OCCUPANT BEHAVIOR STUDY THERMAL COMFORT IN THE CLASSROOM

Boora Architects:

Mike Manzi | Abby Dacey | Jacob Peel | Stephen Endy

PSU School of Architecture Graduate Students: Cameron Davis | Tucker Jones

PSU School of Architecture Advisors: Sergio Palleroni | Kalina Vander Poel



PORTLAND STATE UNIVERSITY :: SCHOOL OF ARCHITECTURE

Project Overview

This is a post occupancy behavior study focusing on thermal comfort in three school buildings in the Greater Portland area designed by Boora Architects. Through a combination of data collection, survey questions and personal observation, the result is an evaluation of the thermal performance of Clackamas High School, Rock Creek Middle School, and Earl Boyles Elementary School.

Each school had specific design considerations and they span 12 years of evolving design strategy and changing trends in an attempt to use more passive approaches to achieve thermal comfort. In conjunction with another student group focusing on the building envelope performance of the same schools, this research intended to provide qualitative information to supplement their investigations and provide a more wholistic understanding of thermal performance.

Conclusions

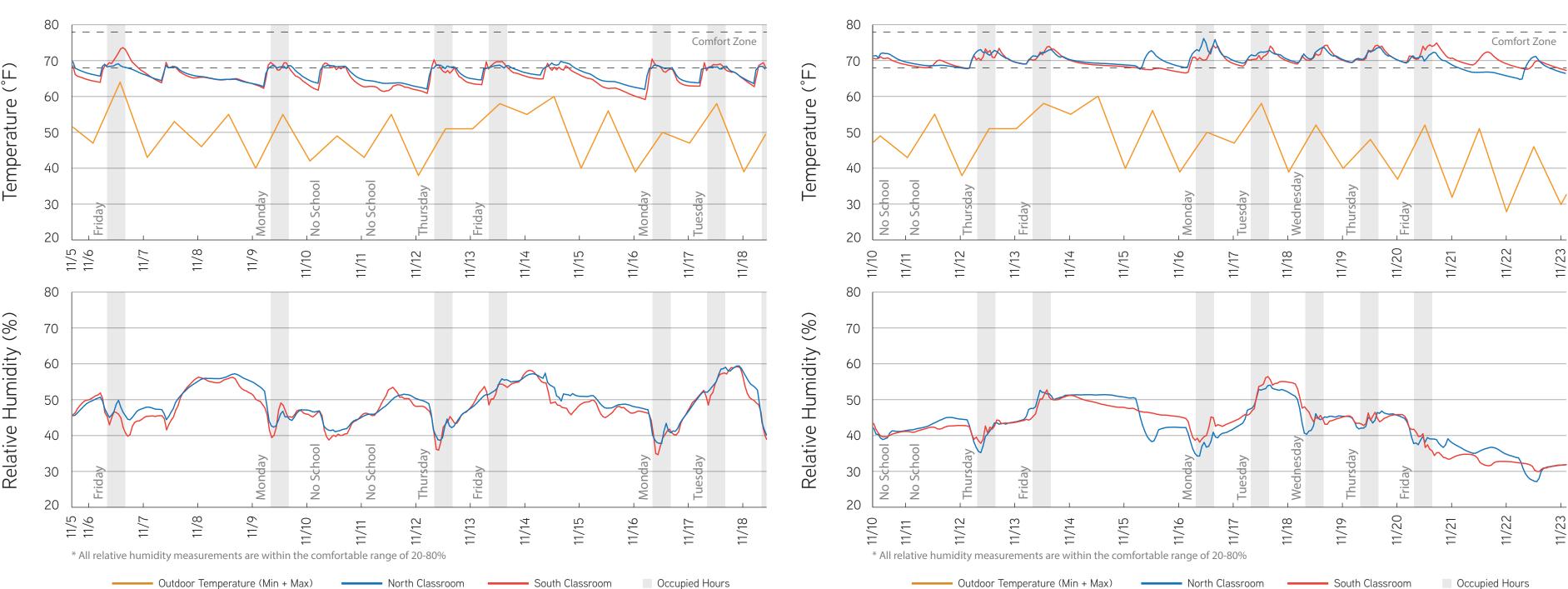
Quantitative data can provide excellent insight into the way design considerations translate into building performance and overall occupancy satisfaction. By comparing collected data to occupant survey data, it becomes clear that there is a great improvement in comfort as considerations became focused on envelope performance and passive heating strategies. It is also important to develope a system to inform occupants of any special design considerations if they are to work effectively throughout the lifecycle of the building.

UPUER 3 Develop goals Selection of schools: Chadceman High School Early Learning Center Rock Create With building partormance group Callaborate with building partormance group Schedule visits to achools Cartinued dialogue with firm: refine project and goals WEEK 4 WEEK 5 Cartinued dialogue with firm: refine project and goals Cartinued dialogue with firm: refine project and goals WEEK 5 WEEK 6 WEEK 7 Visit schools: Callect HOBOs Visit schools: Callect HOBOs WEEK 6 WEEK 7 WEEK 8 WEEK 8 WEEK 8 WEEK 9							
WEEK 3 WEEK 3 WEEK 5 WE	WEEK 1						
WEEK 6 WEEK 8 WEEK 9 Continued dialogues with firm: refine project and goals Develop thermal comfort surveys for occupants Establish measurement rules and guidelines Check out HOBOs Check out Check out Check out Check out Check out Ch		PRO.	Bedground research				
WEEK 4 ABORTON + Cartinued dialogues with firm: refine project and goals WEEK 5 Develop thermal comfort surveys for accupants Establish measurement rules and guidelines WEEK 6 Check out HOBOs WEEK 6 Visit schools: WEEK 6 Place HOBOs WEEK 7 Check out HOBOs WEEK 7 Place HOBOs WEEK 8 Place HOBOs WEEK 8 Place HOBOs WEEK 8 Place HOBOs WEEK 9 Place HOBOs WEEK 9 Place HOBOs WEEK 9 Place HOBOs Creeke presentation boards: Calleort HOBOs: Campario achoole Creeke presentation boards: Callsoration Put data from HOBOs: Campario achoole Creeke presentation boards: Callsboration Particulation WEEK 9 Envelops improved with firm Design features: Unknown Kgroned Unknown Kgroned Unknown Creeke presentation boards: Callsboration Cheateres: Unknown Kgroned Unknown <td>WEEK 2</td> <td>JECT [</td>	WEEK 2	JECT [
WEEK 6 WEEK 7 WEEK 8 WEEK 9 Continued dialogues with firm: refine project and goals Develop themual comfort surveys for occupants Establish measurement rules and guidelines Check out HOBOs Usit schools: Place HOBOs Distribute aurveys Check out HOBOs Callect Campane achools Callect HOBOs Callect HOBOs Callect Campane achools Callect HOBOs Callect HOBOs Callect Campane achools Callect HOBOs Callect Campane achools Callect HOBOs Callect HOBOs Callect Campane achools Callect Campane achools Callect Campane achools Callect Callec		DEVI	Develop	Develop goals			
WEEK 6 WEEK 8 WEEK 9 Continued dialogues with firm: refine project and goals Develop thermal comfort surveys for occupants Establish measurement rules and guidelines Check out HOBOs Check out Check out Check out Check out Check out Ch		Б	Salection of achools: Clacksmas High School Rock Creak Middle School Earl Boyles Elementary School Early Learning Center Callsborete with building centermance provo				
WEEK 4 ABORTON + Cartinued dialogues with firm: refine project and goals WEEK 5 Develop thermal comfort surveys for accupants Establish measurement rules and guidelines WEEK 6 Check out HOBOs WEEK 6 Visit schools: WEEK 6 Place HOBOs WEEK 7 Check out HOBOs WEEK 7 Place HOBOs WEEK 8 Place HOBOs WEEK 8 Place HOBOs WEEK 8 Place HOBOs WEEK 9 Place HOBOs WEEK 9 Place HOBOs WEEK 9 Place HOBOs Creeke presentation boards: Calleort HOBOs: Campario achoole Creeke presentation boards: Callsoration Put data from HOBOs: Campario achoole Creeke presentation boards: Callsboration Particulation WEEK 9 Envelops improved with firm Design features: Unknown Kgroned Unknown Kgroned Unknown Creeke presentation boards: Callsboration Cheateres: Unknown Kgroned Unknown <td></td> <td>ME</td>		ME					
WEEK 3 WEEK 3 WEEK 5 WEEK 5 WEEK 5 WEEK 6 WEEK 7 WEEK 8 WEEK 9 WE	WEEK 3	NT -					
WEEK 6 WEEK 8 WEEK 9 Continued dialogues with firm: refine project and goals Develop thermal comfort surveys for occupants Establish measurement rules and guidelines Check out HOBOs Check out Check out Check out Check out Check out Ch		+ G					
WEEK 6 WEEK 7 WEEK 8 WEEK 9 Continued dialogues with firm: refine project and goals Develop themual comfort surveys for occupants Establish measurement rules and guidelines Check out HOBOs Usit schools: Place HOBOs Distribute aurveys Check out HOBOs Callect Campane achools Callect HOBOs Callect HOBOs Callect Campane achools Callect HOBOs Callect HOBOs Callect Campane achools Callect HOBOs Callect Campane achools Callect HOBOs Callect HOBOs Callect Campane achools Callect Campane achools Callect Campane achools Callect Callec		ĂĽ	ĕ	Schedu	la visita te	a achoola	
WEEK 6 Allow two weeks for data collection WEEK 7 Return to achoels: Collect HOBOs Collect completed surveya Observe occupancy behavior Diacuss comfort with baschers WEEK 7 Pull data from HOBOs: Campare achoels WEEK 8 Pull data from HOBOs: Compare achoels WEEK 8 Pull data from HOBOs: Compare achoels WEEK 9 Constance occupancy behavior Diacuss comfort with baschers WEEK 9 Envelope improved with time: Thermal comfort	WEEK 4	U)	LAB	Centinu	ed dialog	ue with firm: refine project and goals	
WEEK 6 Allow two weeks for data collection WEEK 7 Return to achoels: Collect HOBOs Collect completed surveya Observe occupancy behavior Diacuss comfort with baschers WEEK 7 Pull data from HOBOs: Campare achoels WEEK 8 Pull data from HOBOs: Compare achoels WEEK 9 Constant of the sectors WEEK 9 Unitorown Ignored Unitorown			ORAT	Develop	thermal	comilari surveya ilar accupanta	
WEEK 6 Allow two weeks for data collection WEEK 7 Return to achoels: Collect HOBOs Collect completed surveya Observe occupancy behavior Diacuss comfort with baschers WEEK 7 Pull data from HOBOs: Compare achools WEEK 8 Pull data from HOBOs: Compare achools WEEK 9 Construction	NOI			Establish measurement rules and guidelines			
WEEK 6 Allow two weeks for data collection WEEK 7 Return to achoels: Collect HOBOs Collect completed surveya Observe occupancy behavior Diacuss comfort with baschers WEEK 7 Pull data from HOBOs: Compare achools WEEK 8 Pull data from HOBOs: Compare achools WEEK 9 Construction	WEEK 5		Check out HOBOa				
WEEK 6 Allow two weeks for data collection WEEK 7 Return to achoels: Collect HOBOs Collect completed surveya Observe occupancy behavior Diacuss comfort with baschers WEEK 7 Pull data from HOBOs: Compare achools WEEK 8 Pull data from HOBOs: Compare achools WEEK 9 Construction			Ň				
WEEK 6 Allow two weeks for data collection MEEK 7 Perform to achoels: Callect completed surveys Observe occupancy behavior Discuss comfort with baschers WEEK 7 Pull data from HOBOs: Graph data Compare schools WEEK 8 Pull data from HOBOs: Graph data Compare schools WEEK 9 Create presentation bosnets: Callaboration Reviews with firm WEEK 9 Envelope improved with time: Themal comfort			NG			-	
WEEK 9 WE	WEEK 6				Allow ba	o weeks for data collection	
WEEK 7 POP + OBSERVATION Callect completed surveys WEEK 8 Pull data from HOBOs: Graph data Compare acticols WEEK 8 Pull data from HOBOs: Graph data Compare acticols WEEK 9 Create presentation boards: Callaboration Reviews with firm WEEK 9 Design fastarws: Uninonum Ignored Unintended affacta Envalues improved with time: Thermal carriert Orea each adjuiction				RESI	Return t	n schools:	
WEEK 9 WE				ĀŖ			
WEEK 9 WE				유		Observe occupancy behavior	
WEEK 9 WE	WEEK 7		+ OE				
WEEK 9 WE				BSEF		Greph date.	
WEEK 9 WE				TAVF	Ą	-	
WEEK 9 WE	WEEK 8			FION	YALY		
Themal carrier					SIS,		
Themal carrier					+ 0		
Themal carrier					ONC	-	
Themal carrier	WEEK 9				EUS	Ignored	
Themal carrier					NOI	Unintended effects	
Create and a statistications					S		
	WEEK 10						

Clackamas High School

Location: 14486 SE 122nd Ave, Clackamas, OR Year of Completion: 2002 Square Footage: 275,000 ft² Occupancy: 2,213

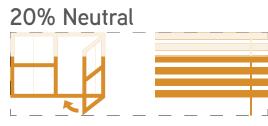




Device Controls







80% Unsatisfied



Natural Ventilation System Understanding/Awareness







Rock Creek Middle School



Location: 14897 SE Parklane Dr, Happy Valley, OR Year of Completion: 2010 Square Footage: 129,000 ft² Occupancy: 750





Occupant Feedback

"Far too cold. We need a manual thermostat. Last week, I had two students wrapped in blankets."

"I am cold constantly. Kids bring blankets to class. I have to wear thermal clothing, scarves, and coats."

"It is too hot when it's hot [outside] and too cold when it's cold [outside]."

"The natural ventilation system works better in the north-side classrooms."

"The thermal comfort is inconsistent - blazing hot in fall - cold in winter."

Building Specific Technology Located at the windowsills are operable vents that allow the influx of outside air without opening the entire window. There seems to be a disconnect between design intent and user understanding. The majority of teachers responded that they had little to no knowledge of how the system operates and even some who did replied that they do not use it.

Outdoor Temperature (Min + Max)

Device Controls



No Occupant Feedback Available



Building Specific Technology Rock Creek has an interactive system that notifies teachers when to open windows and allow for natural ventilation, however without any user feedback it is difficult to understand how well the system is working.

100 % Satisfied

Earl Boyles Elementary

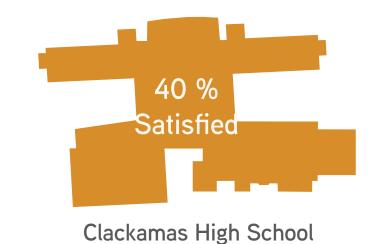
Methodology

In order to collect some quantitative data as a baseline, we placed HOBO sensors in a North and South facing classroom in each building. The sensors measured temperature and relative humidity every 15 minutes over the course of two weeks, averaging the recorded data every hour. In addition, we surveyed teachers in each school (half in Clackamas and all in the Earl Boyles addition) to find out their personal thermal comfort and temperature control ability in each room. We asked a series of questions in each survey set as well as a number of questions that were specific to each building.

Class Observation

To further supplement our findings, we observed two class sessions at Clackamas High School in the rooms where the HOBO sensors were located. This provided some personal insight into how the students and teachers behavied over the course of the day and the type of activities that went on in the rooms that could potentially effect thermal comfort. Clackamas had the most consistent negative feedback which was verified by the HOBO data. We found that most students were dressed in warm clothing over the course of the class period and each teacher we spoke with expressed their problems with the cold classroom environment. Also, the ventilation system seemed to be forgotten and even used as extra shelf space in one of the rooms.

Thermal Comfort Satisfaction



Earl Boyles Elementary School

Location: 10822 SE Bush St, Portland, OR Year of Completion: 2014 Square Footage: 15,000 ft² addition Occupancy: 188



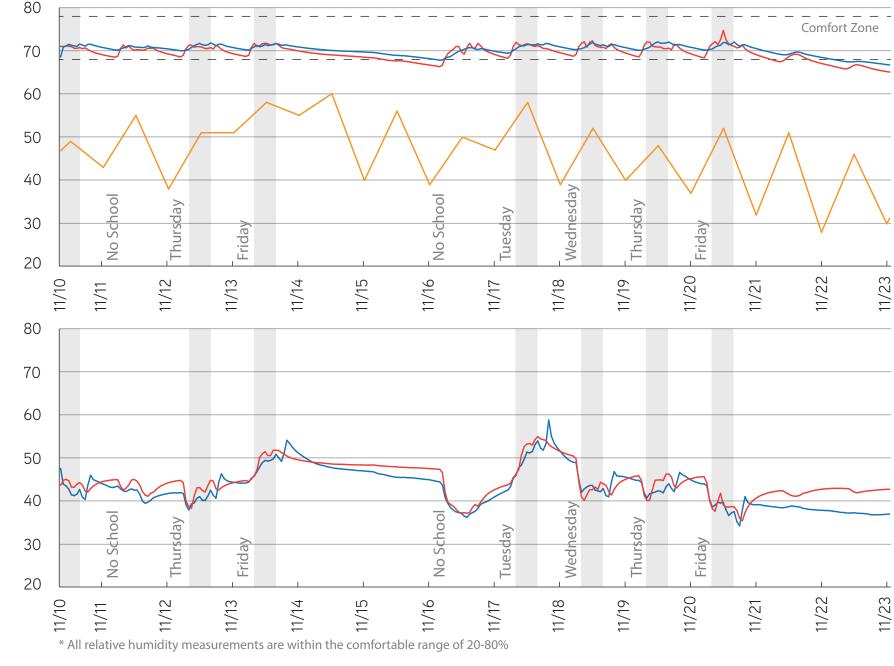
Thermal Comfort Data



Ű

Ð

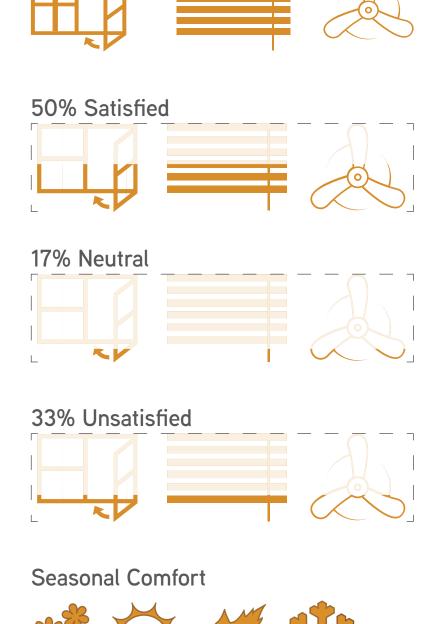
(%)

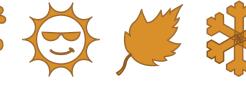


———— Outdoor Temperature (Min + Max) ——— North Classroom

South Classroom Occupied Hours



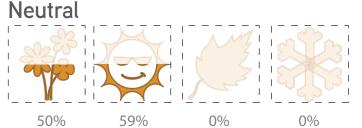




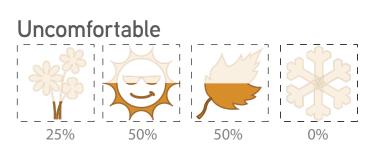
Comfortable

Device Controls

25% 50% 0%



100%





Occupant Feedback

"In early fall, mornings were okay, afternoons were extremely hot."

"On sunny days, by the afternoon it gets very hot."

"I love the fan but can't always use it because it blows the papers around. It only helps 1/2 the class."

"It is frustrating to not have much control over the heat in room, other than opening windows or fan. Fan has to be on low so that it won't blow students' work. Heat coming from the upper walls often makes any student work or posters taped up fall off. This occurs especially in winter. So much sunlight coming in also effects how I can control lights... which in turn effects my SMART board projector."

Building Specific Technology Earl Boyles had the strongest focus on thermal comfort with a very well insulated and airtight envelope. The building is designed to allow the heat generated by the users to keep the interior spaces within the thermal comfort zone. This building tested the strongest in terms of thermal comfort satisfaction.