59; 5.96]
Electric Lighting – satisfaction	1.48 *** [1.02; 2.85]

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Note. WP: Work Performance, The values in brackets are 95% confidence intervals for each OR; The group of occupants without proximity to a window is the reference indicating OR=1.

CONCLUSION

Summary

- The proximity to a window had a positive, statistically significant impact on occupants' satisfaction with both daylighting and electric lighting.
- However, the variation in daylighting satisfaction between occupants having their primary workstation within 15 feet of window space or not was much bigger than the variation in electric lighting satisfaction (DL: 1.81 vs. EL:.49).
- It is not surprising that occupants seated near a window acknowledge the benefit of daylighting in their responses (Hwang & Kim, 2011; Menzies & Wherrett, 2005).
- This result could be due to the fact that windows are more related to daylighting than to electric lighting. The literature also found that occupants at workstations with proximity to windows report higher satisfaction with lighting condition scores.

POE Process and Considerations



- POEs are conducted 9+ months post-occupancy date.
- Typically, 4-7 POEs are conducted each fiscal year depending on CSBR's budget.
- Required B3 POEs are conducted free of charge; other non-B3 buildings pay a fee for a POE.
- Some B3 buildings are exempt from a POE due to:
 - Small number of building occupants
 - At-risk building occupants
- POEs for other building types might be considered for future development.
- It is possible and beneficial to commission a Pre-Design survey to pair with a future POE for a fee.

Conducting the B3 POE: Process Steps



During the Commissioning Phase:

- **B3 POE team reaches out** to the building or agency contact; a liaison for this process is confirmed
 - Parameters are reviewed to confirm that a POE will be conducted
 - Type of POE is confirmed (WP, CR, RH, or PLIB); sometimes more than one (e.g., WP and CR)
- **Timeline is confirmed**
 - Date that the building was occupied (POE 9+ months afterward)
 - Timeframe to conduct the survey: avoiding conflicts

Conducting the B3 POE: Process Steps



During the survey period:

- Accuracy of data in the B3 Tracking Tool confirmed
- Occupants' email addresses: provided by the building liaison for insertion in the survey tool (Qualtrics)—*strictly confidential and deleted after the survey is complete*
- Participation encouraged by institution/agency leader: email sent to building occupants the day before the survey release
- Survey is emailed to the list of occupants the next day
- Reminder(s) is sent midway during the survey period
- Survey closes two weeks after its launch, unless it is extended (by mutual agreement)

Conducting the B3 POE: Process Steps



- Post-survey process:
 - Design team, building owner, and general contractor information is confirmed for the POE team
 - POE report is written by the B3 POE team
 - Building liaison reviews content relative to building facts
 - Final report is provided to CSBR for dissemination:
 - To the design team and building owner
 - Posted in the B3 POE Library
 - Data are entered into the growing CSBR B3 POE database for additional, summary analysis for research purposes.

Looking Forward: Evidence-Based Design (EBD)



Ideally, conduct both Pre-Design and Post-Occupancy Evaluations:

- *Pre-Design (Pre-Occupancy)* sets the baseline or benchmarks for the design team—as part of an EBD-approach.
 - Identify and commit to measurable outcomes
 - Questionnaire completed in old/existing building/space
- *Post-Occupancy* provides responses that establish the degree of success the design team has had in meeting pre-established, measurable outcomes; the percentage of change can be calculated.
 - Conducted 9+ months or more after occupancy
 - Same questions are used (from Pre-Design survey)

For Additional B3 POE Information



- B3 page
<http://www.b3mn.org/>
- B3 POE page
<http://www.b3mn.org/poe/>
- B3 POE Library page
<http://www.b3mn.org/poe/library/>
- Best of B3 page
<http://www.b3mn.org/best-of-b3/>

Q & A

For more information about B3 POEs contact:

- Elizabeth (Liz) Kutschke at kutsc009@umn.edu
Center for Sustainable Building Research (CSBR)
- Caren Martin at caren@mgdesignresearch.com
Martin & Guerin Design Research, LLC

Thank you!



Peer-Reviewed Journal Publications



- Bae, S., Martin, C.S., & Asojo, A.O. (2020). Higher education students' indoor environmental quality satisfaction benchmark. *Building Research & Information*, DOI: <https://doi.org/10.1080/09613218.2020.1813012>
- Bae, S., Martin, C.S., & Asojo, A.O. (2020). Indoor environmental quality factors that matter to workplace occupants: An 11-year-benchmark study. *Building Research & Information*, DOI: [10.1080/09613218.2020.1794777](https://doi.org/10.1080/09613218.2020.1794777)
- Asojo, A., Bae, S., & Martin, C. (2019). A post-occupancy evaluation study of the impact of daylighting and electric lighting in the workplace. *LEUKOS: The Journal of the Illuminating Engineering Society*, 1-12.
- Bae, S., Asojo, A., & Martin, C. (2019). The impact of occupants' demographics on indoor environmental quality satisfaction in the workplace. *Building Research & Information*, 1-15.
- Bae, S., Asojo, A., Guerin, D., & Martin, C. (2017). Post-occupancy evaluation of the impact of indoor environmental quality on health and well-being in office buildings. *Journal of Organizational Psychology*, 17(7).

Peer-Reviewed Presentations



- Bae, S., Martin, C., & Asojo, A. (2020, June). *Student satisfaction with indoor environmental quality (IEQ) factors of higher education classrooms*. International Association People-Environment Studies. Quebec City, Canada (canceled due to COVID-19)
- Bae, S., Asojo, A., & Martin, C. (2019, May). Proceedings from *EDRA 50: Daylighting and electric lighting satisfaction from post-occupancy evaluation lighting module studies*. Environmental Design Research Association. Brooklyn, NY
- Bae, S., Asojo, A., & Martin, C. (2019, May). Proceedings from *EDRA 50: The impact of proximity to window on satisfaction with indoor environmental quality*. Environmental Design Research Association. Brooklyn, NY.
- Bae, S., Asojo, A., & Martin, C. (2019, March). A Post-Occupancy Evaluation Study about Indoor Environmental Quality Satisfaction and Learning Experience in Classroom Buildings. Interior Design Educators Council International Conference. Charlotte, NC

Peer-Reviewed Presentations



- Asojo, A., Bae, S., & Martin, C. (2019, March). *Lighting Conditions and Perceived Learning Experience Among Students in Classroom Buildings: A Post Occupancy Evaluation Study*. Interior Design Educators Council International Conference. Charlotte, NC.
- Bae, S., Asojo, A., & Martin, C. (2018, June). *The impact of indoor environmental quality (IEQ) on Satisfaction in the Workplace: A Demographic Study*. Environmental Design Research Association. Oklahoma City, OK.
- Bae, S., Asojo, A., & Martin, C. (2018, March). *The Impact of Indoor Environmental Quality (IEQ) on Occupants' Performance, Satisfaction, Health and Learning Experience in Workplace and Classroom Buildings*. Interior Design Educators Council International Conference. Boston, MA.
- Alexander, B., Martin, C., & Wingate, C. (2017, November). *Designing for occupant well-being with B3 POEs*. Presentation at the American Institute of Architects-Minnesota Conference on Architecture. Minneapolis, MN.

Peer-Reviewed Presentations



- Martin, C. (2017, September). B3 buildings: What the post-occupancy evaluation (POE) process contributes to outcomes. Presentation for the CSBR at the University of Minnesota. (4 AIA LU/HSW)
- Asojo, A., Bae, S., Guerin, D., & Martin, C. (2017, March). *A post-occupancy evaluation of occupants' satisfaction: A case study of indoor environmental quality in classroom buildings*. Presentation at the Interior Design Educators Council International Conference. Chicago, IL.