

Boston Architectural College | August 13, 2024

Design is a public health intervention.

Erika Eitland, MPH, ScD

Perkins&Will

Design is a public health intervention.



Design for Wellbeing

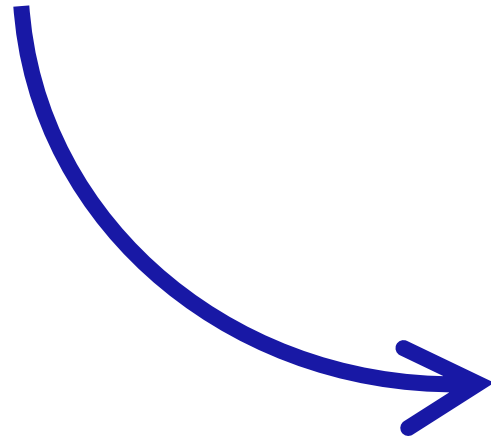
Good design supports health and well-being for all people—considering physical, mental, and emotional effects on building occupants and the surrounding community. (AIA, 2024)



Public health promotes and protects the health of all people and their communities.

This science-based, evidence-backed field strives to give everyone a safe place to live, learn, work and play. (APHA, 2024)

Design is a public health intervention.



An **action** taken to improve or help a situation.

- Oxford Advanced Learner's Dictionary

Raise Your Hand If...

You know a K-12 educator?

Have voted in a school building?

Have a child in a K-12 school?

Attended a K-12 public schools?

Our Action Plan (Agenda)

The Fundamentals

Action in Practice

William E. Carter School

Driving Questions & Resources

Perkins&Will



The Fundamentals

Everyday we make health design decisions

Removing windows from classrooms Asbestos
Outdoor classrooms Filtration or ventilation Interior
Walkability Siting Ramps Fixed chair and desk
Mitigating background noise Glare Temperature
Control Daylighting Color Choice Furniture
Technology Scale Adjacency Flooring Landscape
Stain Repellant Fabric Finishes UVGI Biophilic Design
Signage Wayfinding Layout Operable Windows
Carpeting Views Materials Cleaning Products
Lifecycle Cost Analysis Cost Management

The Open Air Movement



New York City, 1915



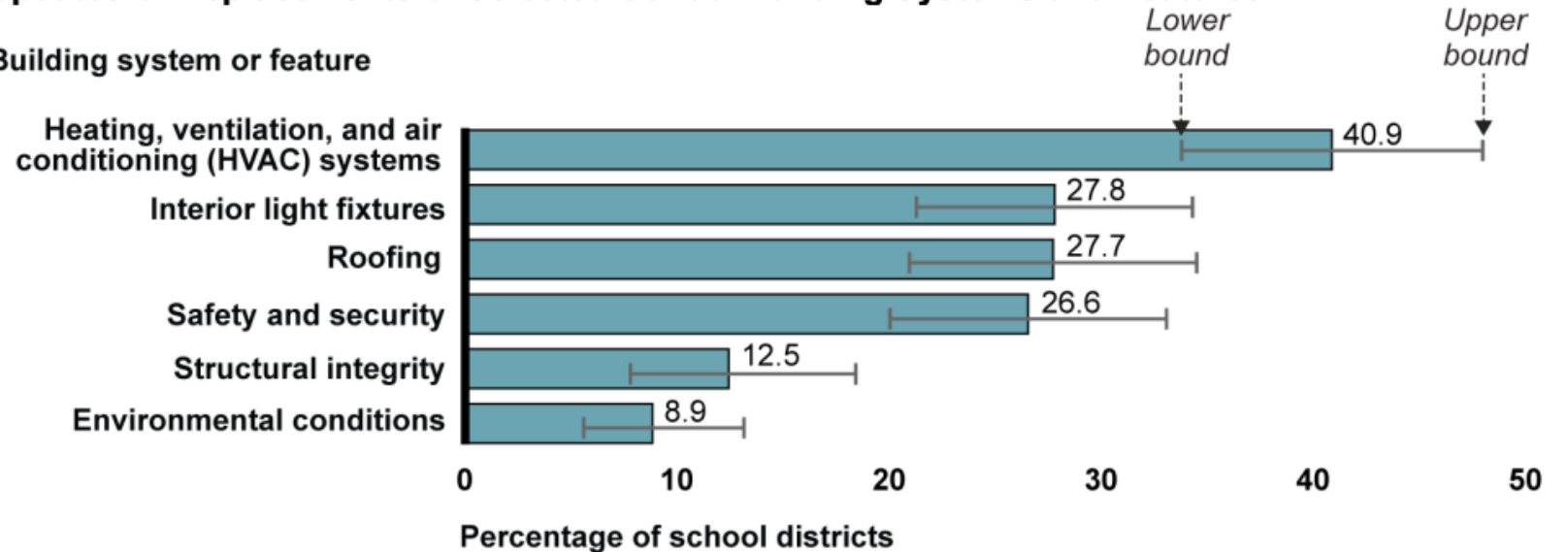
Netherlands, 1957

American Society of Civil Engineers gives the condition of America's 100,000 public school buildings an overall grade of D+



Estimated Percentage of Public School Districts in Which at Least Half the Schools Need Updates or Replacements of Selected School Building Systems and Features

Building system or feature

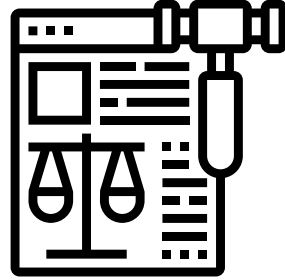
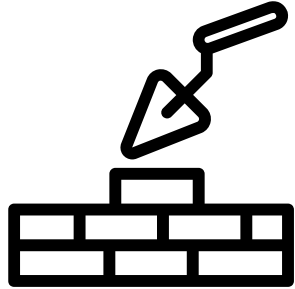
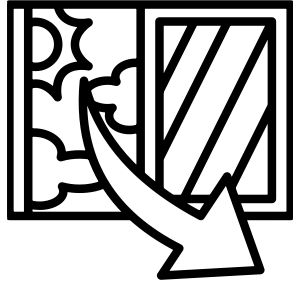


Source: GAO analysis of school district survey data. | GAO-20-494

Note: GAO administered the survey from August to October 2019. Thin bars in the chart display the 95 percent confidence interval for each estimate.

GAO, 2020

History of school buildings and health



1900-1930s

The Open Air Movement

Outdoor classrooms and large windows with students in rows

Tuberculosis & Infectious Disease outbreaks

1940s-1960s

Post War Building Boom

\$20 billion spent on new educational facilities in 20 years

Brown v. Board

1970s

Environmental Reckoning

Pass Toxic Substances Control Act (TSCA)

Anti-Smoking Campaigns

White Flight

Energy Crisis

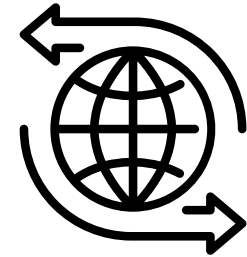
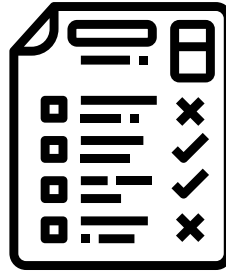
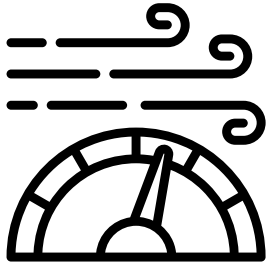
1980s-1990s

Documenting SBS

Congressional reports document the poor environmental quality nationally

EPA regulation on asbestos and lead in drinking water

History of school buildings and health



2000-2010

Emerging Evidence

Studies on portable classrooms, siting, air quality show adverse impact on child health, with widening disparities

Emergence of Certifications (LEED, CHPS)

Economic Recession

2010-2020s

Living with Inaction

American Society of Civil Engineers graded U.S. schools a D+

\$100 billion proposed in Rebuild America's School Act – discharged in December 2020

Massachusetts School Surveys (MSBA)

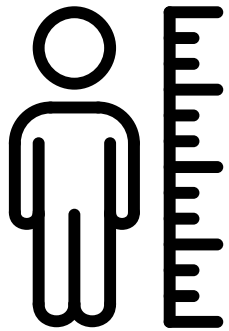
COVID-19 Pandemic

2050

Climate Reckoning

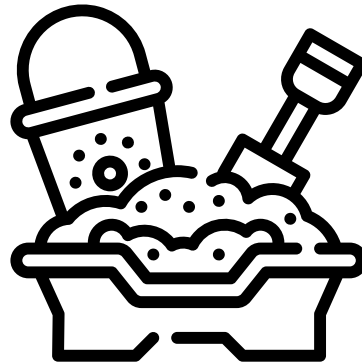
Increased weather variability, extreme heat, precipitation variability, vector-borne illnesses, displacement

How do we define healthy learning environments?



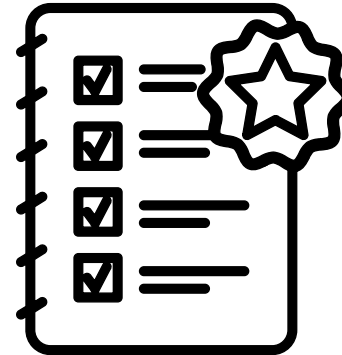
Physiology

Kids breathe 50% more air compared to adults



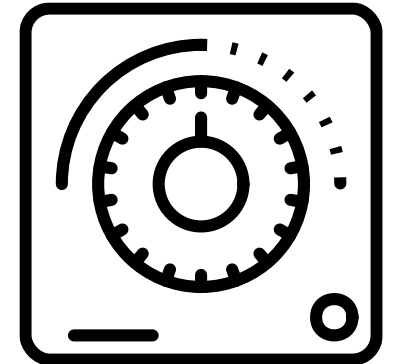
Behavior

Eat 200mg of dust every year



Potential

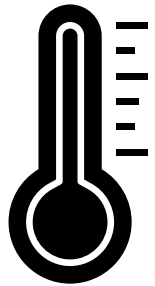
Lungs are growing until the age of 18



Efficacy

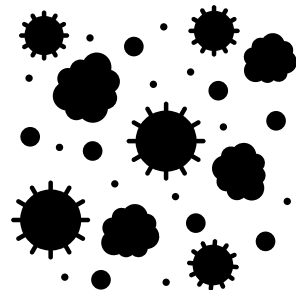
Less decision-making power

How do we support healthy workplaces?



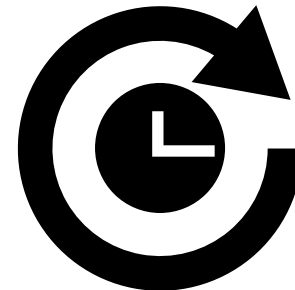
Physiology

77% of public school teachers are female



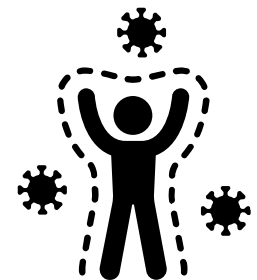
Tenure

~14 years of experience & working ~53 hours a week



Ergonomics

Repetitive work, long periods of standing & frequent lifting



Demographics

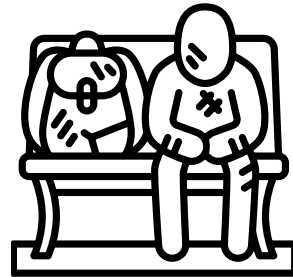
>25% of teachers are over 50 years old

Mental Health & Students of Color

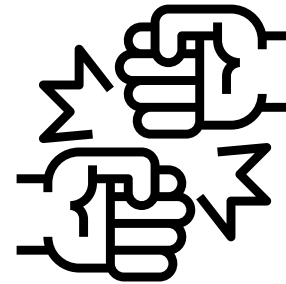
State of Our Students



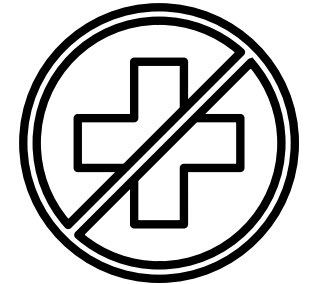
11.5% of youth are experiencing severe major depression, with higher rates in BIPOC and LGBTQIA+ communities (Mental Health America, 2023).



1.1 million U.S. public school students were homeless in 2020-2021 (NCES, 2021).



More than two-thirds of children will experience at least one traumatic event (psychological, physical, sexual, violence) by 16 years old (SAMHSA, 2024).

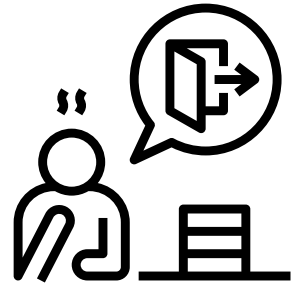


Nearly 60% of youth with major depression do not receive any mental health treatment with Asian youth at greatest risk (MHA National, 2022).

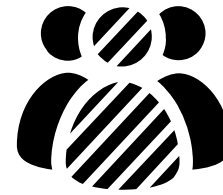
State of Our Teachers



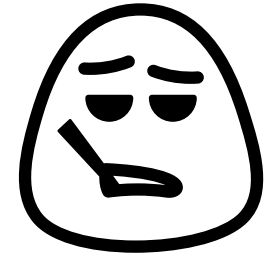
K-12 teachers are twice as likely to experience depression and high levels of job-related stress as the general population (Steiner & Woo, 2021).



Educators report mental health symptoms as reasons for leaving the field (Marinell & Coca, 2013).



62% of Black teachers and 59% of Latine teachers said they planned to leave education sooner than expected, compared to 55% of teachers overall (Carver-Thomas, 2018).



Schools continue to be ill-equipped to provide adequate well-being support for educators, especially educators of color (Corimer et al., 2021).

We can do better than an “average” experience

Embracing human differences across our lifetime.



Pregnant People

Children

Older Adults

Neurodivergent

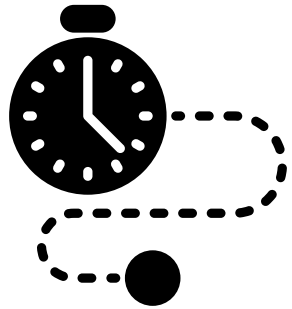
Mobility Impaired

Minoritized Populations

**Individuals with Chronic
Conditions**

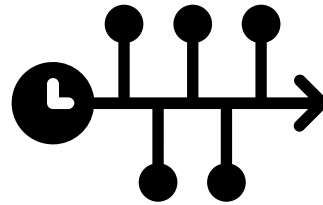


Science of the Invisible



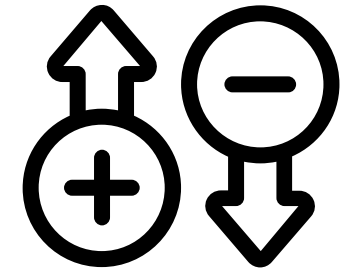
Duration

65% of our time is spent at our homes, what spaces to hangout in the most?



Frequency

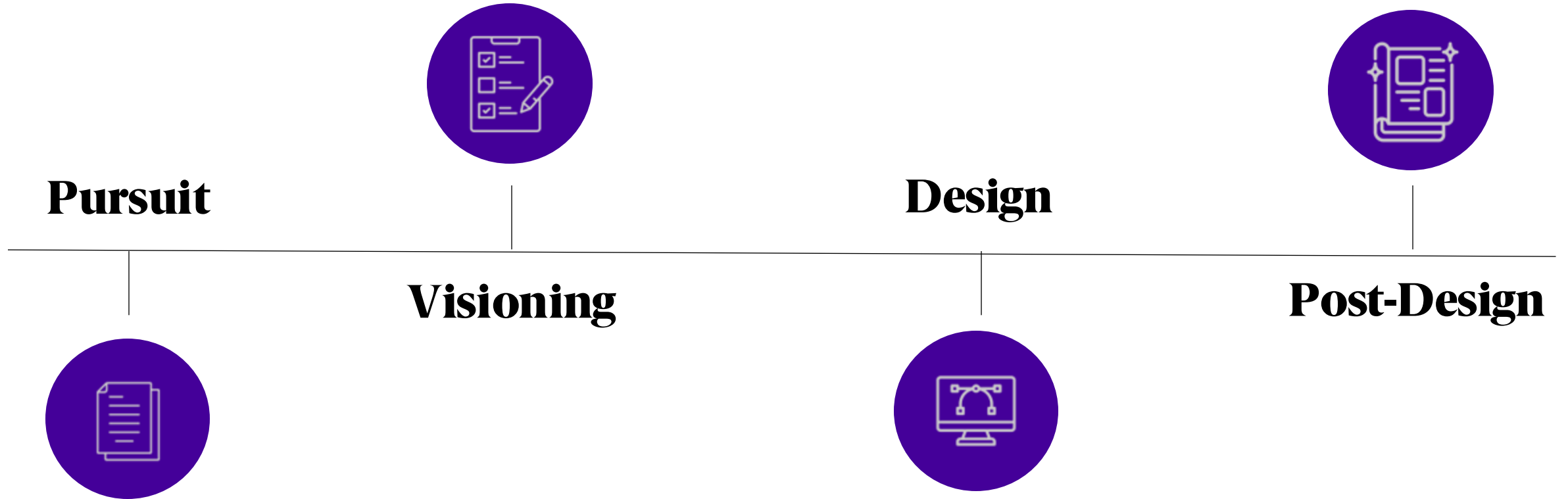
We are likely there everyday, but how often do you visit specific spaces?



Magnitude

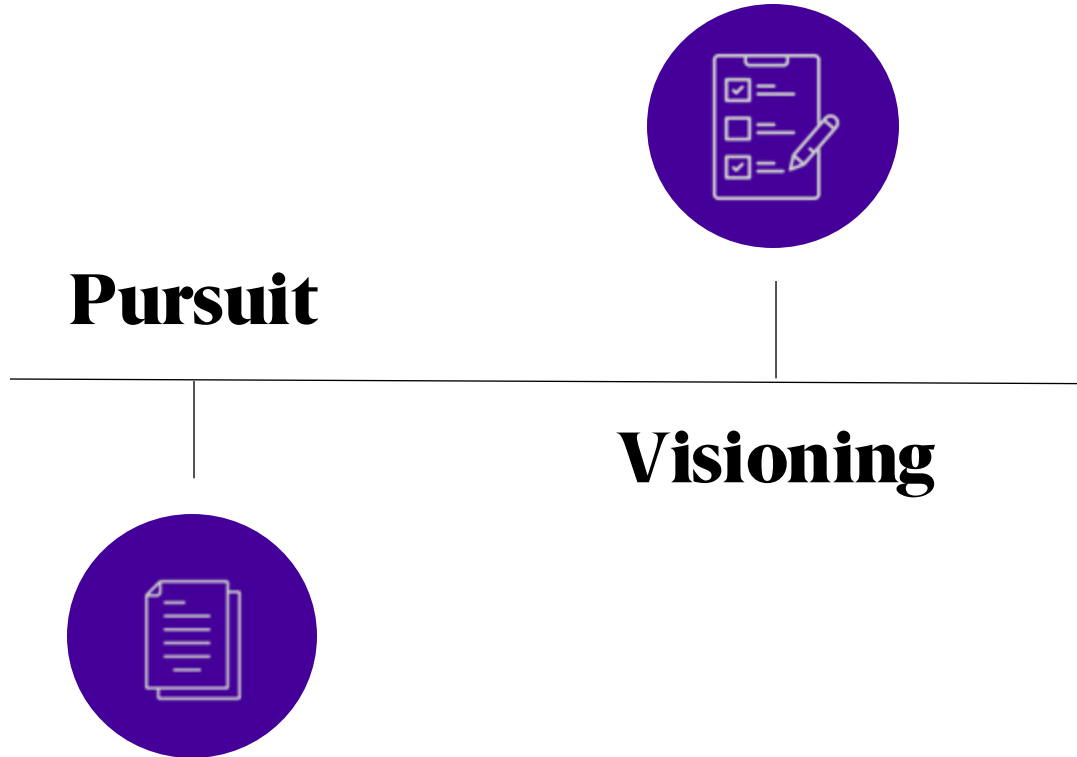
Indoor levels of pollutants are 2-5x times higher than outdoors. How much are we exposed to when at home?

When can we have the most impact?



When can we have the most impact?

Early in the Design Process



Tools Available to Designers:

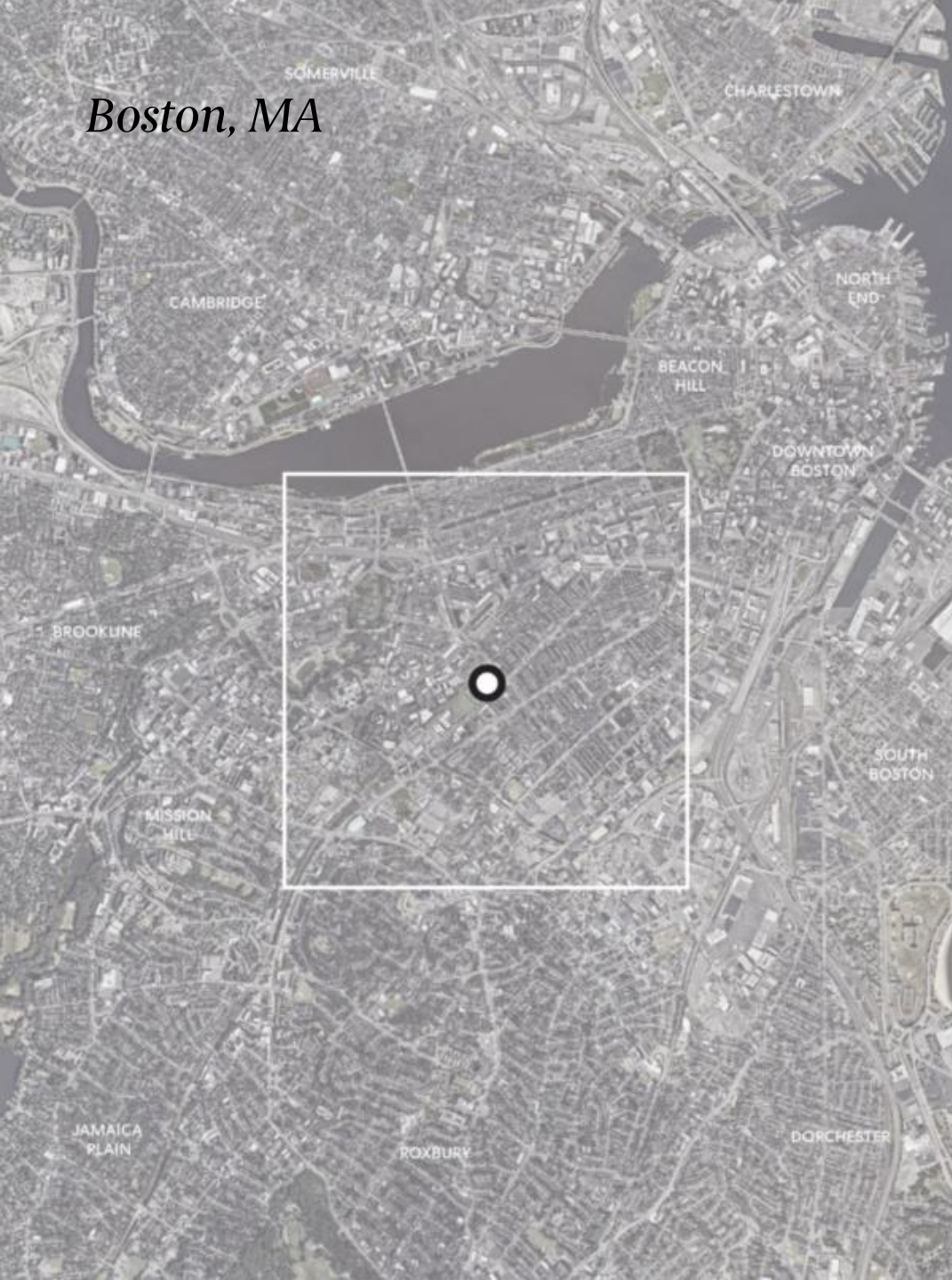
- Literature Review of Existing Research
- Analysis of Publicly Available Health Data
- Indoor Environmental Quality Monitoring
- Occupant Surveys & Interviews
- Co-created Community Health Priorities
- Analysis of Historical Data & Context
- Assessment of Existing/New Facilities

Raise Your Hand If...

**You have used the Symphony T stop?
Know a child living with a disability?**

William E. Carter School

Boston, MA



WILLIAM CARTER
SCHOOL
DEVELOPMENTAL
DAY CARE CENTER





The power of this project is due to the larger Carter School community

Perkins&Will

Student Population

+30 students, and doubling

Students will range from 3-22 years old

Classroom Ratio: 5 Students to 3 Teachers/Staff

Ethnically diverse: 7 languages spoken

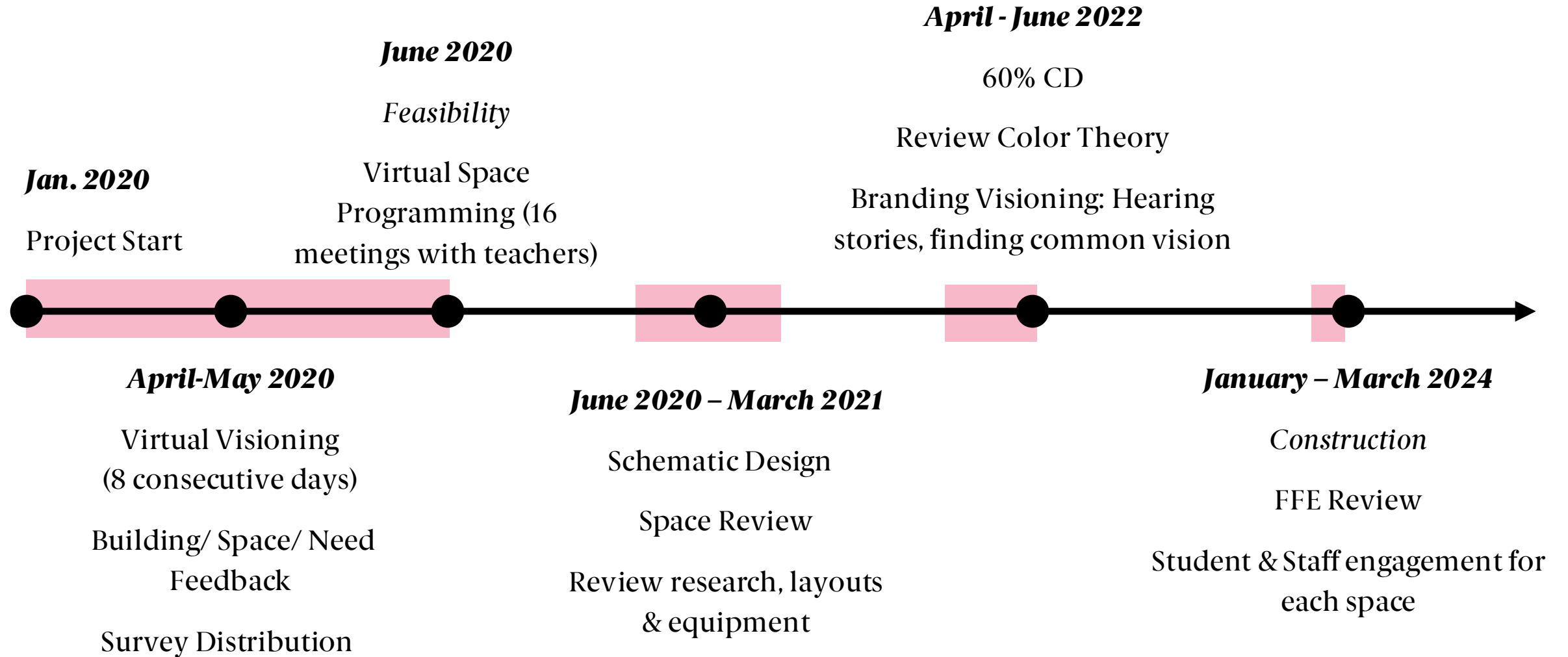
Students live with a complex array of disabilities including Cortical Visual Impairment (CVI), cerebral palsy, downs syndrome, epilepsy, mobility

Perkins&Will



A Visioning Continuum

 **Research**



A Visioning Continuum

Surveys about Outdoors

2. How do you envision the role of outdoor spaces at Carter?



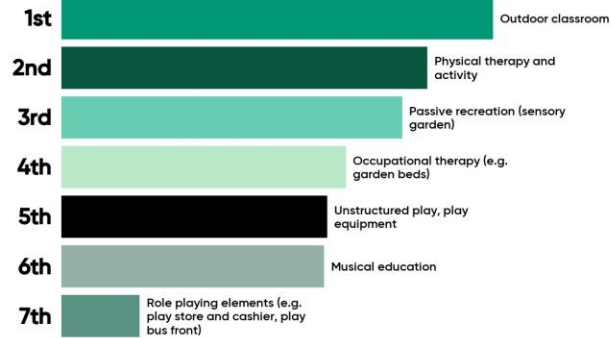
1
Amenities (a nice bonus)

13
Essential (required for the wellbeing and educational goals of the students)

11
Equal amenity and essential

25

3. Please rank the activities that your students would enjoy and benefit from most outdoors?



26

Landscape Questions for Consideration

Great feedback Carter Team!

What do students currently enjoy most about the outdoor space? Is there a most popular area or activity?
6 responses

I think the outside for it or near just the ri
6 responses

What is your dream outdoor space that you currently do not have?
6 responses

MORE! We want more for our students to have access to. Lots of options for sensory components: touch and feel
6 responses

What are staff's biggest challenges in the outdoor areas?
6 responses

On behalf of BPS Facilities Management our biggest concern is ease of maintenance. BPS have a very small grounds crew that must oversee 125 properties, so school gardens need to be designed so that
6 responses

What are students' biggest challenges in the outdoor areas?
6 responses

Despite attempts at making our space accessible - it is still often difficult for students to independently access via wheelchairs - even two w/chairs next to each other.

There are limited things to do. I think it's hard for too many students to use the components of the garden at once. Also, I think they share the same problem as staff where it is very distracting to participate in learning if students are using it for recreation in the same area. Also, not enough shade for students when it's sunny!!

Patrick I Project I BPS Pla
6 responses

Many of our students need a shaded area in order to stay outside longer. Also sometimes it is tricky to get students outside when they are in adapted equipment.

The nee
6 responses

- Lumps from tree roots. Students cannot self-propel over roots.
- Student wheelchairs do not fit under tables.
- Not enough shade.
- Plantings are low on the ground, and so wheelchair students are not able to see, touch, pick, plant, feel, etc. Students could be more interactive with placement that would support their abilities to reach at waist level.

A Visioning Continuum Thought Leadership

Inspiring speakers!

DAY 2

Thought Leadership

TUESDAY

4.28

AGENDA:

1. Welcome
2. Storytelling
 - Tova Francois, Paraprofessional, Carter School
3. TED Talk: Aspirational Thinking
 - Eve Edelstein, Human Experience HxLab, Perkins and Will
 - Susan Bruce, Lynch School of Education, Boston College
 - Oswald Mondejar, Spaulding Rehabilitation Hospital
4. Panelist Q&A

S.W.O.T. Analysis Homework

Session 2 Recap

<https://discovercarter.squarespace.com/day-2-thought-leadership>

Perkins&Will




Eve Edelstein, Ph.D.
 Former Director, Human Experience HxLab, Perkins and Will
 Eve Edelstein, Ph.D. (Neuro), M.Sc., M.Arch., Assoc.AIA, EDAC, F-AA applies her unique background in anthropology, basic research in neuroscience and clinical neurophysiology to inform architecture, planning and design. Dr. Edelstein's clinical practice at the National Hospital for Neurology & Neurosurgery, Queen's Square and University College London, research at the Harvard/MIT hearing science lab, and work at the US Naval Medical Center provides insight to the breadth of user needs in across built settings. With the Academy of Neuroscience for Architecture, the Salk Institute and Univ of California San Diego, Eve's work is at the intersection of education, design, health, and wellbeing. As the former director of the HxLab, and founder of Clinicians for Design, Eve works with educators, clinicians, staff, patients and researchers to undertake original studies, iterative findings, and apply research-based design principles. Dr. Edelstein creates and uses bespoke and validated mixed methods including surveys, and pre and post-occupancy evaluations.

Susan M. Bruce, PhD

Professor and Chair of the Department of Teaching, Curriculum, and Society, Lynch School of Education and Human Development (LEHD), Boston College

Susan M. Bruce, Ph.D., is a Professor and Chair of the Teaching, Curriculum, and Society Department at Boston College. Her research address the needs of learners with multiple disabilities, including dual/disorders. Many of her studies have addressed how these learners develop communication and literacy. She has also conducted collaborative action research studies on a variety of topics selected by teachers and therapists in school settings, including studies on positive behavior supports and humane education. Susan coordinates two Master's Degree programs: Teachers of Students with Severe and Multiple Disabilities and the online program, Global Perspectives on Teaching, Curriculum, and Learning Environments.





Oswald (Oz) Mondejar
 Senior Vice President of Mission and Advocacy, Partners Continuing Care, Spaulding Rehabilitation Hospital
 Oz Mondejar is the Senior Vice President of Mission and Advocacy for Partners Continuing Care, Inc. ("PCC"), the non-profit care services division of Partners HealthCare. Oz works at the intersection of policy, advocacy and media, driving PCC's core values and leveraging the organization's resources to maximize positive social impact - locally, nationally and internationally. Prior to joining Partners HealthCare in 2001, Oz led the New England Region recruitment program for the Social Security Administration and worked as a human resource executive in several different industries including manufacturing, hospitality and finance. Internationally recognized for his expertise on accessibility, disability rights and workplace accommodations, Oz serves on several non-profit boards and is an advisor to others. Oz has received numerous awards, including the Partners for Youth with Disabilities Christopher Durnie Award, Hispanic Executive Making an Impact in Boston 25 on the Move, the Massachusetts Commission for the Blind Employment Leadership Award, the Disability Law Center Leadership Award, and the White House Champion of Change Award. In January of 2015, Oz was one of only seven men again nationally selected for a two-year term by U.S. Secretary of Labor Thomas E. Perez to serve on a new Advisory Committee on Increasing Competitive Integrated Employment.

A Visioning Continuum

Planning Principles

DAY 3

THURSDAY

4.30

Planning Principles

AGENDA:

- Welcome
- S.W.O.T. Analysis Review
- Activity: Rank the Guiding Principles

Critical Adjacencies Homework

Session 3 Recap

<https://discovercarter.squarespace.com/day-3-planning-principles>

Rank the Guiding Principles

Each group was asked to rank the following words (1 being the most important, 10 the least)

- Student Centered Innovative Equity Collaborative Flexible
 Augmentative Communication Development Focused Families are Valued
 Culturally and Linguistically Sustaining Joyful Data Driven

1	Student Centered
2	Families are Valued
3	Culturally and Linguistically Sustaining
4	Equity
5	Collaborative
6	Augmentative Communication Development Focused
7	Joyful
8	Flexible
9	Innovative
10	Data Driven

Group 1

1	Equity
2	Student Centered
3	Collaborative
4	Families are Valued
5	Culturally and Linguistically Sustaining
6	Data Driven
7	Augmentative Communication Development Focused
8	Innovative
9	Flexible
10	Joyful

Group 2

1	Student Centered
2	Equity
3	Families are Valued
4	Collaborative
5	Culturally and Linguistically Sustaining
6	Joyful
7	Flexible
8	Innovative
9	Augmentative Communication Development Focused
10	Data Driven

Group 3

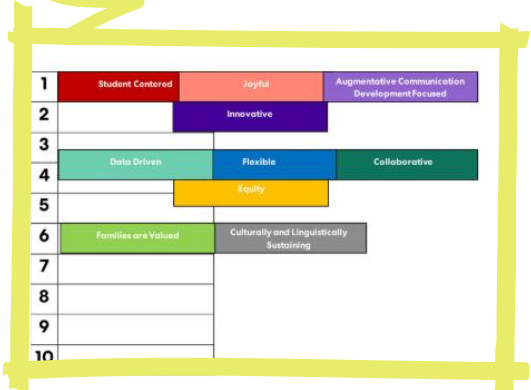
1	Student Centered
2	Joyful
3	Equity
4	Collaborative
5	Culturally and Linguistically Sustaining
6	Families are Valued
7	Innovative
8	Flexible
9	Data Driven
10	Augmentative Communication Development Focused

Group 4

1	Student Centered	Joyful	Augmentative Communication Development Focused
2		Innovative	
3			
4	Data Driven	Flexible	Collaborative
5		Equity	
6	Families are Valued		Culturally and Linguistically Sustaining
7			
8			
9			
10			

Group 5

Outside-the-box thinking!



A Visioning Continuum

Critical Adjacencies

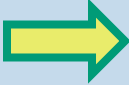
DAY 4 **Critical Adjacencies**

FRIDAY

5.1

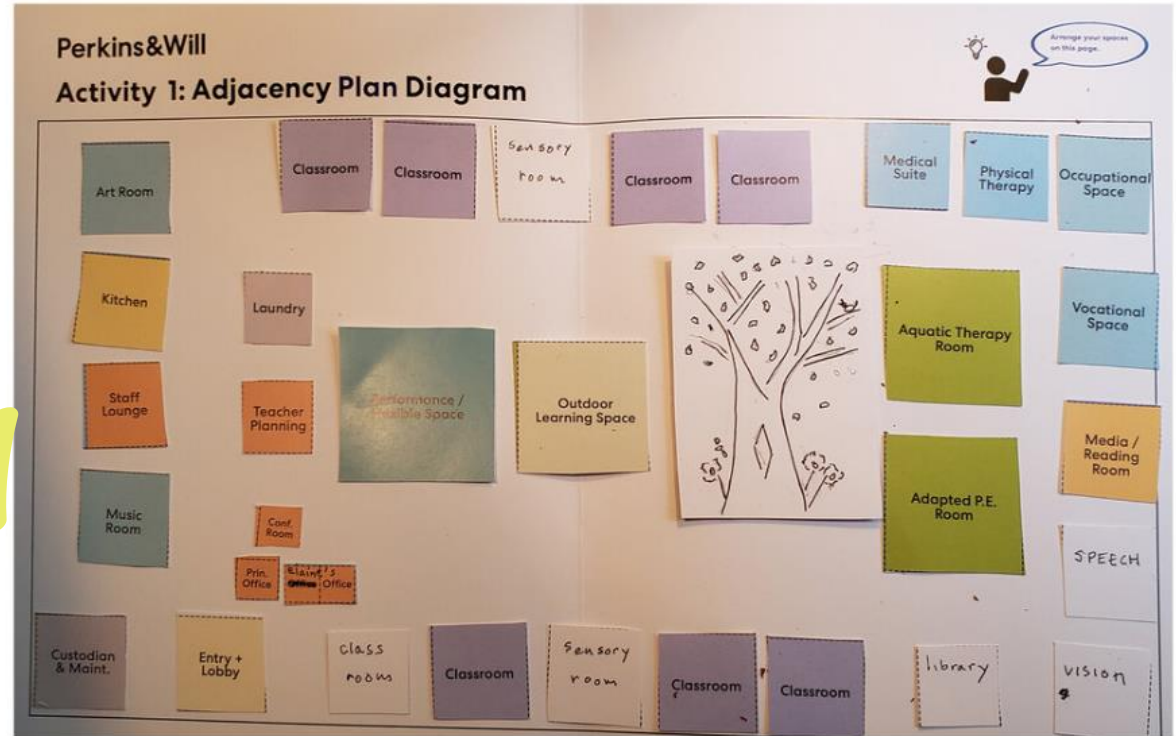
AGENDA:

1. Welcome
2. Storytelling
3. Critical Adjacencies: Reporting Back
4. Closing Remarks: Week 1

 **Session 4 Recap**

<https://discovercarter.squarespace.com/day-4-critical-adjacencies>

Designers in the making!



Joann Doherty



A Visioning Continuum

Aspirational Spaces

DAY 5

Aspirational Spaces

MONDAY

5.4

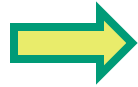
AGENDA:

1. Welcome to Week 2
2. Storytelling
3. TED Talk: Elizabeth Hartmann
4. Aspirational Space Talk

Virtual Scavenger Hunt Homework

Aspirational Spaces

Session 5 Recap



<https://discovercarter.squarespace.com/aspirational-spaces>

Aspirational Spaces at The Carter School

Elizabeth Hartmann



Making Space for People to Thrive



Making Space for People to Thrive



Sense of Identity



Sense of Identity



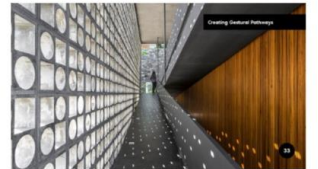
Sense of Identity



Creating Gestural Pathways



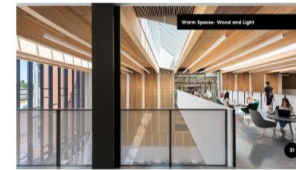
Creating Gestural Pathways



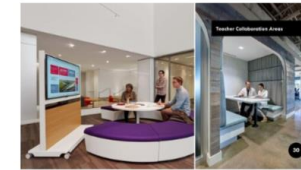
Creating Gestural Pathways



Authentic and Differentiated Learning



Warm Spaces - Wood and Light



Teacher Collaboration Areas



Teacher Collaboration Areas



Hide the Health Care



Re-define Normal



Equitable Spaces



Interpretive Elements - Mile Markers

A Visioning Continuum

Aspirational Spaces Homework

Look at this detail.
Slide by slide!

Ryan, Kathleen
to me

Hello,
Attached are some photos of things/places I find inspirational or have something interesting to consider. These are spaces and visual ideas I like for different reasons. I don't necessarily always like the actual things, but they are a great idea as they are at wheelchair level but I am not crazy about the actual containers.....
The attachment called universal design entryway has 6 photos. I was mostly interested in the top left photo entrance with the large covering and the sink photo. I couldn't separate those out from the others.

17 Attachments

Baizerman, Tasha
to me

I am sharing some visual inspiration for other spaces in the building: collaborative office space, space that inspired me in thinking about non-classroom spaces within the new building.

The third picture is from the Leonard Florence Cohen Center for Living in Chelsea and it was [accessible-smart-home-t174909](#) and the entire facility was very thoughtfully designed.

Tasha

Tue, May 5, 4:39 PM (2 days ago)

27. -Foot pedals are not that extended and patient is leaning forward. Many of our students wear chest harnesses for positioning.

28. - Use?

-/+ Perhaps for smaller pull out sessions, this would work as it is adjacent to the classroom.
13. -Bending over to reach for materials not ideal for staff.
- Changing/ bathroom areas need to be within classrooms, so that staff can keep an eye/ear on what is happening with other students, and to be able to receive immediate assistance if

Aspirational Spaces- Day 5

1. - Undirected space. + Rug color identifies space.
2. - Not want to scoot into a booth to meet. - Not applicable for student meetings
3. + Great light and ceiling
- Tables need to be adjustable for individual wheelchair (WC) and need for staff to be next to student helping hand under hand.
- Artwork hanging from ceilings too distracting.
- Sink needs to be WC accessible and motorized for different heights.
+ Flooring is good for keeping clean and WC mobility.
4. + Good to have multiple tables.
- Too grey and fluorescent.
5. + In house tasks, might be laundry, dishwasher. In community, Whole Foods, CVS.
+ Staff is considering what types of vocational training would be appropriate.
6. -/+ Not sure we need a performance space, but rather a multipurpose room that could be cafeteria, whole community gathering space, Thanksgiving dinner, if opened up with gym space.
7. + Good size for professional development with large groups from other schools.
- Would like windows.
8. - Windows should allow students in WCs to be able to see ground level as well as sky.
- Flexible classroom spaces with folding doors seem like a good idea, but we have only used them at Thanksgiving, as so many materials typically housed near these folding doors have to be moved away before folding doors can be opened.
- The larger the group size, the more noise and distraction, which is not optimal for many of our students who have such subtle movements of response.
9. + Curtains/shades which can be opened/closed seems to be a good idea.
- Most Carter students need WC bracing and support to position them for health reasons.
+ Currently we have Achieve tables that can be totally flat, or have the back or leg areas raised varying amounts.
10. - Equipment and classroom materials storage takes up a lot of room. With one wall devoid of storage capability, this needs to be considered.
-/+ Not sure of use for open space outside of classroom in center area.
11. + A smaller version of this garage door opening to outdoor space would help with the movement of so much equipment outside more quickly.
12. -/+ Perhaps if the adjacent area was a lunch area, this would work, although a cafeteria is planned.

+ This works -Not so much +/- Could work or not

<https://discovercarter.squarespace.com/aspirational-spaces>

Inspiring Images.
Thank you for sharing

A Visioning Continuum

Learning from Research

DAY 6

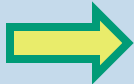
Learning from Research

TUESDAY

5.5

AGENDA:

1. Welcome
2. Storytelling
3. Learning from Research



Research Homework

Research - Questions for Consideration

Session 6 Recap

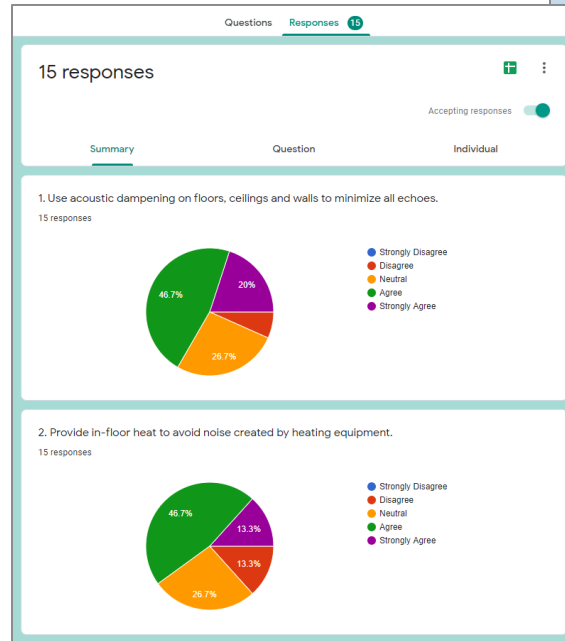
<https://discovercarter.squarespace.com/day-6-learning-from-research>

Color Use of Red

Perkins&Will

UTAH SCHOOLS FOR THE DEAF AND BLIND
Salt Lake City, UT

Erika Eitland



There is still time to do your Research Homework!

Research Homework

TUESDAY | 05.05

Research is to tap into your expertise working with the Carter students. Much of the research available is about a population of students. For example, only students with auditory or visual impairments. By reflecting on the points below, we can identify which research is applicable to Carter and where we need to dive deeper. Your feedback is deeply valued and appreciated.

Do you agree with the following research statements about acoustics...
* Required

1. Use acoustic dampening on floors, ceilings and walls to minimize all echoes. *

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

2. Provide in-floor heat to avoid noise created by heating equipment. *

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

A Visioning Continuum Equipment Strategies

DAY 7 Equipment Strategies

THURSDAY

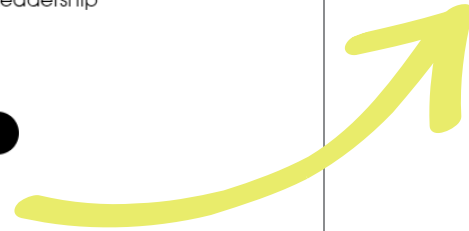
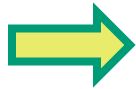
5.7

AGENDA:

1. Welcome
2. Equipment Strategies: Thought Leadership
3. Ask the Speakers

Equipment Strategies Homework

Session 7 Recap



<https://discovercarter.squarespace.com/day-7-equipment-strategies>

Let's think about
partnerships!



Susan Norwell

Susan Norwell

Co-Founder and Instructor, *Bett University*

Susan Norwell is a M.A. Special Education, has worked with a wide array of students, including those with both Syndrome, Autism and Multiple Disabilities for the last 40 years. She has spent the last 26 years in private practice working primarily with children on the Autism spectrum and girls who have *Bett Syndrome*. She is trained in "Casperan's Floortime" model and would consider herself a relationship based educational specialist.

John Campbell, CHCIO

Chief Information Officer, *Spaulding Rehabilitation Network*

John Campbell has served for the past 14 years as the Chief Information Officer for the Spaulding Rehabilitation Network, a network of post-acute hospital and ambulatory centers within the Partners Healthcare System and more recently as CIO for Partners Continuing Care, which includes the Spaulding Rehabilitation Network and Partners Healthcare at Home. At Spaulding, John has led the implementation of numerous clinical and administrative technology initiatives to improve quality and reduce cost, including PCC's Epic implementation and Spaulding's telemedicine program.

John Campbell



Sarah Wakabayashi

Sarah Wakabayashi, M.S., CCC-SLP

Speech Language Pathologist, *Carter School SPS - Assistive Technology Team*

Sarah Wakabayashi has been a speech language pathologist in the Boston Public Schools since 1996, and at the *Carter School* since 2007. She provides clinical services for students ages 3 to 22 years of age with various communication and speech and language impairments, specializing in children with severe multiple disabilities and autism spectrum disorders. She also provides support and consultation in the area of augmentative and alternative communication to SPS staff and other speech language pathologists, as well as set up communication systems from low to high technology speech generating dynamic display devices for students in the district.

Ms. Wakabayashi received her Master of Science in Speech from Emerson College, Boston, and a Bachelor of Arts in Public Policy Studies and Medieval/Renaissance Studies from Duke University, Durham, North Carolina.

Sarah's Presentation

A Visioning Continuum

Learning from the Carter Families

DAY 8

Learning from the Carter Families

FRIDAY

5.8

AGENDA:

1. Welcome
2. Storytelling
3. Carter Family Questions: Translated
4. Open Discussion: Aspirations, Wishes and Thoughts
5. Press Release
6. Closing Remarks

Carter Family Questions

Translating the survey so all can participate!

So much to learn from the families!

Carter Family Questions

Chinese

Haitian Creole

Spanish

English

www.discovercarter.squarespace.com
password: carterschool

Home About Team Contact

Carter Visioning Family Questions

FRIDAY | 05.08

Help the design team gather feedback and engage families in the Carter School community.

English Español 中文 Haitian Creole

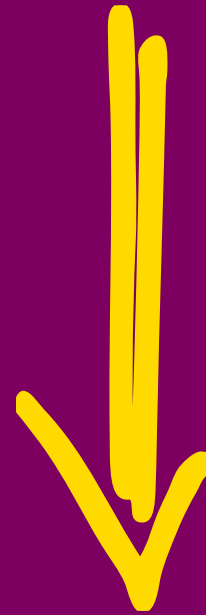
Perkins&Will

The Carter School Virtual Visioning

Challenge

Visioning

Research



Solution

Challenge

90% of Carter School students have cortical visual impairment (CVI) making them more sensitive to glare, visual clutter, and color.

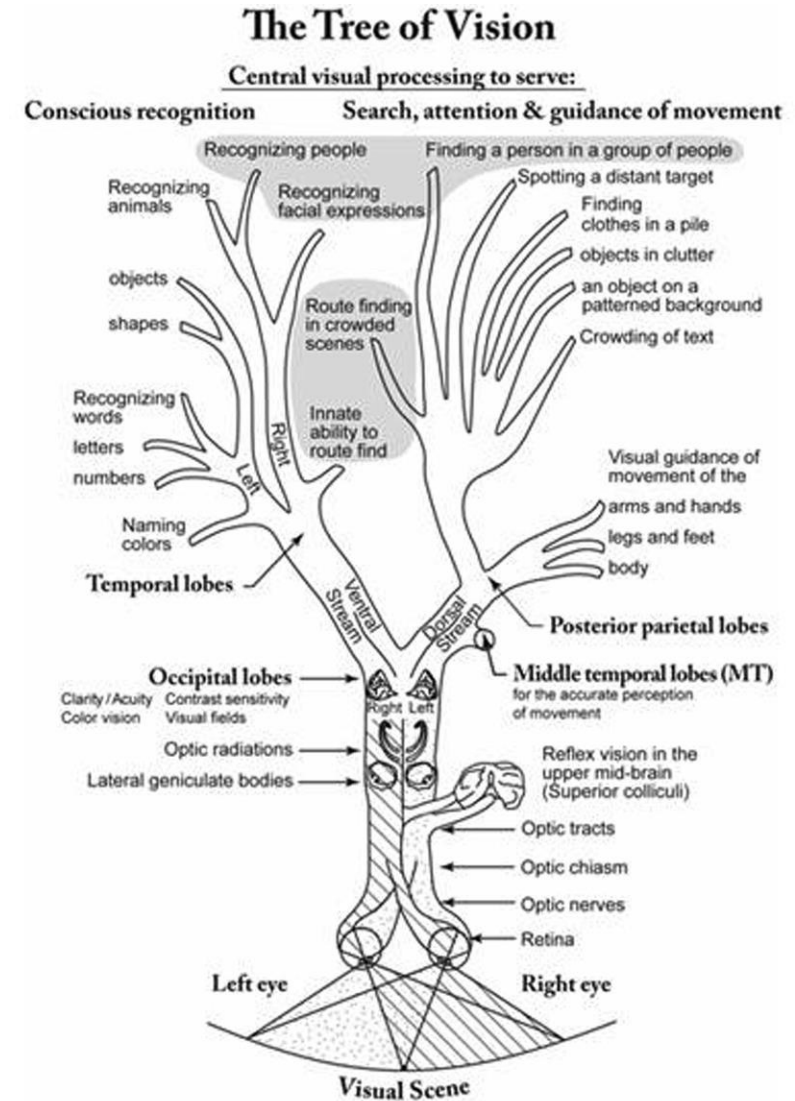
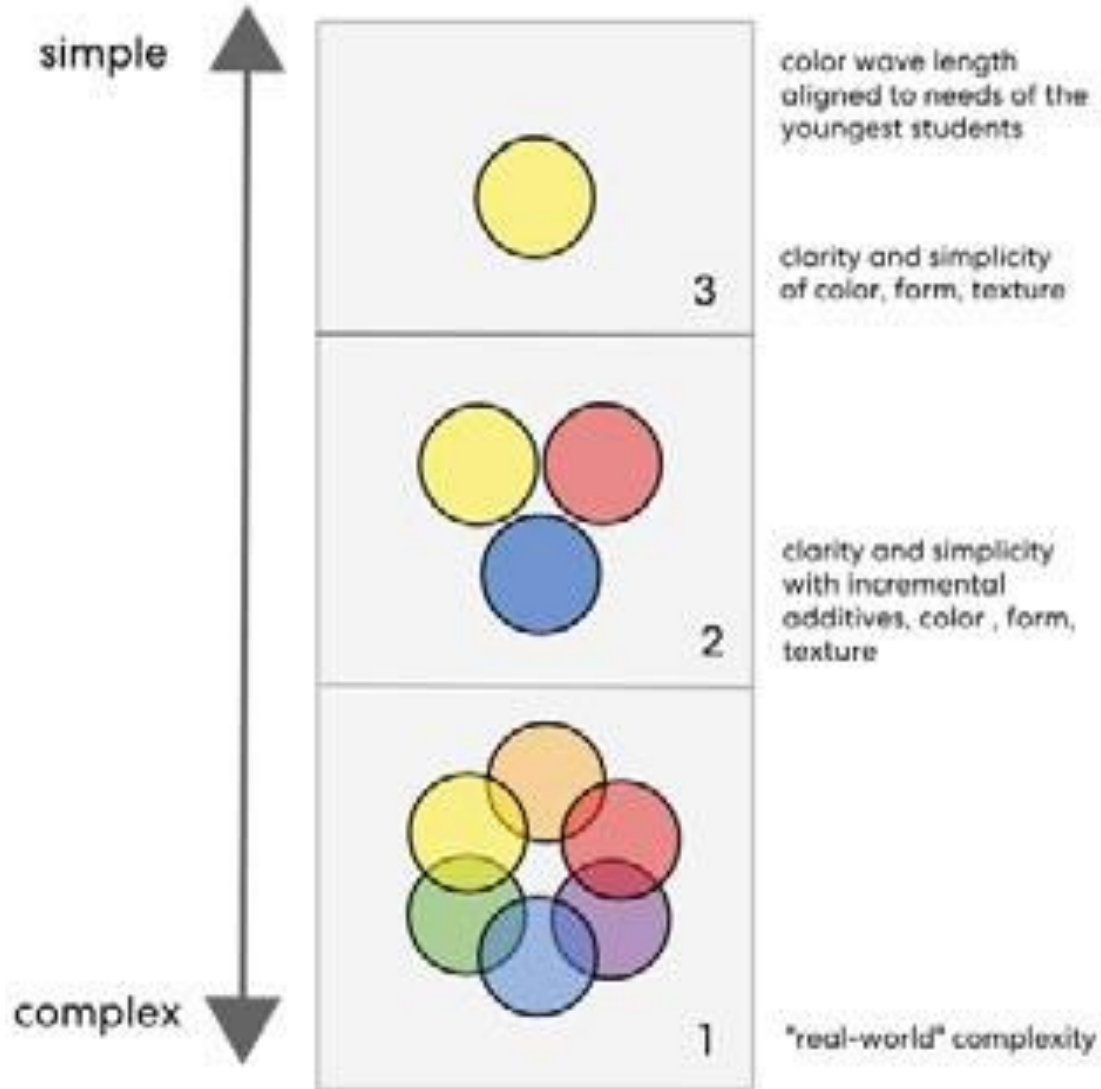
Visioning Input

CVI research is constantly evolving and broad. It encompasses neuroscience.

Building walkthrough revealed the sensitivity to glare and efforts to manage it in the classroom.

CVI does not occur alone including mobility and auditory constraints.

Research Input: Cortical Visual Impairment



Research Input: Literature Review

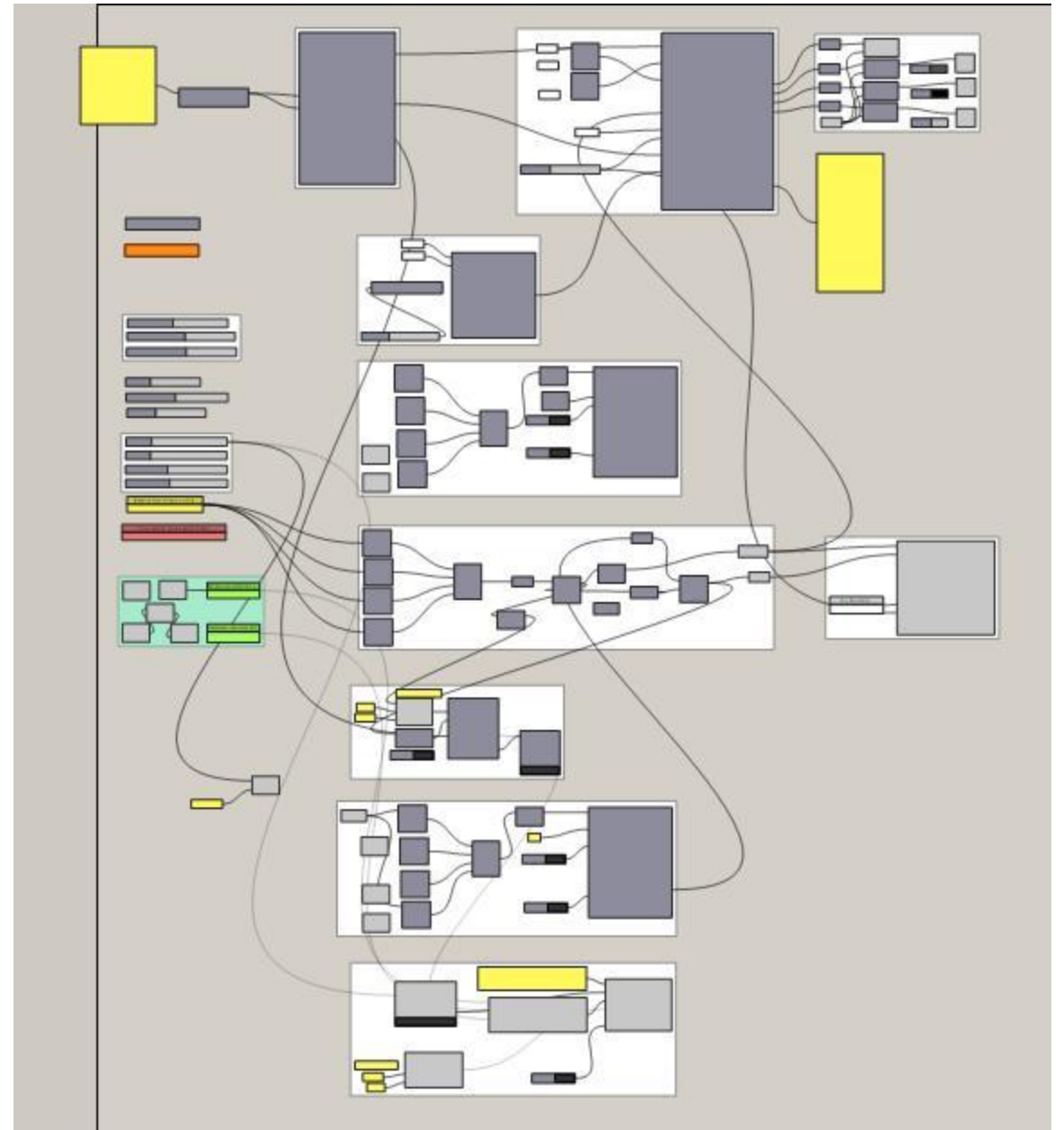
	A	B	C	D	E	F	G
1	Demand of the Student	Design Consideration	Room	Other Keywords	Sub-Category	Population	Type of Study
70	Sensory	Provide visual supports/elements: visual representations (real objects, photographs, drawings or words) to aid in comprehension and communication; provide a visual schedule.	TVI/Classroom	Visual	Signage/Wayfinding	ASD	
71	Sensory	Provide window coverings to remove distractions that occur with a view outside - and reduce glare	Windows	Visual	Window cover	ASD/CVI	
72	Mobility/Movement	Rails along the steps and building, temperature, light, position of switches, object arrangement, floor texture, width of desk; For Communication: sign language interpreter, listen and speech training device	Hallways/Stairs	Space	Accessibility - Interiors	Students w/Hearing Disability	Special ed schools in Thailand. (N = 116 special need students)
73	Visual	Removed shelves and repositioned them higher on the wall to eliminate visual clutter and keep things out of reach	Classroom	Storage	Clutter	ASD	Home environment, survey, n = 168
74	Mobility/Movement	Replaced carpets with hardwood flooring to increase durability and cleanability	Flooring	Materials	Flooring	ASD	Home environment, survey, n = 168
75		Route finding can be very difficult and affected children get lost very easily. Both objects of reference and sounds of reference along commonly used routes can help considerably. Children can then learn the sequence of objects and / or sounds which is needed for a specific route. (Setting the sequence to a song can help considerably.)	Hallways	Layout	Wayfinding	CVI	Guidance informed the design of two other schools for visually impaired students
76	Mobility/Movement	Separate group from independent work areas; create separate learning zones and spaces of various sizes; compartmentalise space.	Classroom	Space	Micro-environments	ASD	
77	Safety	Sightlines for staff to observe the children at all times from anywhere in the classroom or on the playground	Hallways	Views	Student monitoring	ASD	Review/Observational Study; Ireland, architects worked with teachers to develop ASD classroom design - iterative process
78	Cognitive	Signage requires high contrast, wide letter separation and minimum content. Pictorial signage should ideally be three dimensional for tactile analysis as well.		Visual	Signage	CVI	Resource provided by Carter
79	Mobility/Movement	Simplicity in planning increases comprehension and make the structure and order evident	Adjacency	Space	Design	ASD	
80		Staff accommodation could comprise an upper storey. This would provide staircases for mobility training	Staff	Location		CVI	Guidance informed the design of two other schools for visually impaired students
81	Sensory	Stimulatory and sensory tools (e.g., soundproofing, sound systems, special lighting, coloring, and exercise equipment)	OT/PT Rooms	Overall	Acoustics, Lighting, Color	ASD	Home environment, survey, n = 168
		The appropriate number and spacing of visual targets, what distance is optimal, preferred visual field,					

Research Input

Shading Analysis Script in Grasshopper

Grasshopper is a visual programming language and environment that runs within **Rhino**

Perkins&Will



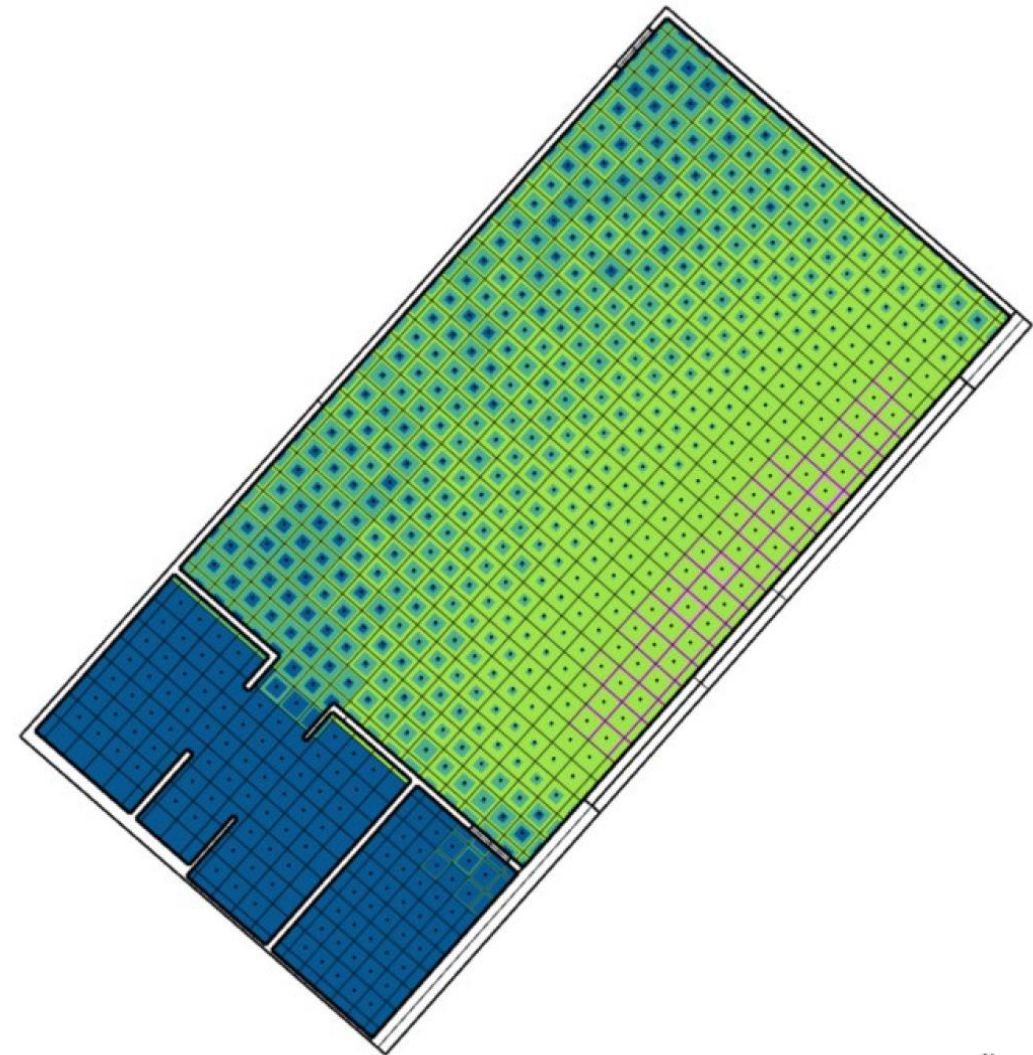
Credit: Cheney Chen, Vancouver Studio

Research: Daylight

45 louver + Translucent Upper

Avg. UDI (Useful Daylight Illuminance)

- 38.3%

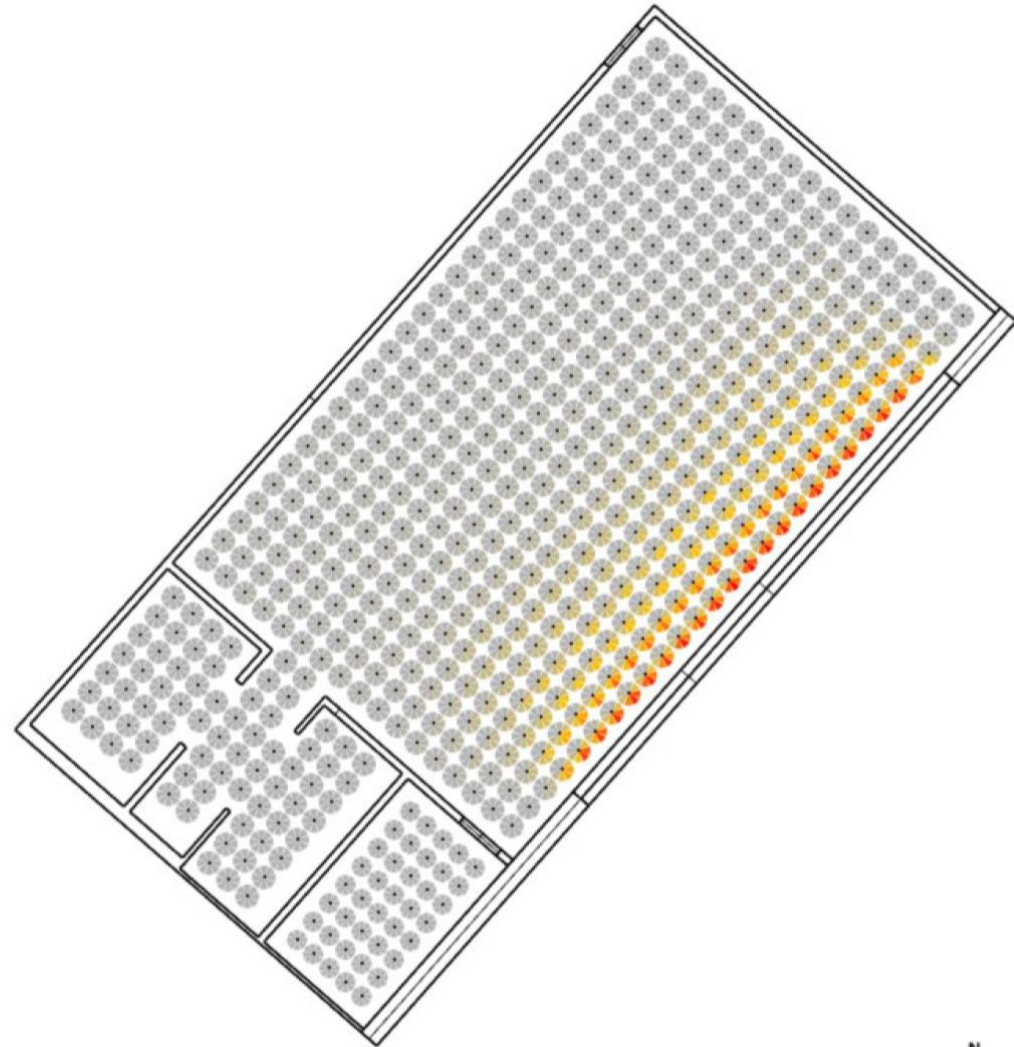
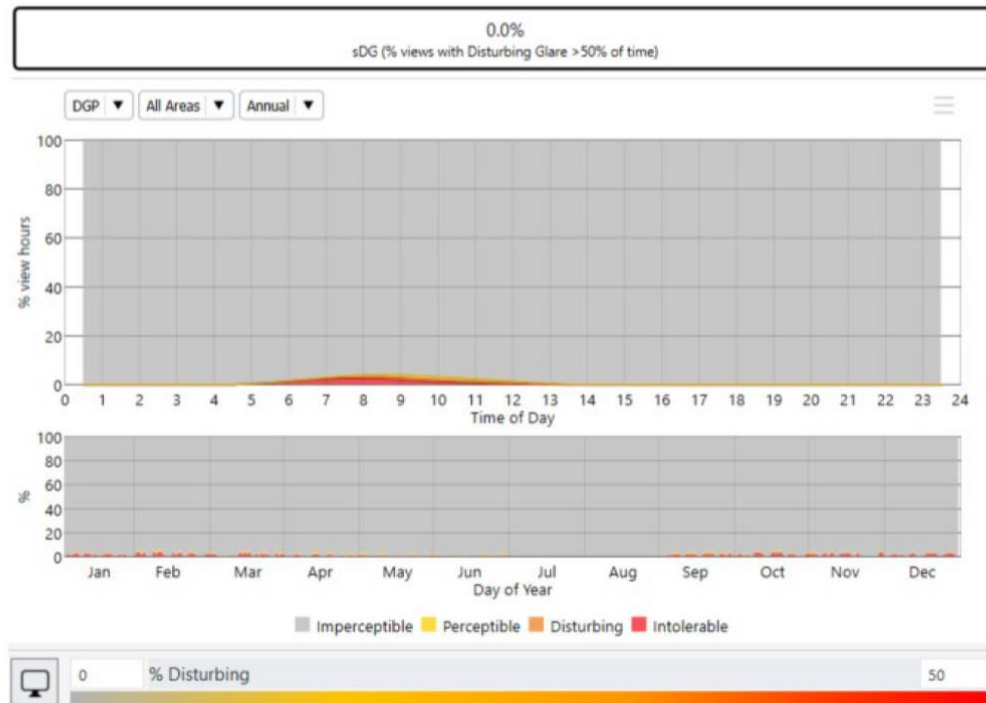


Research: Glare

45 louver + Translucent Upper

sDG-5 (Simplified Daylight Glare)

- 7.2%

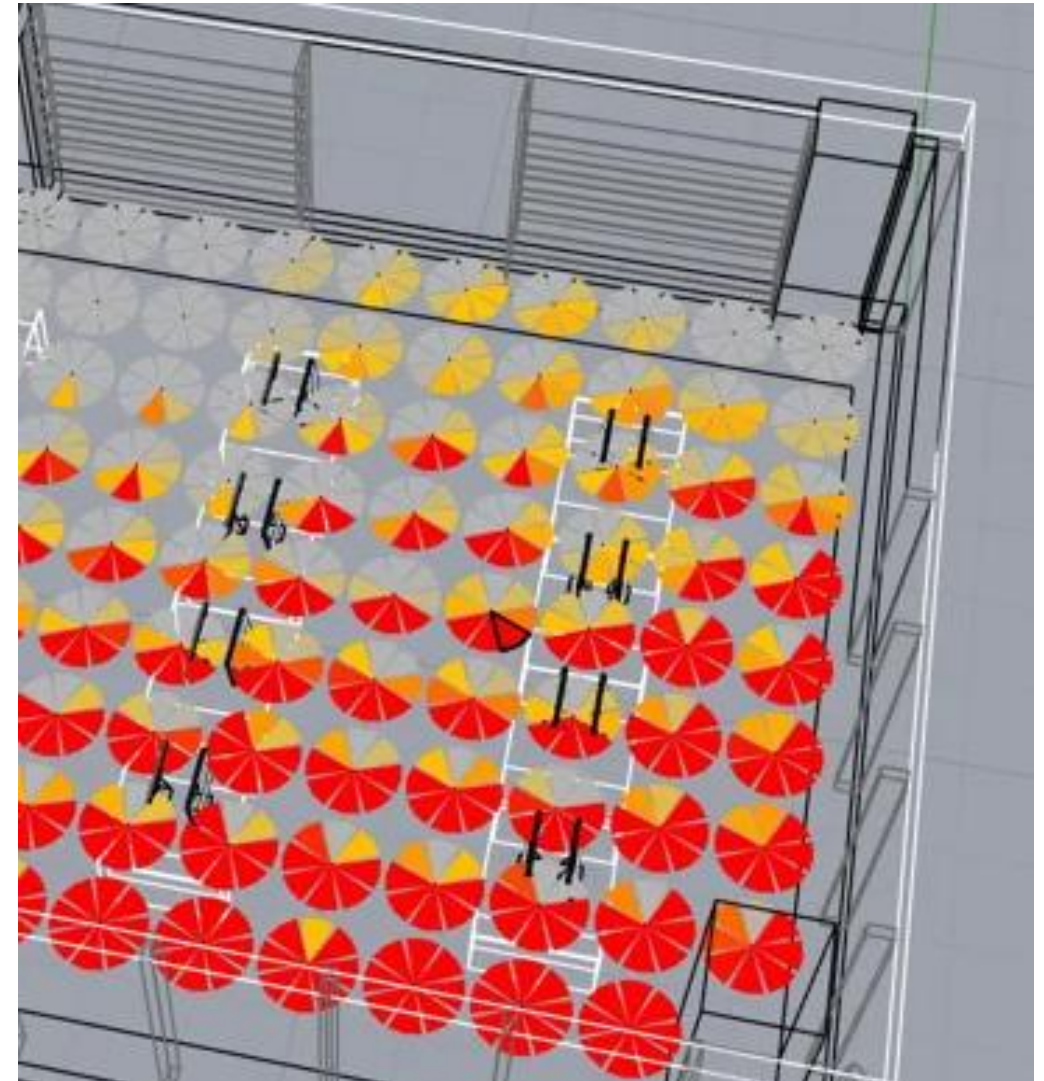
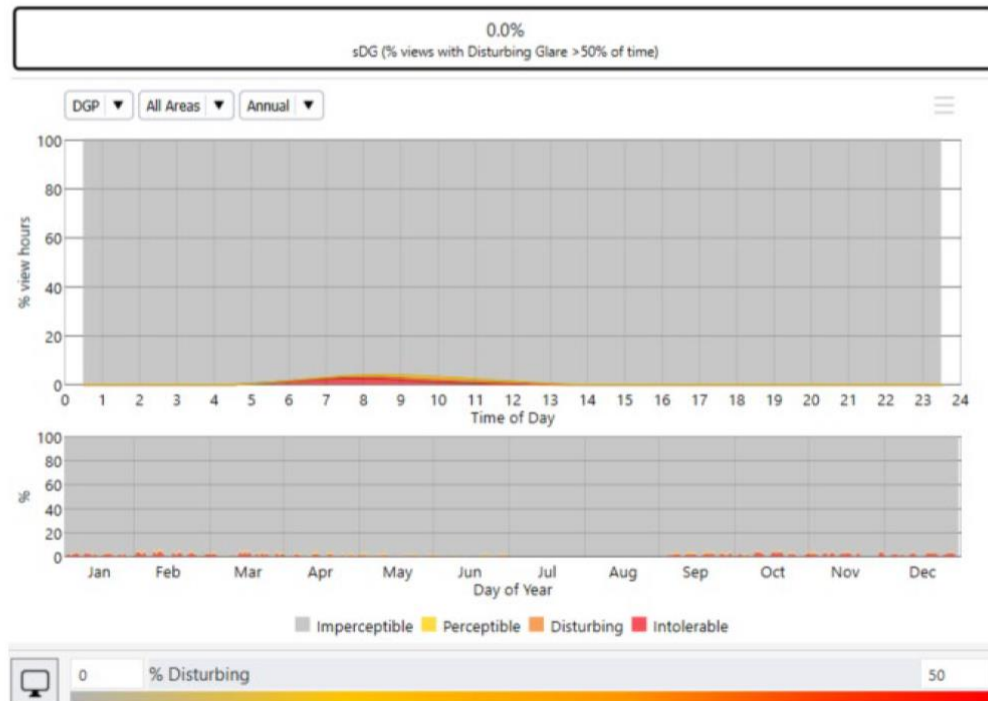


Research: Glare & Student Experience

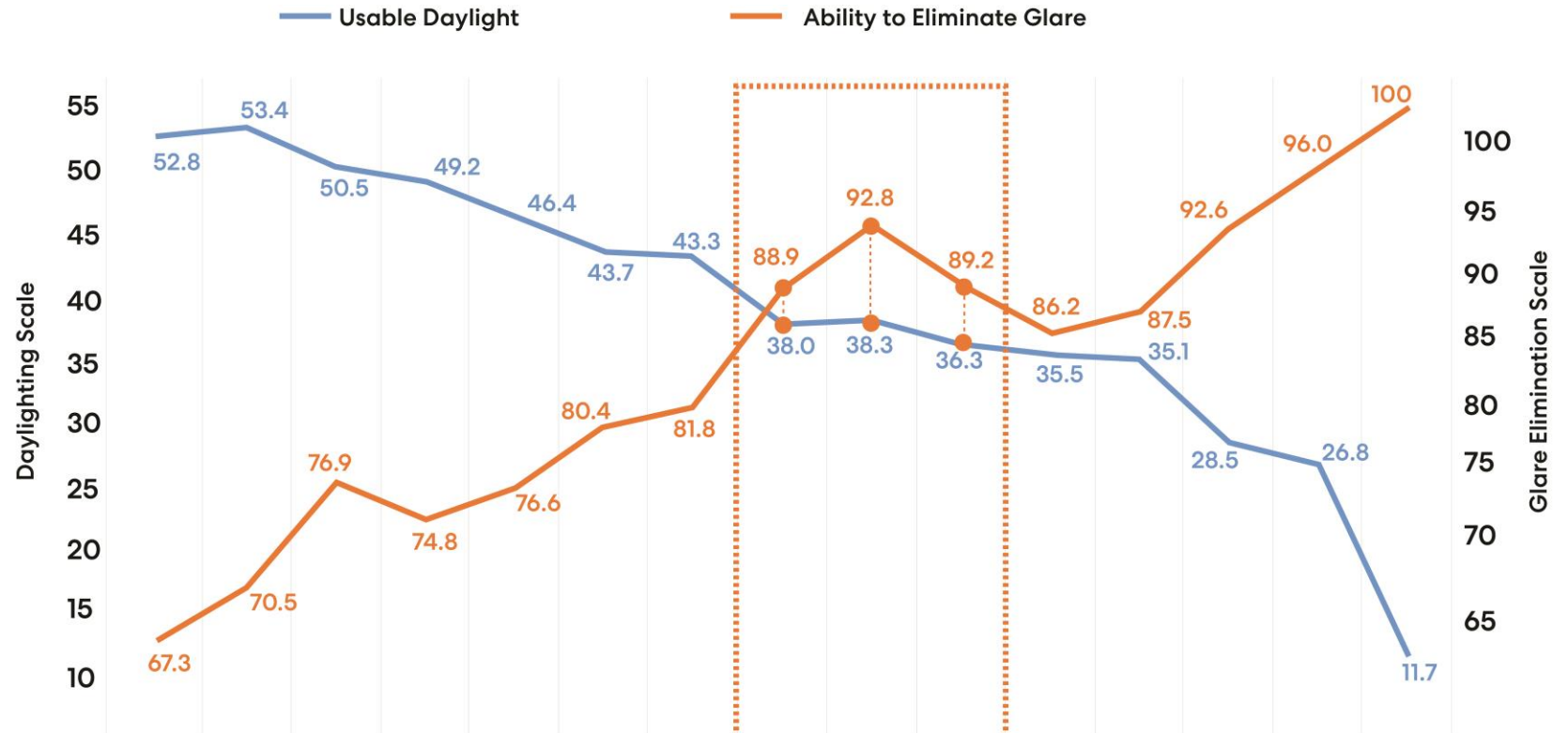
45 louver + Translucent Upper

sDG-5 (Simplified Daylight Glare)

- 7.2%



Research: Daylight Optimization, Glare Mitigation



Spacing	N/A	12"	12"	18"	18"	12"	18"	12"	12"	18"	18"	12"	18"	12"	N/A
Depth	N/A	9"	9"	12"	18"	9"	12"	9"	9"	12"	18"	9"	18"	9"	N/A
Facade Angle	N/A	HOR.	HOR.	VERT.	VERT.	DIA.	VERT.	DIA.	HOR.	VERT.	VERT.	DIA.	VERT.	DIA.	N/A
Blade Rotation	N/A	N/A	45°	N/A	N/A	N/A	45°	45°	45°	45°	45°	N/A	45°	45°	N/A
Micro Louver Interlayer	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	✓	✓	N/A	✓	✓	✓	N/A

High Daylight/High Glare

Best Performing

Low Glare/Low Daylight

Solution

Daylight mediated by vertical louvers.

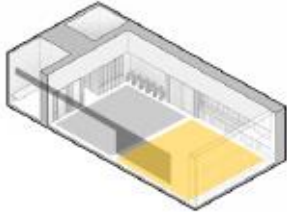
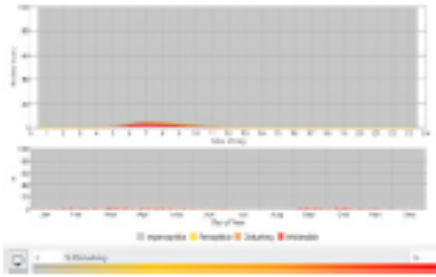
L-shaped window for learning zones.

Red and yellow doorways for aiding transitions.

Solution: Managing Daylight and Glare



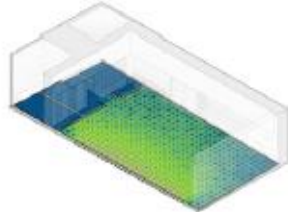
DAYLIGHTING AND GLARE ANALYSIS



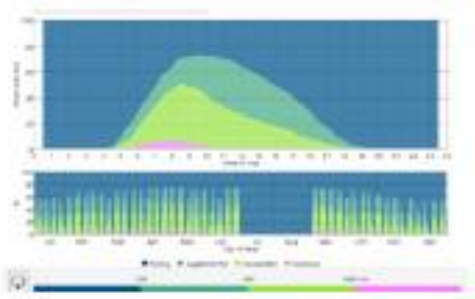
Classroom Zoning



Spatial Disturbing Glare
(7.4%)



Useful Daylight Illuminance
(28.5%)



Solution: Creating an experience they could “see”

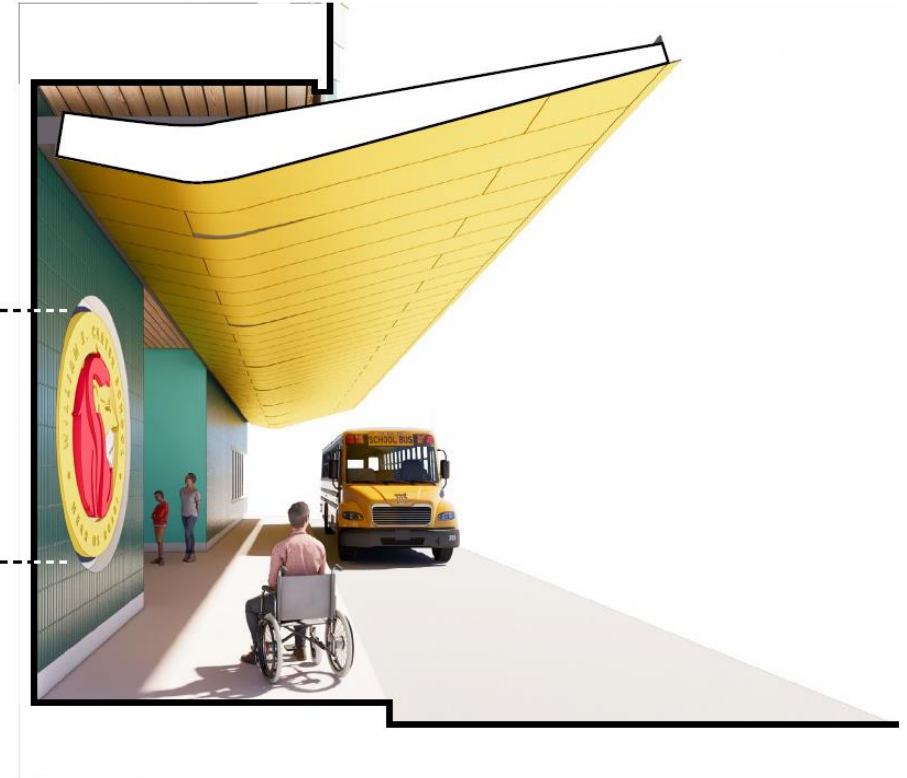


Color Recognition



The Research

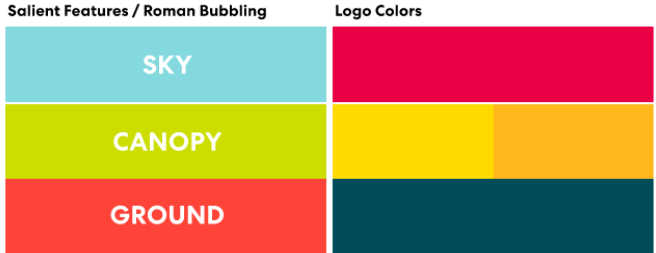
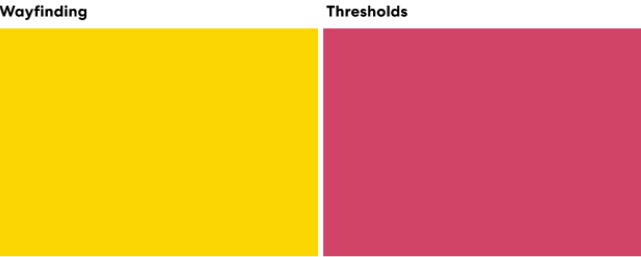
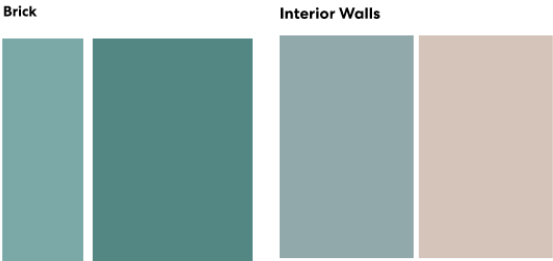
Research shows students who present cortical visual impairments (CVI) can more easily identify high wavelength hues. These colors are used throughout the new school at moments of transition and action.



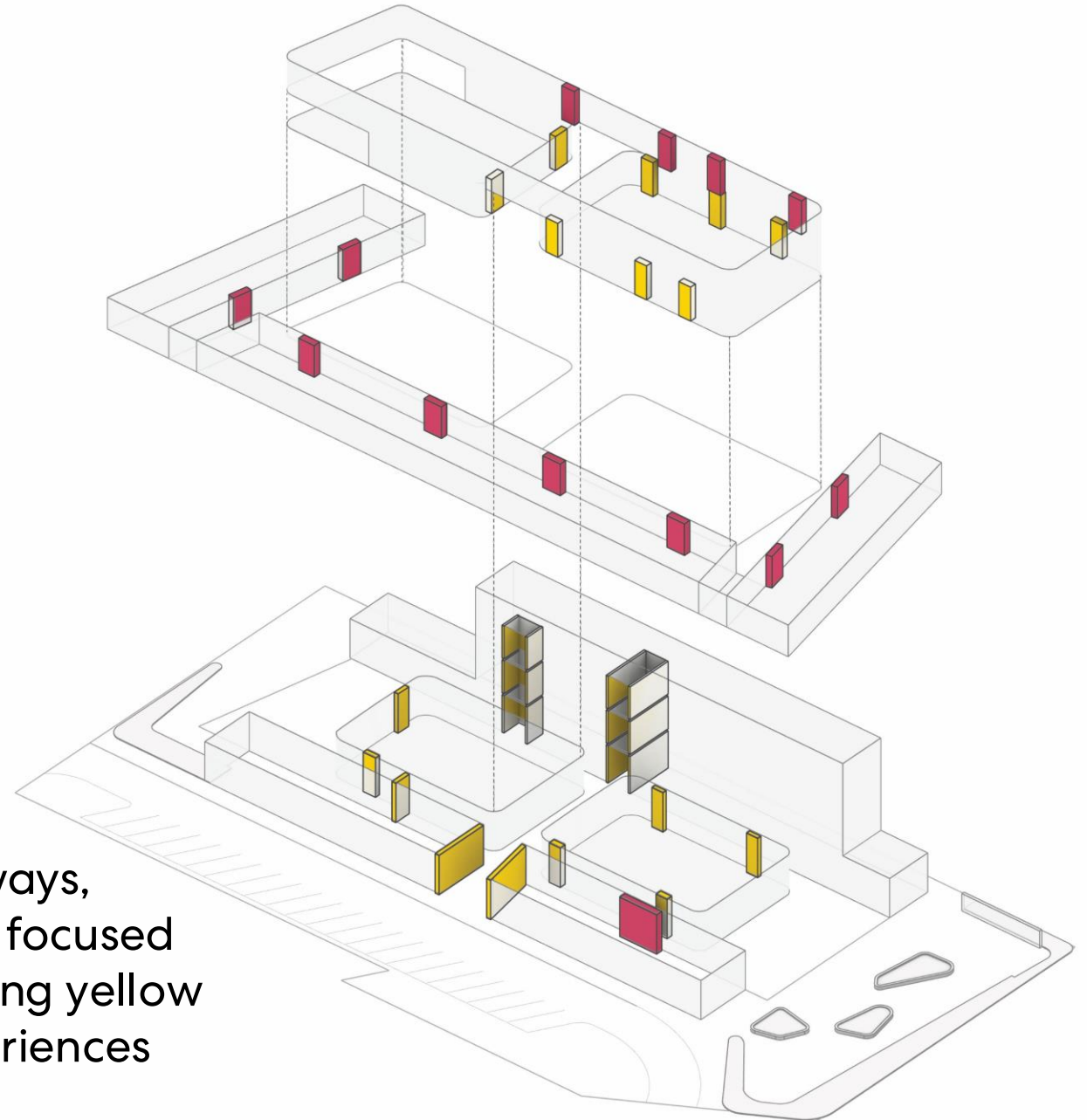
8:15am - A welcoming Arrival

Carter Students are welcomed by vivid, high wavelength colors on both the entry canopy (for students who's body position is reclined) and the school's new logo, creating a sense of recognition, rhythm and thus security as they transition into their school day.

Solution: Creating an experience they could “see”



Solution: Supporting Visual Latency

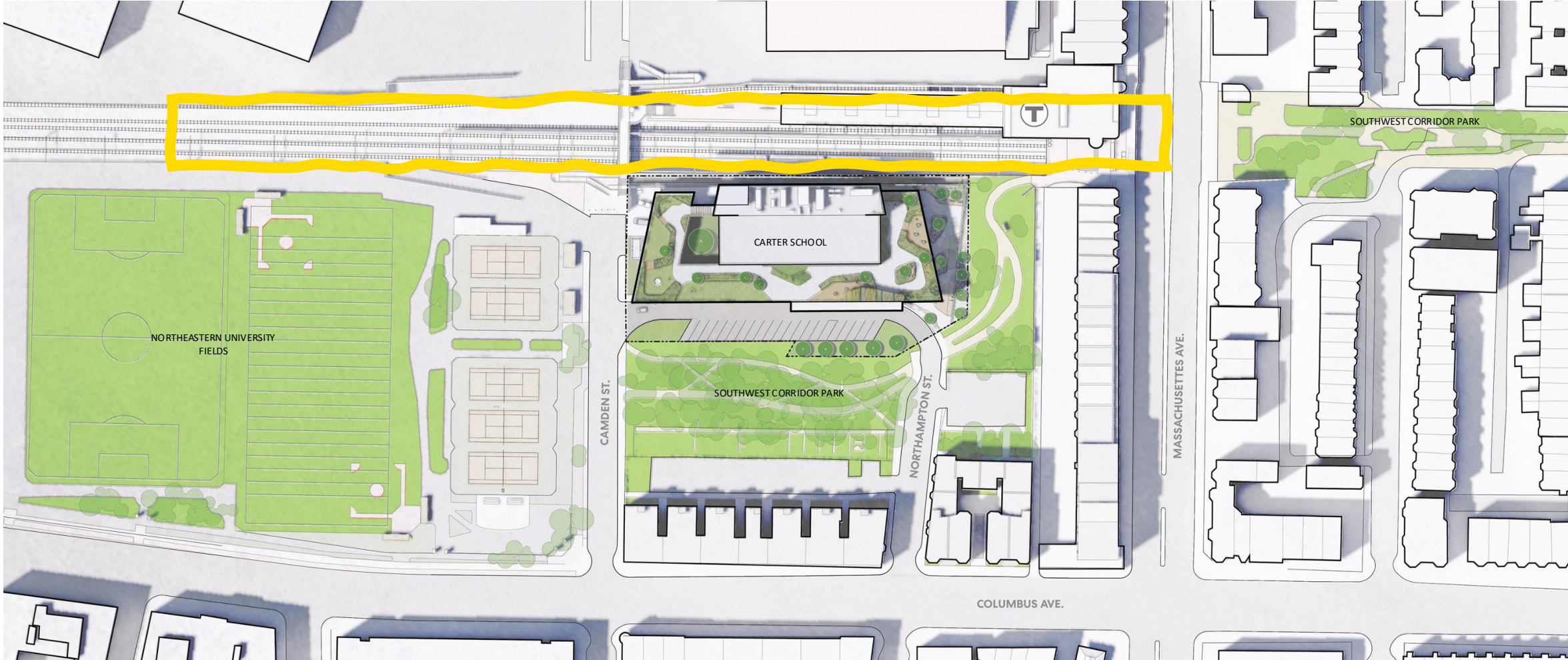


While approaching red classroom doorways, students can prepare themselves for the focused tasks on the other side. When approaching yellow doorways, more active, stimulating experiences await on the other side.

Challenge

Students need public transit to access the community, but chronic vibration and background noise impacted learning and focus.

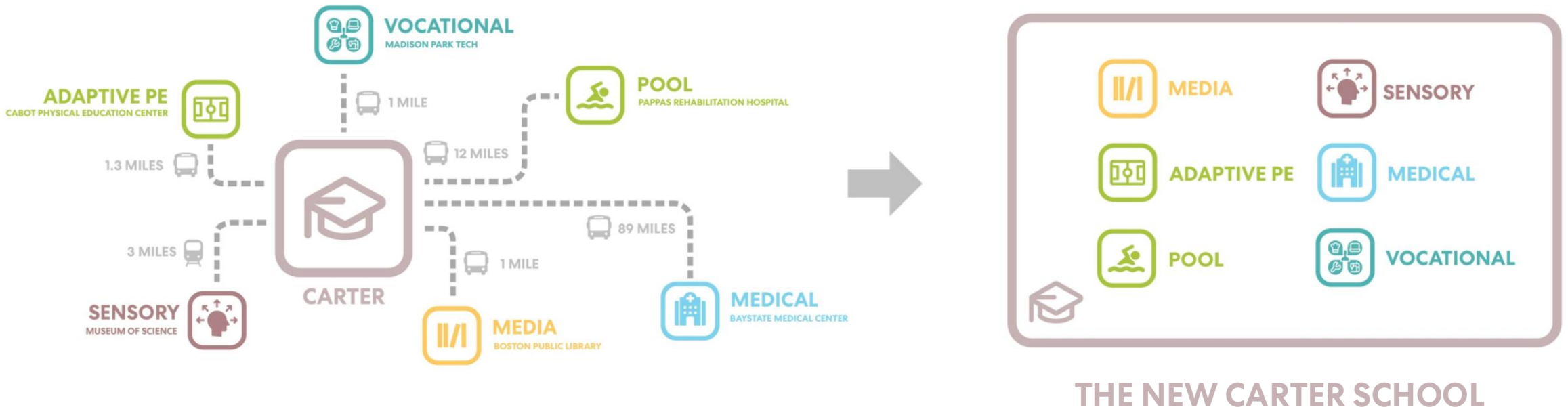
Challenge: Responding to the Site



Visioning Input

We want students to use their skills outside of school and in their community. The city is a classroom exposing our children to the unpredictable.

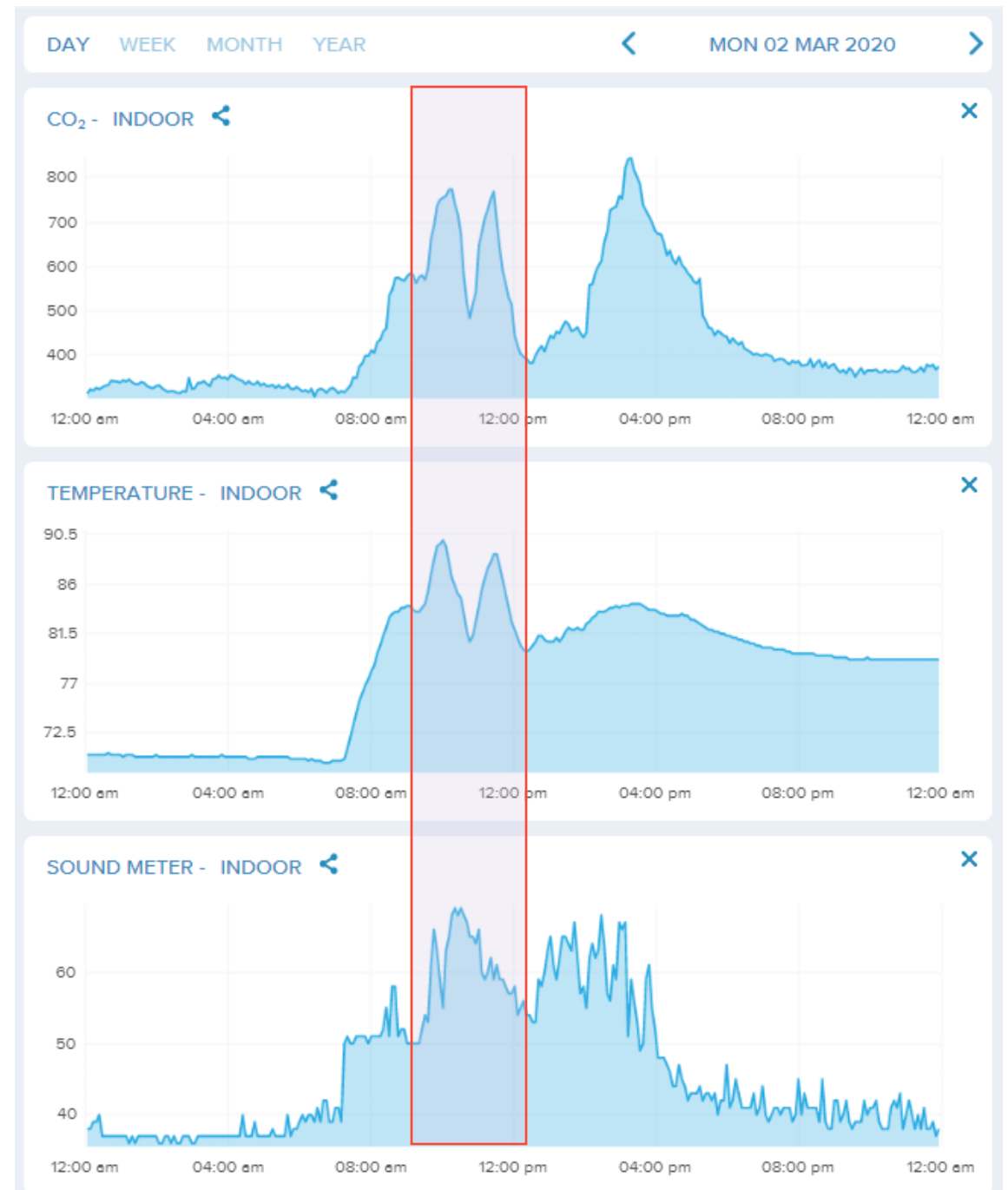
Cost of a School Bus for Activities: \$120/Carter student versus ~\$10/Average BPS student.



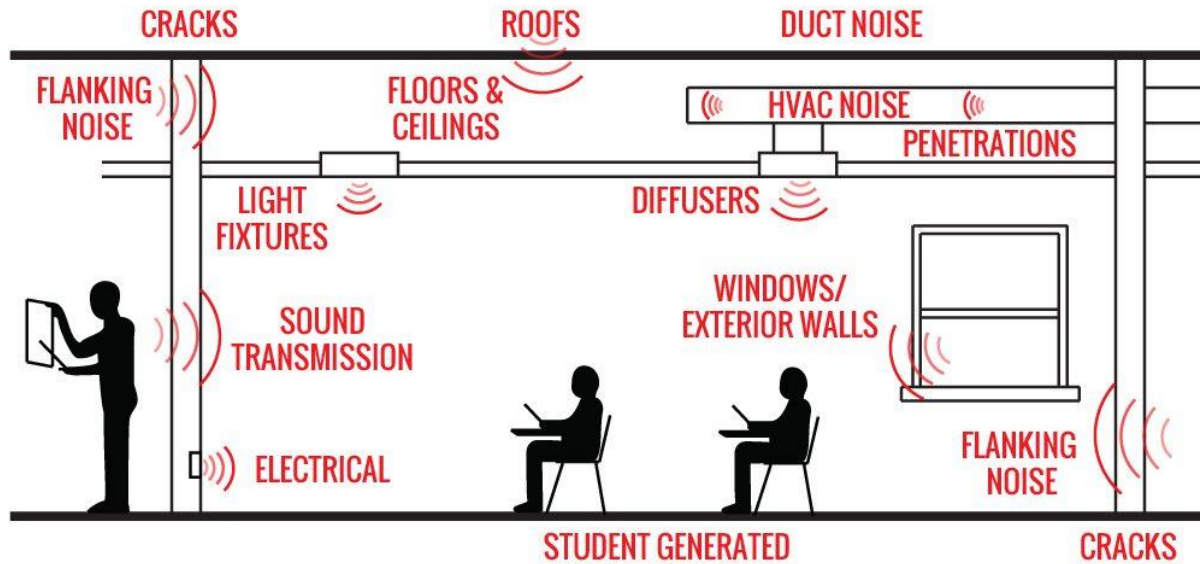
Research Input

Deploying sensors to understand the environmental baseline

Pre-COVID Front Classroom



Research Input: Understanding Noise & Learning



Compared with adults, **children have more difficulty with complex listening tasks** (Sullivan et al., 2015).

Children under age 15 are more sensitive to difficult listening conditions because they are **still developing mature language skills** (Nelson et al., n.d.).

In noisy conditions, children require a greater signal-to-noise ratio (SNR) or **less distortion from background noise to perform on par with teenagers and adults** in speech recognition tasks (Blomberg et al, 2019).

Noise interference in the classroom can impair:

Children's speech and listening comprehension (Klatte et al., 2013)

Concentration, understanding of verbal information (Seabi et al., 2015)

Reading comprehension, and memory (Stansfeld & Clark, 2015).

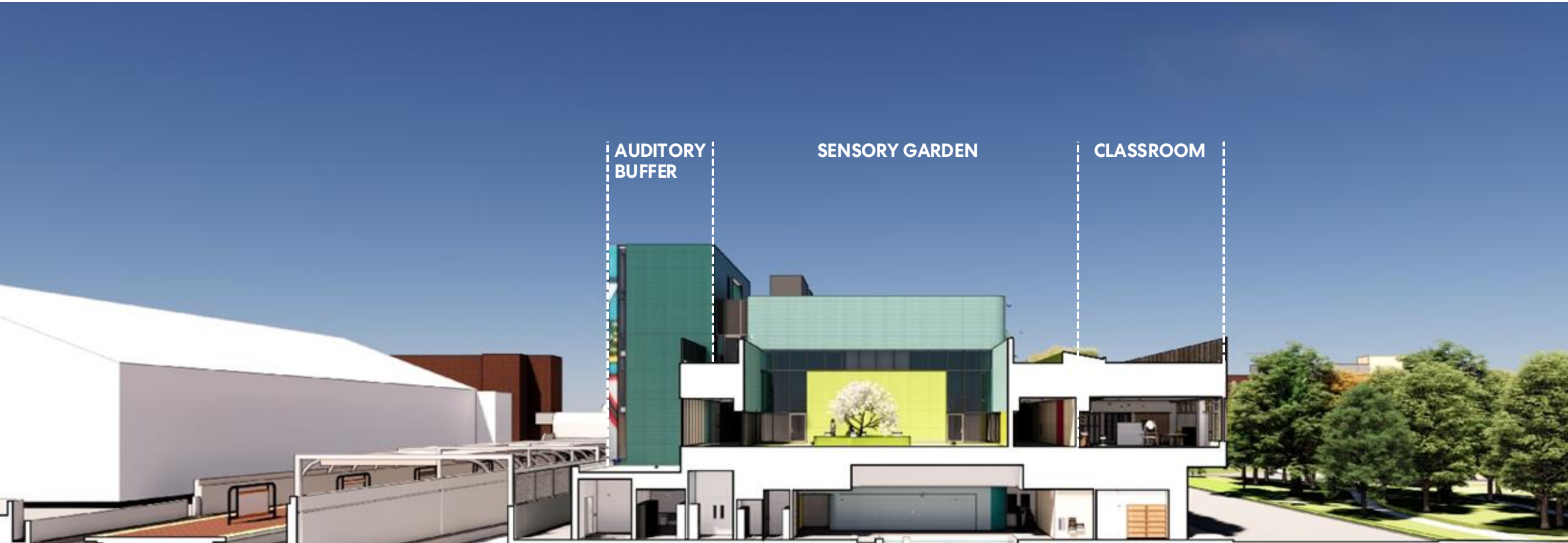
Solution

Classrooms and educational spaces were placed away from public transit with views towards the park and an auditory buffer was created to reduce chronic distraction for students.

Solution: Auditory Buffer

VISUAL

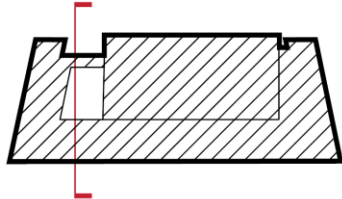
AUDITORY



AUDITORY
BUFFER

SENSORY GARDEN

CLASSROOM



Solution: Auditory Buffer



- | | | | | |
|------------------------|-----------------------|----------------------------|--------------------------------|--------------------------------------|
| 01 Aquatic Therapy | 07 Literacy Commons | 13 Outdoor Sensory Garden | 19 Motor Therapy Suite | 25 Speech Language Pathologist |
| 02 Locker Room | 08 Music Therapy | 14 Outdoor Stage | 20 Mobility Training Space | 26 Teacher for the Visually Impaired |
| 03 Admin Suite | 09 Art Therapy | 15 Outdoor Dining | 21 Adaptive Physical Education | 27 Huddle |
| 04 Teacher's Work Room | 10 Vocational Therapy | 16 Upper School Classroom | 22 Medical Suite | 28 Staff Space |
| 05 Conference Room | 11 Café Commons | 17 Middle School Classroom | 23 Multisensory Room | 29 Outdoor Classroom |
| 06 Collaboration Space | 12 Kitchen | 18 Upper School Social Hub | 24 Lower School Classroom | 30 Trash/Recycling/Receiving |



Challenge

Constraints of an urban site meant the new building would displace the existing treasured sensory garden.

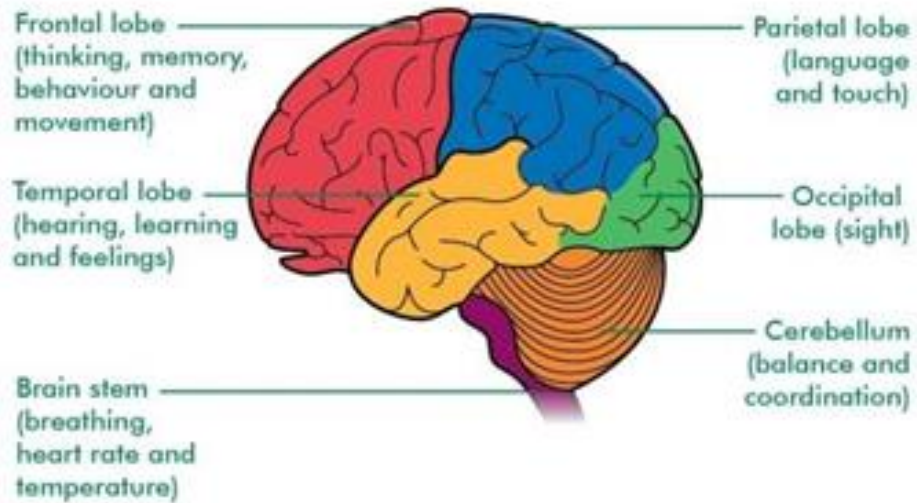
Visioning Input

In the existing school, the sensory garden was an important part of our identity and provided needed space and experiences for students.

The garden needs to support community engagement, restoration, play, and education.



Research Input



Solution

Every floor includes access to outdoor spaces.

Sensory Garden: Level 1

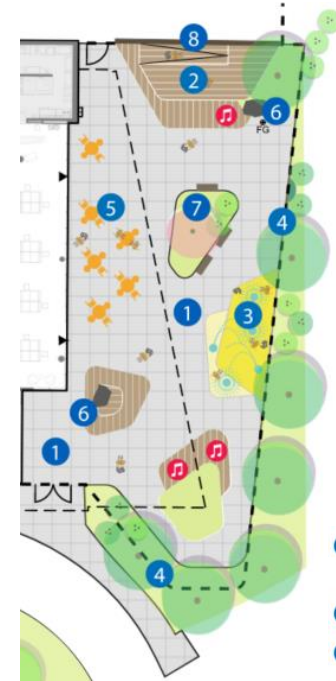
MOVEMENT

VISUAL

BEHAVIORAL

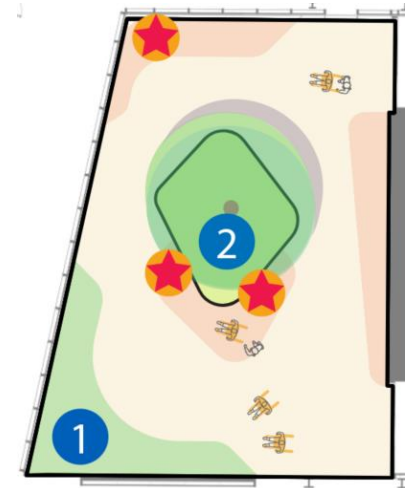
AUDITORY

COGNITIVE



- 1 ACCESSIBLE PAVING THROUGHOUT
- 2 STAGE
- 3 SPLASH PAD
- 4 SECURITY FENCE
- 5 OUTDOOR DINING
- 6 SENSORY -ROXBURY PUDDINGSTONE BOULDERS
- 7 RAISED PLANTER
- 8 FENCE AND STAGE BACKDROP
- 9 RIVER ROCK + SHADE PLANTING
- 🎵 MUSICAL INSTRUMENT

Sensory Garden: Level 2



- 1 ARTIFICIAL TURF
- 2 RAISED PLANTER
- 3 SENSORY PLAY

Sensory Garden: Level 3

MOVEMENT



VISUAL



BEHAVIORAL



AUDITORY



COGNITIVE



- 1 ACCESSIBLE PAVING THROUGHOUT
- 2 PLAY:
 - WHEELCHAIR SWINGS
 - ACCESSIBLE SWING
 - UNIVERSAL CAROUSEL
 - SWAY FUN
 - BOUNCER
- 3 SHADE CANOPY
- 4 LANDSCAPE BUFFER FROM TRACKS
- 5 ACTIVITY TABLES
- 6 RAISED GARDEN BEDS
- 7 ARTIFICIAL TURF
- 8 STAFF SPACE
- 9 RESTORATIVE AREA
- 10 OUTDOOR CLASSROOM
- 11 LION SCULPTURE
- 12 SENSORY TUNNEL
- 13 FACADE SHADE EXTENTION
- 🎵 MUSICAL INSTRUMENT
- ★ SENSORY PLAY

Sensory Garden: Level 3



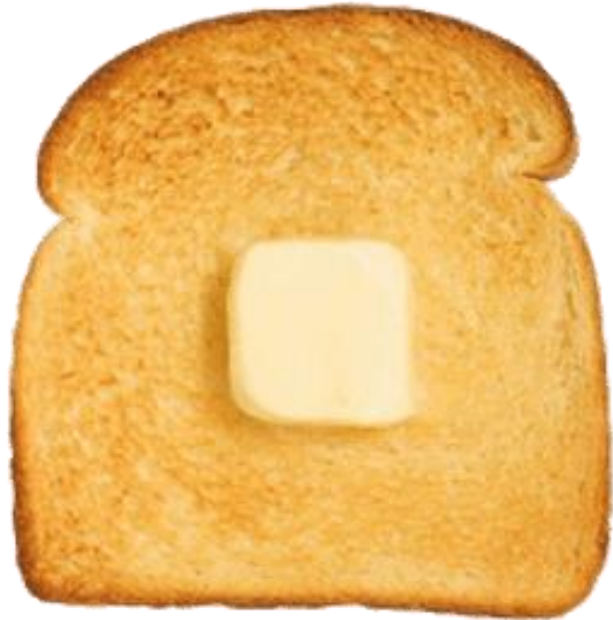
- 1 ACCESSIBLE PAVING THROUGHOUT
- 2 PLAY:
 - WHEELCHAIR SWINGS
 - ACCESSIBLE SWING
 - UNIVERSAL CAROUSEL
 - SWAY FUN
 - BOUNCER
- 3 SHADE CANOPY
- 4 LANDSCAPE BUFFER FROM TRACKS
- 5 ACTIVITY TABLES
- 6 RAISED GARDEN BEDS
- 7 ARTIFICIAL TURF
- 8 STAFF SPACE
- 9 RESTORATIVE AREA
- 10 OUTDOOR CLASSROOM
- 11 LION SCULPTURE
- 12 SENSORY TUNNEL
- 13 FACADE SHADE EXTENSION
- 🎵 MUSICAL INSTRUMENT
- ★ SENSORY PLAY

Sensory Garden: Level 3



Driving Questions & Resources

How can we ensure that health research is holistically integrated into practice?



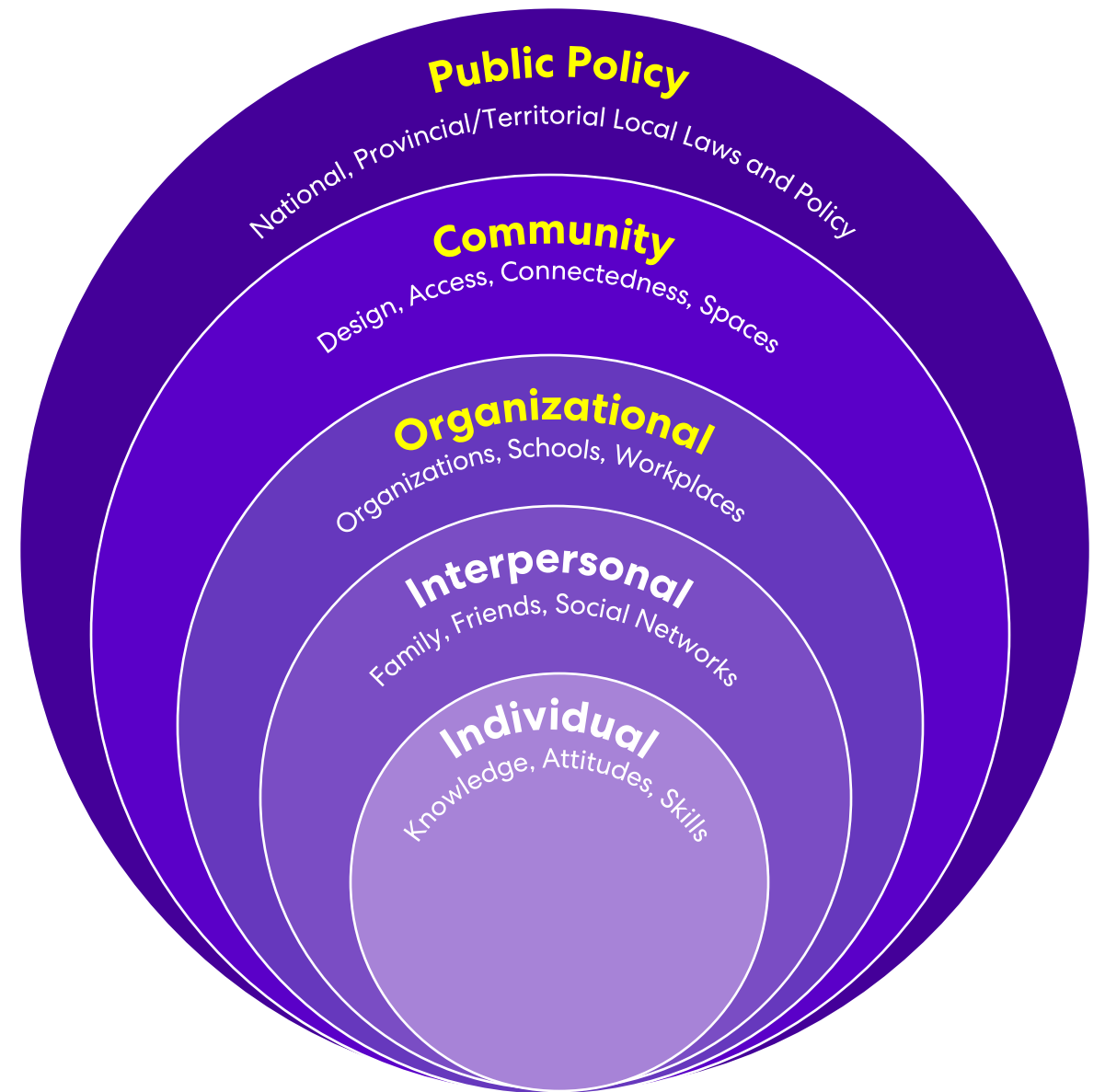
versus



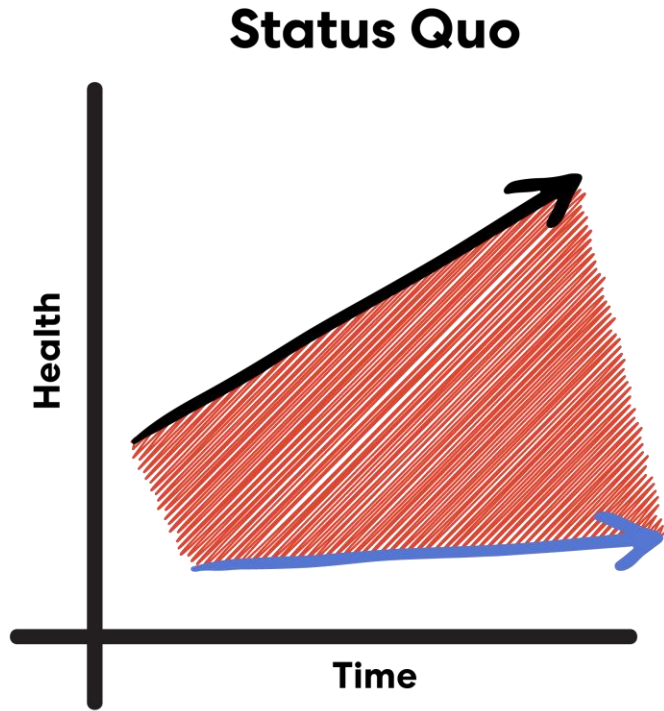
Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO, 1947).

Design works across the Socio-Ecological model.

How can we inform health at multiple levels?



How can design serve as a form of reparations and restorative justice?



Public Policy

Measuring Energy & Health in Existing Massachusetts Schools



>30 Years

250+ Research
Articles

70+ Health
Performance
Indicators

SCHOOLS FOR HEALTH

FOUNDATIONS FOR STUDENT SUCCESS
HOW SCHOOL BUILDINGS INFLUENCE
STUDENT HEALTH, THINKING AND PERFORMANCE



HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH
Center for Health and the Global Environment

FOR HEALTH
forhealth.org

Schools.forhealth.org

SCHOOLS FOR HEALTH

I. EXECUTIVE SUMMARY.....5

II. INTRODUCTION.....6
The Importance of the School Building
21st Century Learning in 20th Century Schools
Lessons from Recent History
9 Foundations of a Healthy Building

III. EXAMINING THE EVIDENCE.....10
Ventilation and Indoor Air Quality
Water Quality
Thermal health
Lighting and Views
Acoustics and Noise
Dust, Pests, Mold & Moisture
Safety & Security

IV. BEYOND THE 4 WALLS: CONTEXT MATTERS.....28
Socioeconomic Status
Existing Health
Access to Green Space
Air Pollution
Early Childhood Experiences

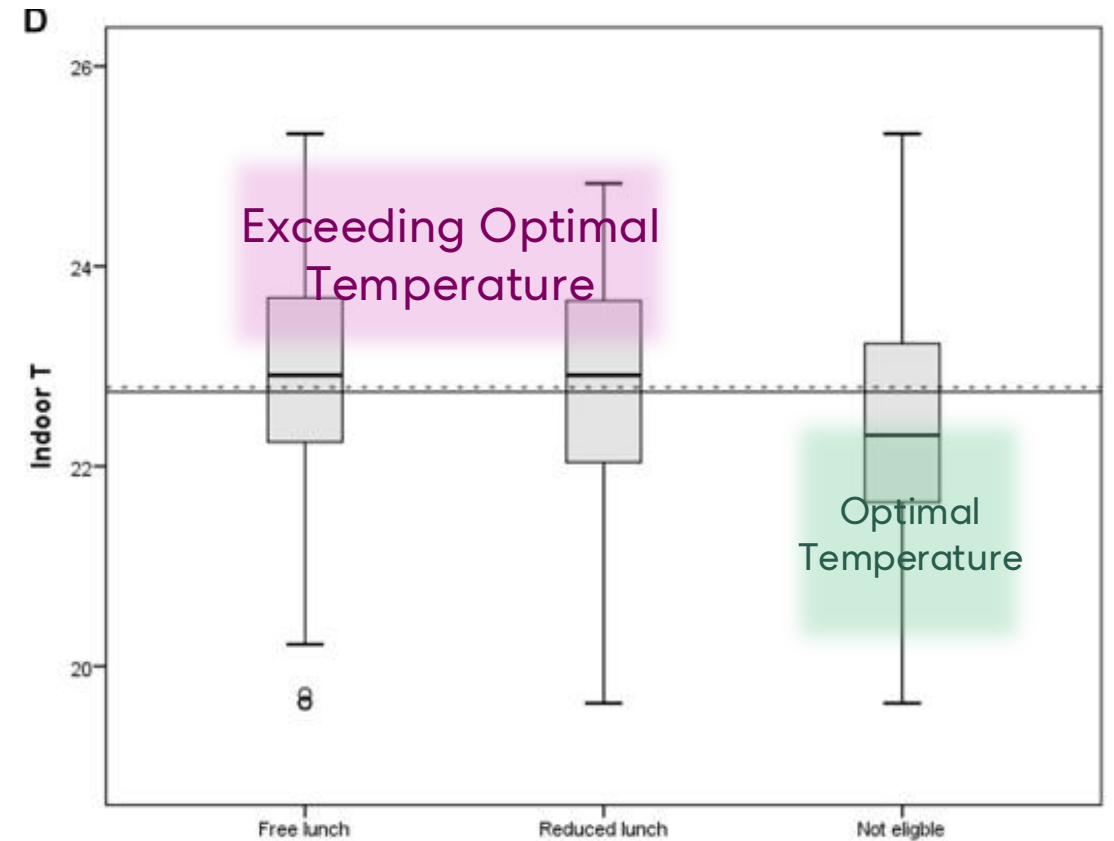
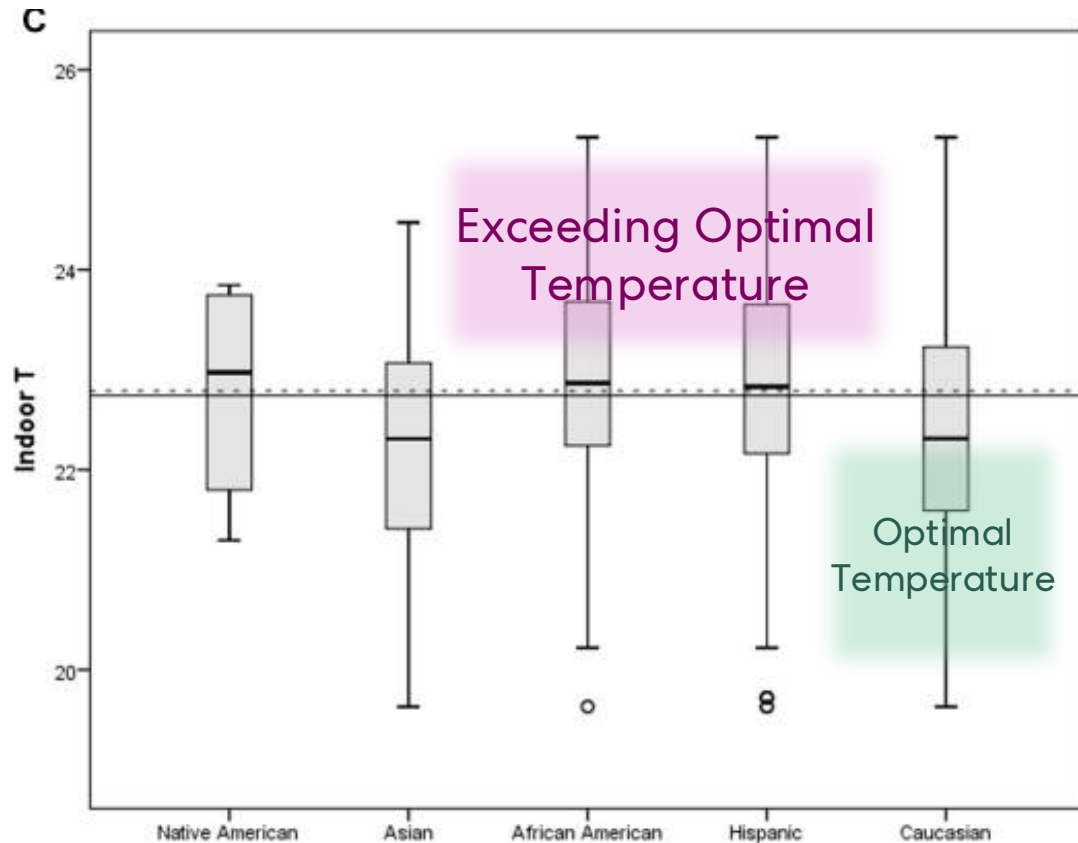
V. BUILDING A SCHOOL FOR THE 21ST CENTURY.....30
The Urbanization Mega-Trend
A Changing Climate
A Call for Standardized Health Performance Indicators (HPis)
A Call for a National School Infrastructure Assessment

VI. SCHOOLS FOR HEALTH.....32
Evidence for action
When We Act It Makes a Difference
The Evidence is Unambiguous

VII. REFERENCES.....33

FOR HEALTH 5
FORHEALTH.ORG

African American and Hispanic students, as well as free lunch eligible were exposed to higher temperatures



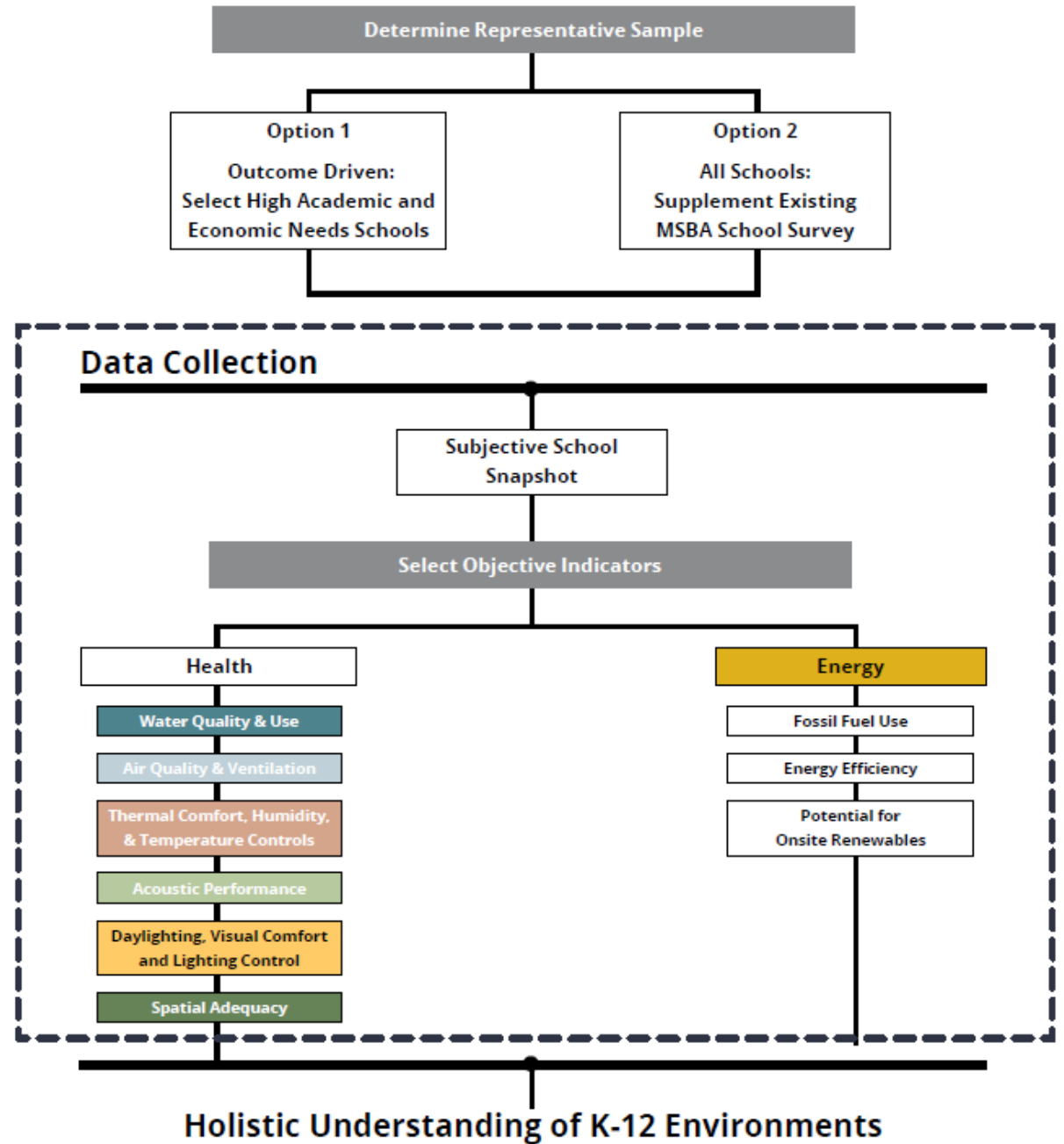
Haverinen-Shaughnessy, U., & Shaughnessy, R. J. (2015). Effects of Classroom Ventilation Rate and Temperature on Students' Test Scores. PloS one, 10(8), e0136165.

Policy: Measuring Energy & Health in Existing Massachusetts Schools

tinyurl.com/HealthyMASchools



→
Our Central Framework



Start with a walk through checklist...

IN YOUR SCHOOL OR CLASSROOM...		INTERPRETATION
Water	Lead/Copper in Drinking Water: Was the plumbing system replaced after 1991?	<input type="radio"/> Yes <input type="radio"/> No No, your plumbing system likely has elevated lead levels because it predates EPA's Lead and Copper Rule . Get water tested.
	Low flow water fixtures: Are there low flow water fixtures present throughout the building (e.g., toilets , faucets , or showers)?	<input type="radio"/> Yes <input type="radio"/> No No, count the number of high flow fixtures to identify water conservation opportunities.
	Presence of Mold or Mold Odor: Can you see or smell mold or musty smell ?	<input type="radio"/> Yes <input type="radio"/> No Yes, even without visible signs of mold, smell can indicate hidden mold, a known trigger of asthma.

IN YOUR SCHOOL OR CLASSROOM...		INTERPRETATION
Light Control	Views: Are there views to the outdoors available to room occupants?	<input type="radio"/> Yes <input type="radio"/> No No, views and access to nature are associated with better student satisfaction and comfort. Consider strategies to improve access to views or biophilic design.
	Pattern, Orientation & Condition: Do you notice stark unevenness in lighting, glare, inadequate distribution, hum, flicker, or other light concerns?	<input type="radio"/> Yes <input type="radio"/> No Yes, uneven, flickering light can lead to headaches. Consider age of lighting system and available improvements for energy efficiency and controllability.
	Visual assessment of windows: Are they single-paned or double-paned?	<input type="radio"/> Yes <input type="radio"/> No No, older windows may include legacy pollutants (e.g., lead, asbestos).

Acoustics	Background Noise: Do you hear clear disruption from adjacent classroom's activities? Do you see an interconnecting door or movable wall, unit ventilator, central HVAC air system, corridor plenum or duct work?	<input checked="" type="radio"/> Yes <input type="radio"/> No	If yes, there is likely increased sound transmission and opportunities to improve acoustical performance.
	Have acoustical finishes have been painted?	<input type="radio"/> Yes <input checked="" type="radio"/> No	Painting and non-porous coverings reduce the acoustical effectiveness of ceiling tiles.

Acoustics	Building have the ability to be cooled (e.g. air conditioning, operable windows)?	<input type="radio"/> Yes <input type="radio"/> No to see how the building can provide comfortable temperatures during hot days.
	Background Noise: Do you hear clear disruption from adjacent classroom's activities? Do you see an interconnecting door or movable wall, unit ventilator, central HVAC air system, corridor plenum or duct work?	<input type="radio"/> Yes <input type="radio"/> No If yes, there is likely increased sound transmission and opportunities to improve acoustical performance.
	Have acoustical finishes have been painted?	<input type="radio"/> Yes <input type="radio"/> No Painting and non-porous coverings reduce the acoustical effectiveness of ceiling tiles.

Energy	Spatial or uneven surfaces within the school?	<input type="radio"/> Yes <input type="radio"/> No especially for individuals with mobility impairments. Unsafe environments may require repairs.
	•Is there a lack of consistent and reliable heat in occupied spaces?	<input type="radio"/> Yes <input type="radio"/> No Yes, additional energy analysis is required.
	•Is there a history of temperature fluctuations or uneven distribution?	
	•Is there localized control (within a range of 8 degrees or less) of the temperature?	

Dive deeper with objective measures...

Potential Metrics for

School Acoustic Performance

Students spend a large percentage of time focused on listening, especially early in their educational process. Children are still developing mature language skills and have poorer speech perception than young adults. Background noise can interfere with concentration, learning, comprehension, and memory. Many learners may also have undiagnosed hearing disabilities, second language learning challenges or attention deficit issues that make learning in acoustically busy spaces more difficult. Therefore, other sound considerations should include reverberation, echogenicity, and the duration or number of times loud noise levels occur. Chronic outdoor noise, such as road and aircraft noise, can also impede learning and can trigger cardiovascular health issues and vocal strain in both students and staff. Achieving modern acoustic standards (ANSI 12.60) is difficult in older buildings. The age of the building, building envelope, and HVAC system can identify common acoustic problems.

The [American Speech-Language-Hearing Association \(ASHA\)](#) provides resources tailored for school buildings and students.

MSBA 2016 School Survey Collected the Following Variables:

- **No metrics relevant** in 2016 School Survey

This category was not identified as a health indicator in Section 83 of Chapter 179 of the Acts of 2022. However, these environmental parameters are a part of a healthy school facility and may influence energy use or interact with other health indicators including indoor air quality and thermal comfort.

● Easy ▲ Medium ■ Difficult

OCCUPANCY STATUS	METRIC	RATIONALE
Occupied/ Unoccupied	Background Noise ▲ <ul style="list-style-type: none"> • Decibel measurements of an unoccupied, space where the worst-case receiver is located (e.g. by the window unit, collect 30 seconds uninterrupted). 	Evening data collection allows for accurate background noise measurements because the space is unoccupied and can measure noise or sound from mechanical systems. Make sure HVAC is on or air conditioning if samples are collected during the winter.
Occupied/ Unoccupied	Area of acoustical absorption ● <ul style="list-style-type: none"> • Measure Classroom Acoustical Ceiling Tile (ACT) or Acoustical Ceiling Panel (ACP) Area relative to room area • Visual counting of acoustical finishes in percentage of surface area to total ceiling area (acoustical ceiling panel area / total ceiling surface area inclusive of lights and soffits). 	This observational assessment of classroom acoustics helps to determine whether the room is reducing reverberation and activity noise build up to appropriate levels. (ANSI S12.60) While not all acoustic tiles have the same Noise Reduction Coefficient, 80% of the ceiling surface area should be made up of sound absorptive acoustical panels. Different standards apply to specialized classrooms including Language Arts, Music, and Special Education classrooms.
Unoccupied	Sound transmission between floors, windows, and walls ▲ <ul style="list-style-type: none"> • Impact sound transmission floor to floor • Impact sound transmission (metered/two-person process) • Laterally (metered/two-person process) 	This indoor measurement captures sources of noise that may disrupt a student's ability to hear, especially when mastering language skills. Measuring sound transmission helps understand acoustical privacy, disruption from surrounding environments, and exposure to common daily outdoor noises (e.g., traffic, aircraft noise). Collecting the measurements during the school day can capture the lived experience. This is interior-source background noise.
Occupied/ Unoccupied	Sound Leakage ● <ul style="list-style-type: none"> • Observation of ceiling cavity and doorways for light leaks between wall, ceiling, gasketing, floor seal. Are there interconnecting doors or operable partitions? • Sound transmission at windows and doors, directly measurable with a sound level meter. • Visual assessment of windows: Are they single-paned? Well-sealed? 	Sound can be transmitted between spaces in the building or from outdoors into occupied spaces. Visual observations highlight opportunities for improving the sound isolation within the building. These metrics also relate to air sealing and energy savings
N/A	Outdoor Sources of Noise ● <ul style="list-style-type: none"> • Map proximity to major roadways, highways, airports, or other high impact sources. • Measure the shortest distance between the school campus and the source. 	This objective site analysis does not capture the experience inside the classroom but identifies a well-studied source of noise that impacts academic performance. This information can be collected in advance of a site visit.

But if we had resources what would we want to measure...

Potential Metrics for
Water Quality & Use

MSBA School Survey Collected the Following Variables:

- Plumbing - Building Condition Rating
- Site Condition - Drainage
- Site Condition - Water Supply
- Site Condition - Septic/Septage/Waste Water Disposal System

The age of water fixtures and plumbing in a school building can result in the use of more water than is needed and cause draining water to be harmful organic and inorganic substances including microbes and heavy metals. Aged school buildings can quickly identify water conservation strategies and support human behavior and education messaging. Access to clean drinking water (MSBA 2021, 2022) and proper development, operation and health components include: Legitimate growth and added when buildings are retrofitted for increased capacity to ensure they require flushing all water from building pipes.

OCCUPANCY STATUS	METRIC	RATIONALE
Unoccupied	Water Composition - Heavy Metals ▲ Lead, copper, magnesium - Complete a qualified lead-based paint inspection (MSHA 2021) and MSBA Water Quality Metrics (MSBA 2021) through the Assessment Program for Lead in School Drinking Water - Measure total dissolved solids in drinking water	There is no safe level of lead in drinking water. Exposure at low levels can result in children's slowed growth, learning and behavior problems, lower IQ and anemia. High levels of lead in the drinking water is more than the EPA action level of 1.0 mg/L. It may cause individuals to experience nausea, vomiting, diarrhea, and stomach cramps. For some schools the short-term solution is flushing faucets to allow the lead to flush out of the pipes, which is done when the lead exceeds its maximum allowable level. The long-term solution is using lead-free faucets, installing lead-reducing devices, and installing filters.
N/A	Use Contaminated Water ● Identify historical water change locations near the school. Use the Department of Environmental Management's Contaminated Water Identification to identify potential risks.	This site analysis identifies contaminated groundwater or surface water and air in the area, which may affect water or air surrounding the site.
Occupied/Unoccupied	Low Flow Water Fixtures ● - Are low flow water fixtures present, including toilets, sinks, or shower stalls? - Does the fixture have an aerator that has a flow rate of 0.5 gpm per minute or less (aerated)?	Identification of these fixtures can improve where water is used daily.
Occupied	Indoor Water Use Intensity ▲ - Calculate by analyzing all indoor water meter by the building's square footage and accounts for toilets, showers, showers, showers.	This measurement allows benchmarking across public schools to identify opportunities for water conservation in the building portfolio.

Potential Metrics for
Thermal Comfort, Humidity & Temperature Controls

MSBA School Survey Collected the Following Variables:

- HVAC Heating Type
- Ventilation/AC Type
- Ventilation/AC Coverage
- HVAC - Building Condition Rating
- Older/ Older Boilers - Building Condition Rating
- Second Older Boilers - Building Condition Rating

The temperature and humidity in a learning environment have direct and indirect impacts on student and teacher outcomes from influencing infectious disease spread, cognitive function, and academic performance. For example, a [study](#) of New York City schools found a 2.2% decrease in exam scores was observed for every 1°F increase in temperature, suggesting a student can gain an average 30 degree day (or 1.2% more days to get an exam than on a 75 degree day). Thermal comfort is a common means for making decisions on the environment, but the highly subjective measure does not account for student activity level, metabolic rate, or clothing choices.

The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) is a national association that guides indoor environmental quality via [ASHRAE 55](#) to specify conditions for acceptable thermal environments. Also, ASHRAE recommends humidity levels below 60%. There are no lower level recommendations for relative humidity, however, it should be noted that humidity levels that are too low (below 30%) leads to health issues like skin irritation and increased indoor humidity during winter months and can [cause](#) [asthma](#) [and](#) [allergies](#).

Potential Metrics for
Lighting

MSBA School Survey Collected the Following Variables:

- How many classrooms lack natural daylight (windows)?
- Electrical Lighting - Building Condition Rating
- Electrical Services and Distribution - Building Condition Rating

This energy use was identified as a health indicator in Section 83 of Chapter 17B of the Act of 2022 because these environmental parameters are a part of a healthy school facility and may influence energy use or interact with the other health indicators including indoor air quality and thermal comfort.

The goal of good classroom lighting is to balance student and health with energy efficiency in order to enable visual attention without including unnecessary eye strain. Light may have direct effects on cognitive function, attention, executive function, and memory. High color temperature is associated with active atmosphere, productive workplaces, among cognitive performance in elderly, and reducing depression. Low color temperature has been associated with serene, stable, and relaxed spaces. Conversely, circadian lighting with good color range and access to natural light is highly beneficial to room occupants. Controlling about occupants to directly manage light levels and glare. Overly aggressive use of window shades on the other hand denies the health benefits of views and exposure to daylight.

The [International Ergonomics Society \(IES\)](#) provides additional metrics, educational resources, and standards on the impact of lighting and illumination on energy and health.

Potential Metrics for
Lighting

MSBA School Survey Collected the Following Variables:

- How many classrooms lack natural daylight (windows)?
- Electrical Lighting - Building Condition Rating
- Electrical Services and Distribution - Building Condition Rating

This energy use was identified as a health indicator in Section 83 of Chapter 17B of the Act of 2022 because these environmental parameters are a part of a healthy school facility and may influence energy use or interact with the other health indicators including indoor air quality and thermal comfort.

The goal of good classroom lighting is to balance student and health with energy efficiency in order to enable visual attention without including unnecessary eye strain. Light may have direct effects on cognitive function, attention, executive function, and memory. High color temperature is associated with active atmosphere, productive workplaces, among cognitive performance in elderly, and reducing depression. Low color temperature has been associated with serene, stable, and relaxed spaces. Conversely, circadian lighting with good color range and access to natural light is highly beneficial to room occupants. Controlling about occupants to directly manage light levels and glare. Overly aggressive use of window shades on the other hand denies the health benefits of views and exposure to daylight.

The [International Ergonomics Society \(IES\)](#) provides additional metrics, educational resources, and standards on the impact of lighting and illumination on energy and health.

Impacts of Daylight on Health

Potential Metrics for
Air Quality & Ventilation

MSBA School Survey Collected the Following Variables:

- HVAC Heating Type
- Ventilation/AC Type
- Ventilation/AC Coverage
- HVAC - Building Condition Rating

Indoor air quality (IAQ) is critical for child health and performance since they breathe 50% more air than adults, have immature immune systems, and are more likely to be exposed to dust in learning environments. The COVID-19 pandemic highlighted the need for expansive improvements in our school's ventilation and filtration capacity. Existing buildings often exceed the acceptable level of Indoor Air Quality in schools ([ASHRAE 62.1](#)) by 2-5 times.

The MA DPH, [Bureau of Environmental Health](#) has an existing [Indoor Air Quality Program](#) under M.G.L. c. 111 sec. 5, which "conducts sanitary investigations and investigations as to the causes of disease" and "advises the government concerning the location and other sanitary condition of any public institution." They conduct both an IAQ and radon assessment and already have methods for improving air quality in schools, public buildings, and housing, completed reports and assessments of public buildings, and guidelines and checklists. The Bureau of Environmental Health will be a valuable partner in identifying the appropriate IAQ metrics and assist in training assessors or collecting the subsequent metrics.

The Massachusetts Asthma Action Partnership released their [2021-2026 Strategic Plan](#), which identified eleven cities due to the highest asthma burden across the state. Their plan highlights increasing capacity of statewide partnership, reducing environmental exposures that trigger asthma, and advancing primary prevention of asthma by using innovative evidence-based interventions.

OCCUPANCY STATUS	METRIC	RATIONALE
Occupied	Indoor Carbon Dioxide/PM2.5 ▲ Deploy portable sensors or use building management system to measure classroom conditions for two weeks. Many sensors provide the ability to measure multiple indoor air conditions.	Classrooms with high levels of CO2 and PM2.5 have been shown to have higher levels of asthma and lower test performance. This indoor measurement approach captures weather variation, rush hour traffic, and any indoor pollutants sources. If using portable indoor air quality, repeat seasonally to capture different conditions driven by human behavior or temperature (e.g. use of windows or AC).
Occupied/Unoccupied	Airflow/Air Change Rate ▲ Using an anemometer measure airspeed in duct work and calculate air change rate. Air change rate is calculated by (Airflow (cubic ft./min.) x 60 min.) / Room Volume (cubic ft.)	This indoor measurement allows us to understand the rate of removal or dilution of indoor air pollutants.
Occupied/Unoccupied	Volatile Organic Compounds ● Measure total volatile organic compounds using Flame Ionization Detection and Photo Ionization Detection. Measure specific VOCs in the air using a thermal desorption tube.	These gaseous air pollutants can be measured indoors with the assistance of an industrial hygienist and external lab analysis once samples are collected. Measuring for two weeks can identify different air pollution sources (e.g. traffic related air pollution, cleaning, office school supplies).
N/A	Outdoor PM2.5 ▲ Deploy portable sensors to measure ambient conditions for two weeks.	This continuous outdoor site measurement captures weather variation, rush hour traffic, and various outdoor pollutants sources.
N/A	Proximity to Outdoor Air Pollution ● Sources Via EPA's EIScreen , we can rapidly evaluate sources of outdoor air pollution by community. - Proximity to Major Roadway - Proximity to Superfund Site - Proximity to Hazardous Waste - Proximity to RMP Facility - Built on a Brownfield	This site analysis can be completed prior to a building visit to identify sources of air pollution that may infiltrate indoors.

Potential Energy Metrics for
Massachusetts Public Schools

MSBA School Survey Collected the Following Variables:

- HVAC Heating Type
- Ventilation/AC Type
- Ventilation/AC Coverage
- HVAC - Building Condition Rating
- Older/ Older Boilers - Building Condition Rating
- Second Older Boilers - Building Condition Rating

Assessment of existing building Mechanical, Electrical, and Plumbing (MEP) systems could capture data on the age, condition, and distribution of heating and cooling as a measure of system resiliency and as a step towards planning for replacement of existing fossil fuel burning systems with more efficient all-electric systems. Vulnerable fossil fuel burning systems will become more challenging to replace in the next ten to fifteen years leaving schools at risk of unexpected closures. Metrics might also help to observe building and site conditions that relate to the suitability of schools for electrification projects and the potential for installation of renewables, presently identified as photovoltaic or geothermal.

A school's energy use does not directly correlate with health impacts but is a critical source of operational vulnerability to the school building and district budget due to energy cost fluctuation and changing code requirements. Assessment of a school's energy consumption and efficiency offers useful diagnostic information that can aid capital planning efforts. The same data can also be used by DOER to determine progress on Commonwealth climate goals.

Augmenting school infrastructure through the installation of renewable energy systems is a recommendation of the state's Climate Plan and DOER's updated [Stretch Code](#) requirements, such systems can increase building and community resiliency and reduce electrical costs. Existing buildings and sites should be assessed for factors that can indicate suitability or unsuitability for installation of onsite renewables, including photovoltaics and geothermal systems.

Criterion for Energy Metrics:

01. Fossil Fuel Use and Replacement Planning	02. Energy Efficiency	03. Adaptability
--	-----------------------	------------------

Criterion 1: Fossil Fuel Use and Replacement Planning

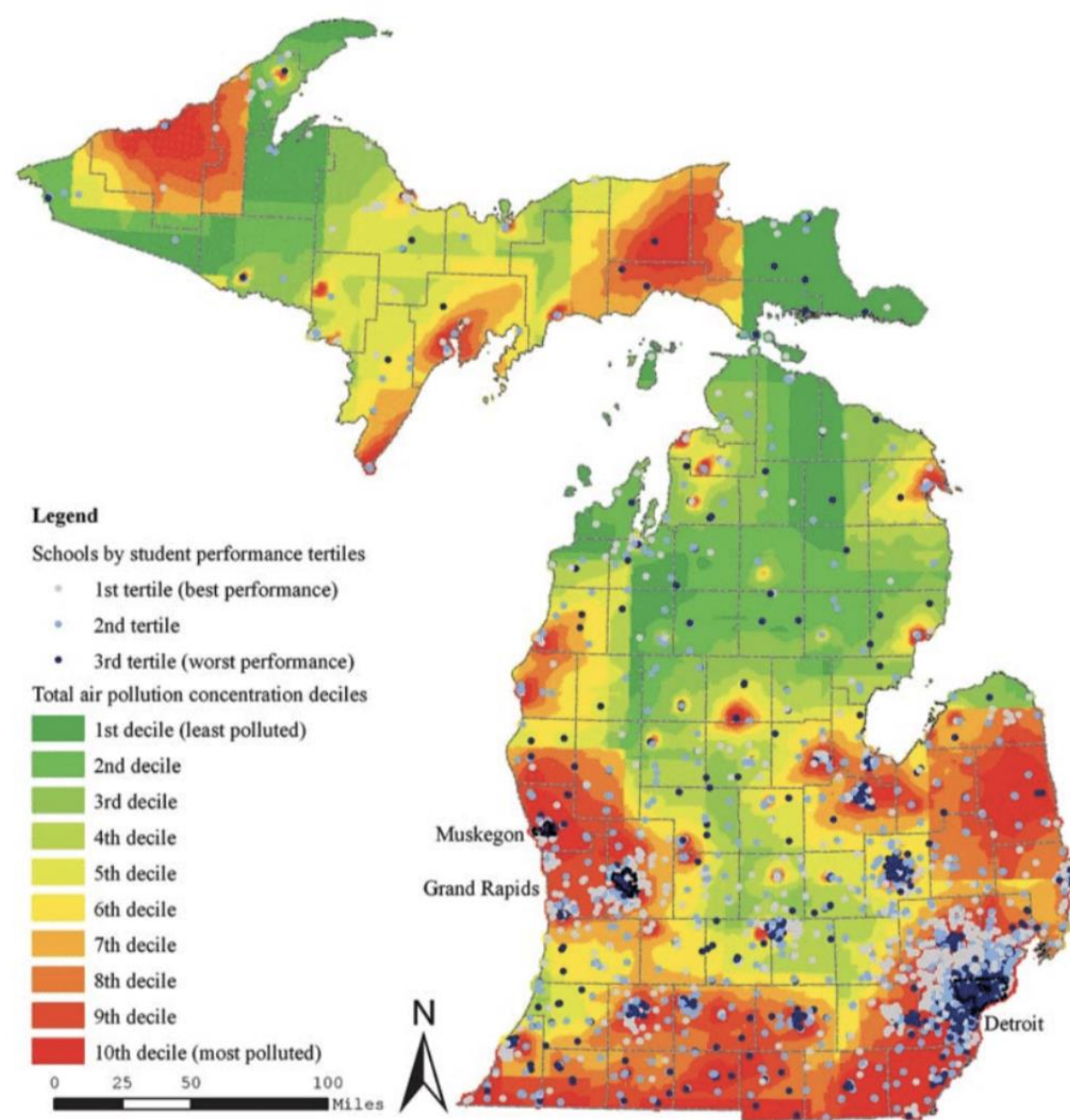
METRIC	RATIONALE
Fuel Source - Fossil Fuel Combustion System ● - What is the age, condition and life expectancy of the primary furnace or boiler? - Is there a working redundant furnace or boiler? - Is the efficiency of the system greater than, equal to or less than 80%?	Replacement of fossil fuel burning heating systems is discouraged under the proposed IECC 2021 and MA Stretch Code. The vulnerability of aging combustion systems is a critical measure of resilience or vulnerability.
Heating Distribution - Describe systems in place. ● - If water based, is the system steam or hot temp water or low temp water? Steam systems are older, less energy efficient to operate and harder to retrofit. - If air based - what is the fuel source of the heating coil? - What is the age, condition, and life expectancy of the handling system?	Similarly, the heat delivery system and its capacity to serve the needs of the school are a critical measure of resilience or vulnerability.
Cooling Distribution - Describe systems in place. ● - Does the system provide cooling? If so, is cool air delivered centrally or through wall units? - What is the age, condition, and life expectancy of the system? - How much outdoor ventilation is provided compared to current code requirements?	The availability of cooling is increasingly important to the learning environment as extreme heat events grow more frequent. Data on the presence of cooling systems has not historically been collected but is an important measure of school and district climate vulnerability.
Dependencies ● - Does the school have an onsite generator sized to maintain operation of existing structural systems, roof system, electrical room and electrical panels as well as the ability to maintain the electrical heating/cooling with adequate emergency power. Gathering data on these existing systems will be essential to reviewing the cost of system conversion. - Electrical system capacity/condition - Is there adequate ceiling space for ductwork (~12' ft)? - Calculate Floor to Floor Height and roof framing size/spacing - Roof condition	The ability of the school to support an electrification conversion (air sourced or ground sourced), depends on the capacity of the existing structural systems, roof system, electrical room and electrical panels as well as the ability to maintain the electrical heating/cooling with adequate emergency power. Gathering data on these existing systems will be essential to reviewing the cost of system conversion.

Community

**Public Repository to Engage
Community and Enhance
Design Equity (PRECEDE)**

By Paul Mohai, Byoung-Suk Kweon, Sangyun Lee, and Kerry Ard

Air Pollution Around Schools Is Linked To Poorer Student Health And Academic Performance



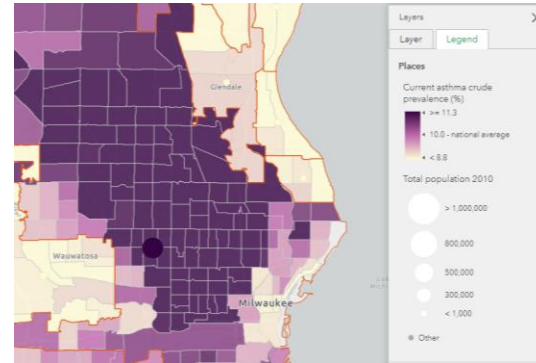
SOURCE Authors' analysis of geographic microdata for 2006 from Note 23 in text. **NOTES** Only locations of elementary and middle schools are shown. Schools are sorted into three groups (tertiles) based on the percentage of students (grades 3–8 combined) who do not meet the Michigan Educational Assessment Program standards for English. The schools in the first tertile ("best performance") have the lowest percentage of students failing to meet the standards. For more details about the values of air pollution, see the Appendix (see Note 24 in text).

Data exists. Barriers Persist.



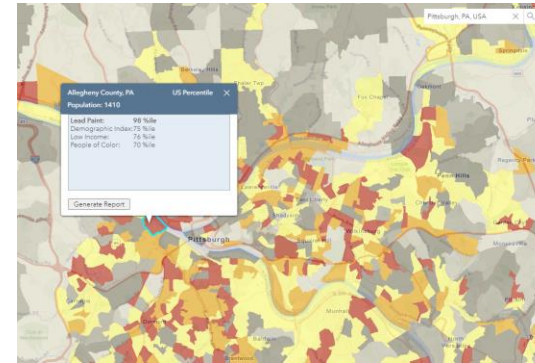
City Health Dashboard

- 500 of U.S. cities
- Comparative statistics to national average



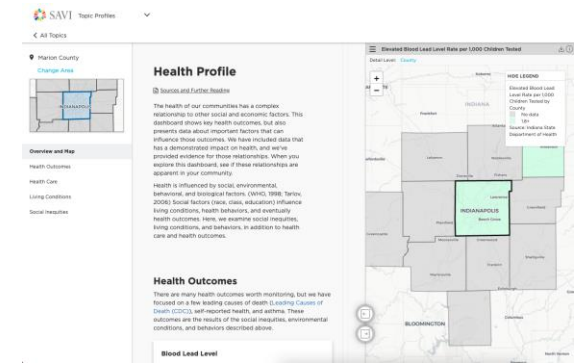
CDC Places

- Provides data on preventative healthcare
- Does not provide information on environmental exposures



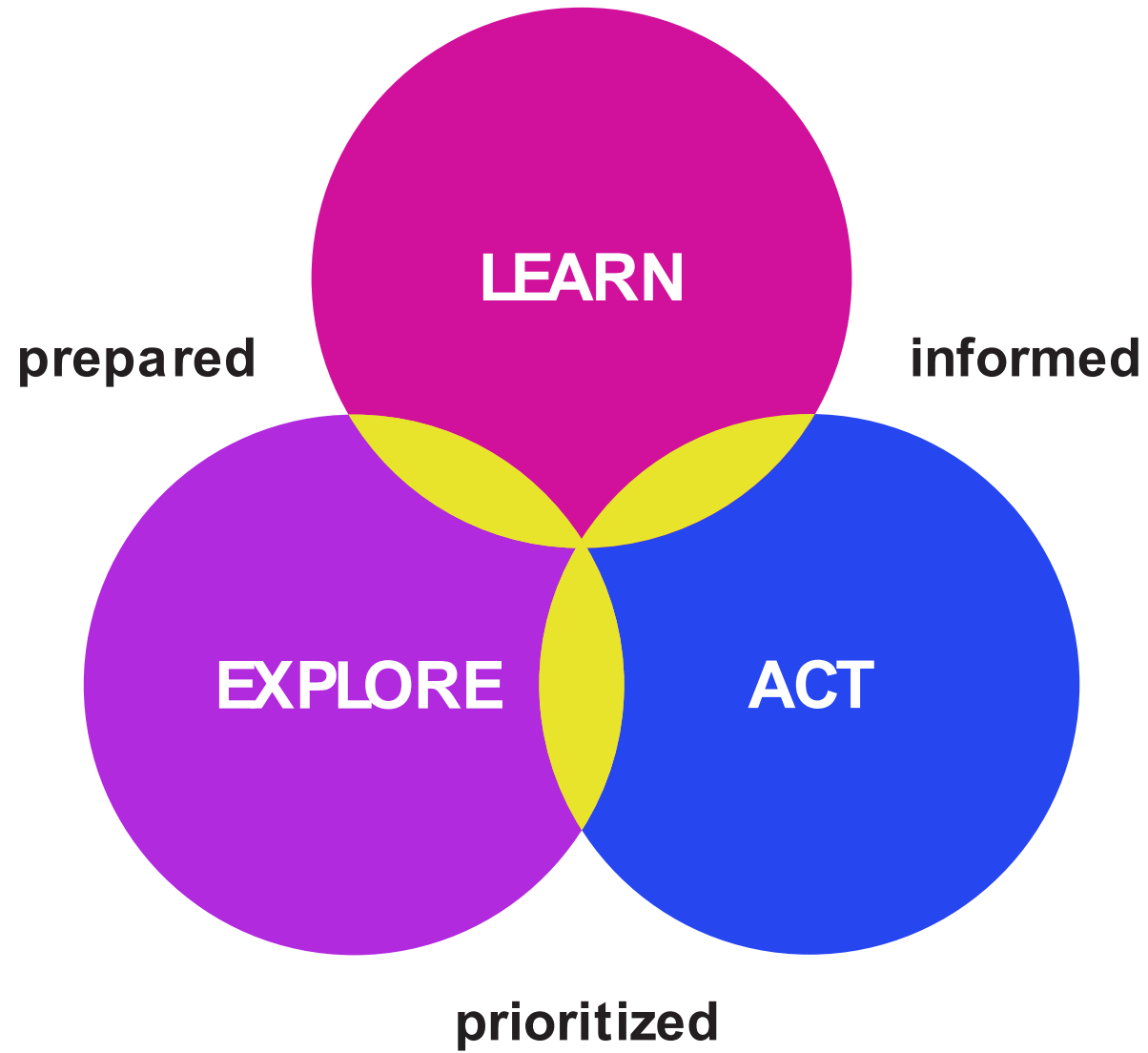
EJScreen

- Educate users on how to interpret the results
- Do not educate users on the significance of these health outcomes



SAVI Dashboard

- Provides a diverse set of health, access, and community indicators
- Provides useful context to indicator significance
- Only provides data for the Indianapolis Metro Area

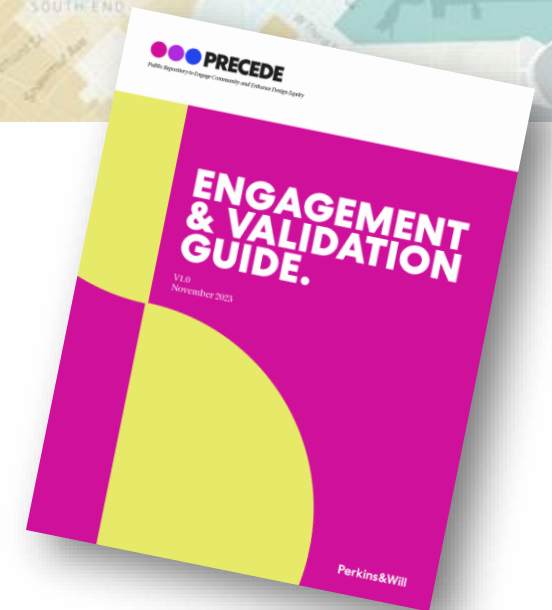
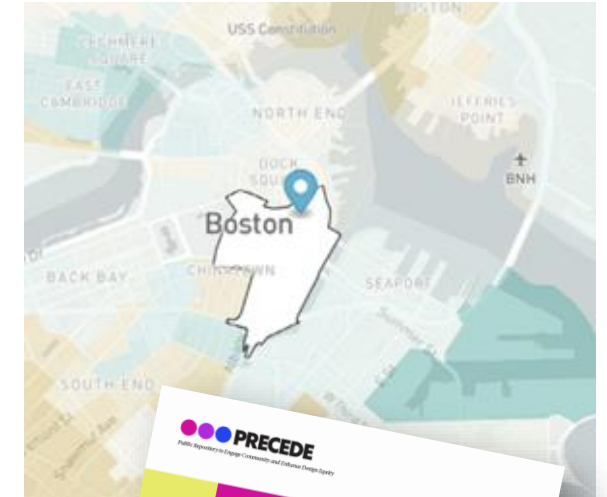
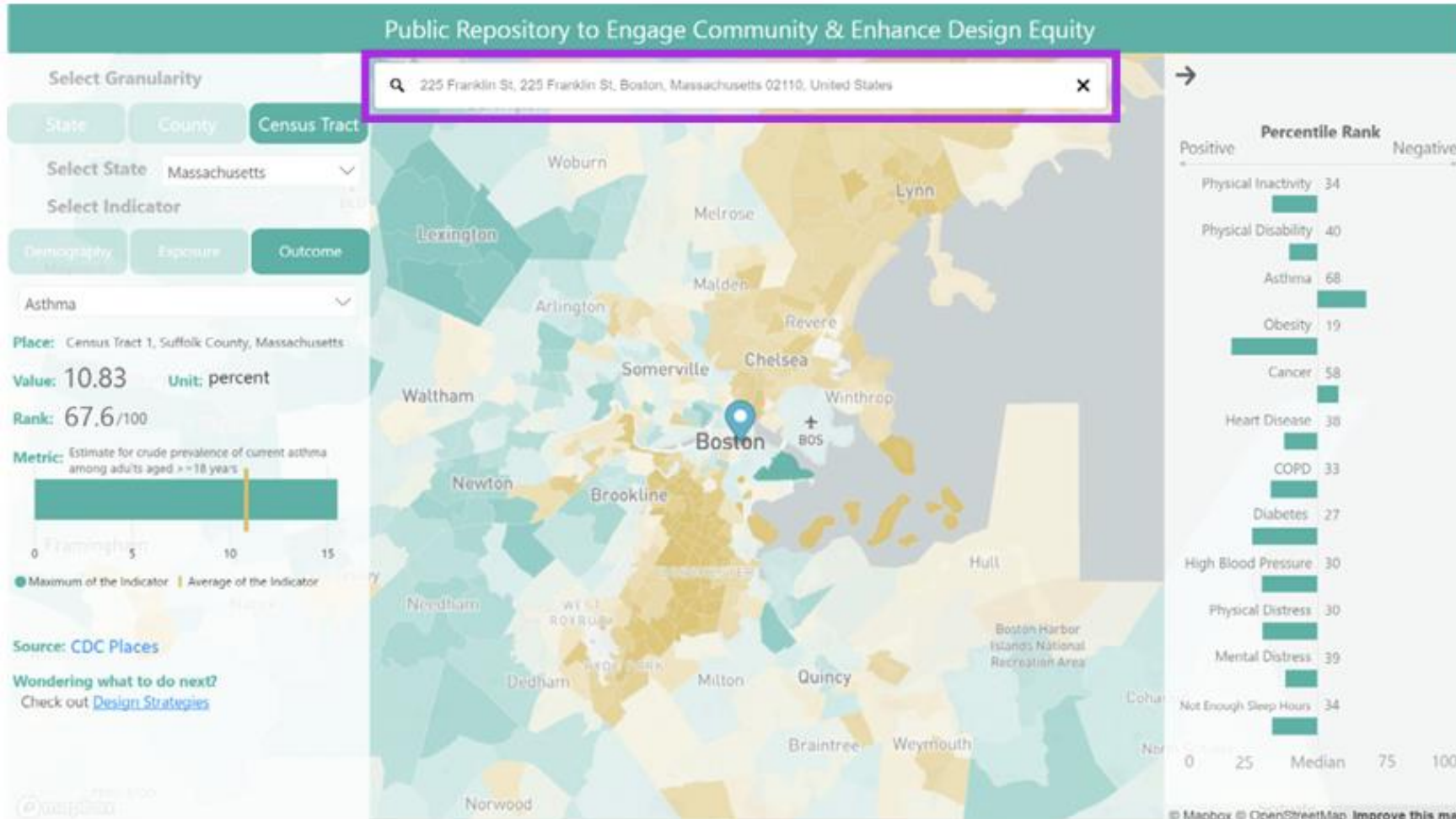


Embedding Health Data into Design

www.precede.perkinswill.com



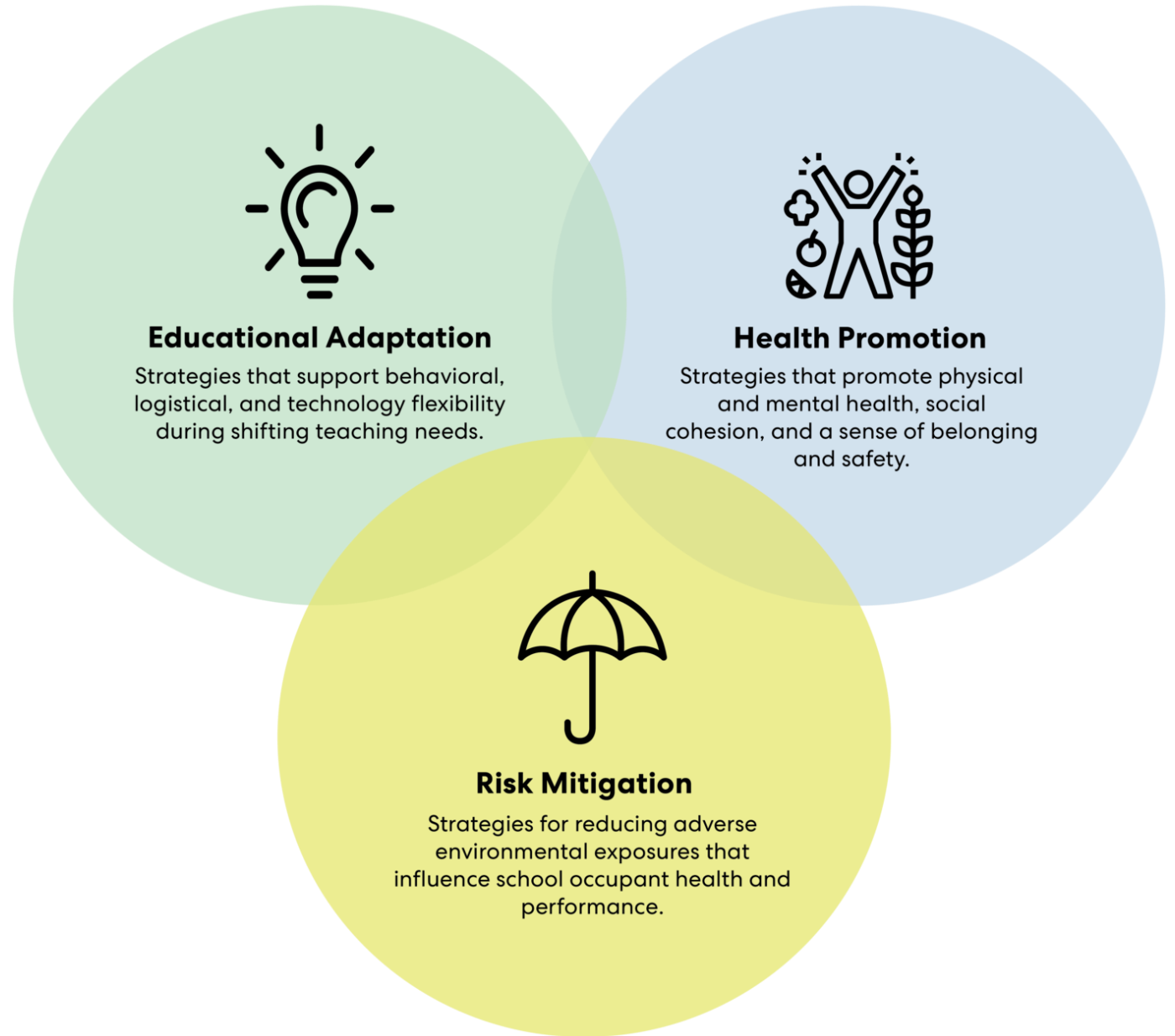
Public Repository to Engage Community and Enhance Design Equity



Organizational

Healthy Schools by Design

Promote well-being without compromising students' learning potential.



Organizational: Every Space Should be Considered a Healthy Place

healthy12.perkinswill.com



Educational Adaptation

Strategies that support behavioral, logistical, and technology flexibility during shifting teaching needs.



Health Promotion

Strategies that promote physical and mental health, social cohesion, and a sense of belonging and safety.



Risk Mitigation

Strategies for reducing adverse environmental exposures that influence school occupant health and performance.



Hi, I'm Riley.

Follow along as we make sure that the spaces I occupy every day are safe and healthy.



Outdoor Siting



Entry and Exit



Circulation Space



Classroom



Materials



Library



Cafeteria



Nurse



Restroom



What do school stakeholders and designers need?

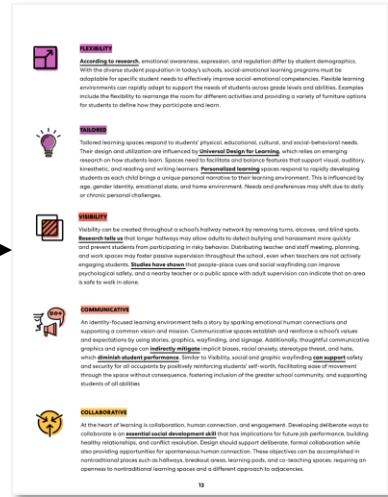
Extrapolating research to make it actionable



Healthy Schools by Design



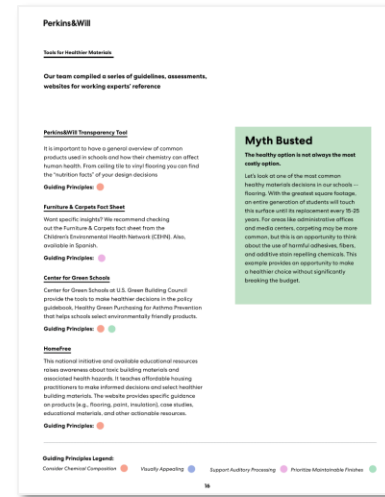
White Paper



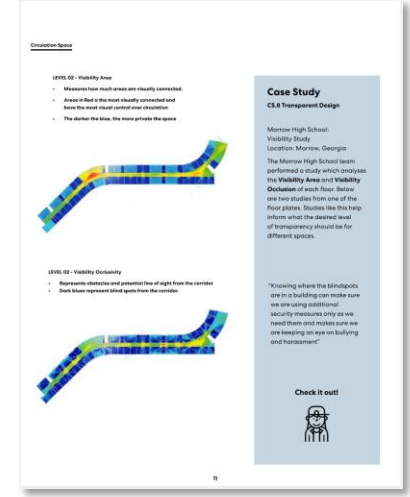
Literature Review

STRATEGY	CATEGORY	NEW/EXISTING	IN YOUR SCHOOL
L1 Zone elements to include quiet areas or open desks, book carts, and/or mobile work and storage options for collaboration and group learning.	Health Promotion Educational Adaptation	New Construction Existing Building	Yes No Not Applicable
L2 Include large and small collaborative areas adjacent to classrooms that create opportunities for connections between classes for community building.	Risk Mitigation Health Promotion Educational Adaptation	New Construction Existing Building	Yes No Not Applicable
L3 Increase flexibility by integrating activities including storage, printing and distribution to support learning and inform collaboration.	Risk Mitigation Health Promotion Educational Adaptation	New Construction Existing Building	Yes No Not Applicable
L4 Increase diversity of learning methods by offering teachers and students flexibility by including features such as group/desk, movable furniture, dual access walls (lockers/benches), and mobile work that create a variety of learning zones.	Risk Mitigation Health Promotion Educational Adaptation	New Construction Existing Building	Yes No Not Applicable
L5 Provide classroom technology to increase content learning opportunities 200-degree corners, interactive, mobile, and portable screens, and amplified sound systems so students can participate in lessons in a variety of ways.	Risk Mitigation Health Promotion Educational Adaptation	New Construction Existing Building	Yes No Not Applicable
L6 Extend technology and internet to allow for consistent flexibility, including outdoor learning spaces.	Risk Mitigation Health Promotion Educational Adaptation	New Construction Existing Building	Yes No Not Applicable
L7 Provide desks, storage options, or tables with charging ports to include additional tables, mobile classroom technology increases the need for power for each student.	Risk Mitigation Health Promotion Educational Adaptation	New Construction Existing Building	Yes No Not Applicable
L8 Provide flexible, mobile, in-line storage to reduce physical and visual clutter, increase ease of cleaning and maintenance.	Risk Mitigation Health Promotion Educational Adaptation	New Construction Existing Building	Yes No Not Applicable
L9 Provide alternative furniture (such as adjustable height desks and seating arrangements), built-in storage, and other furniture and fixtures for alternative student uses when a variety of options are provided.	Risk Mitigation Health Promotion Educational Adaptation	New Construction Existing Building	Yes No Not Applicable
L10 Collaborate and strategically located existing graphics and signage to encourage, reinforce learning environment.	Health Promotion Educational Adaptation	New Construction Existing Building	Yes No Not Applicable

Strategies Checklist



Tools & Resources



Case Studies & Design Hypotheses



Schools are uniquely positioned to identify and mitigate daily mental health issues and offer support.

←
Holy Innocents' Episcopal School,
Upper School Humanities Building



FLEXIBILITY

According to research, emotional awareness, expression, and regulation differ by student demographics. With the diverse student population in today's schools, social-emotional learning programs must be adaptable for specific student needs to effectively improve social-emotional competencies. Flexible learning environments can rapidly adapt to support the needs of students across grade levels and abilities. Examples include the flexibility to rearrange the room for different activities and providing a variety of furniture options for students to define how they participate and learn.



TAILORED

Tailored learning spaces respond to students' physical, educational, cultural, and social-behavioral needs. Their design and utilization are influenced by **Universal Design for Learning**, which relies on emerging research on how students learn. Spaces need to facilitate and balance features that support visual, auditory, kinesthetic, and reading and writing learners. **Personalized learning** spaces respond to rapidly developing students as each child brings a unique personal narrative to their learning environment. This is influenced by age, gender identity, emotional state, and home environment. Needs and preferences may shift due to daily or chronic personal challenges.



VISIBILITY

Visibility can be created throughout a school's hallway network by removing turns, alcoves, and blind spots. **Research tells us** that longer hallways may allow adults to detect bullying and harassment more quickly and prevent students from participating in risky behavior. Distributing teacher and staff meeting, planning, and work spaces may foster passive supervision throughout the school, even when teachers are not actively engaging students. **Studies have shown** that people-place cues and social wayfinding can improve psychological safety, and a nearby teacher or a public space with adult supervision can indicate that an area is safe to walk in alone.



COMMUNICATIVE

An identity-focused learning environment tells a story by sparking emotional human connections and supporting a common vision and mission. Communicative spaces establish and reinforce a school's values and expectations by using stories, graphics, wayfinding, and signage. Additionally, thoughtful communicative graphics and signage can **indirectly mitigate** implicit biases, racial anxiety, stereotype threat, and hate, which **diminish student performance**. Similar to Visibility, social and graphic wayfinding **can support** safety and security for all occupants by positively reinforcing students' self-worth, facilitating ease of movement through the space without consequence, fostering inclusion of the greater school community, and supporting students of all abilities.



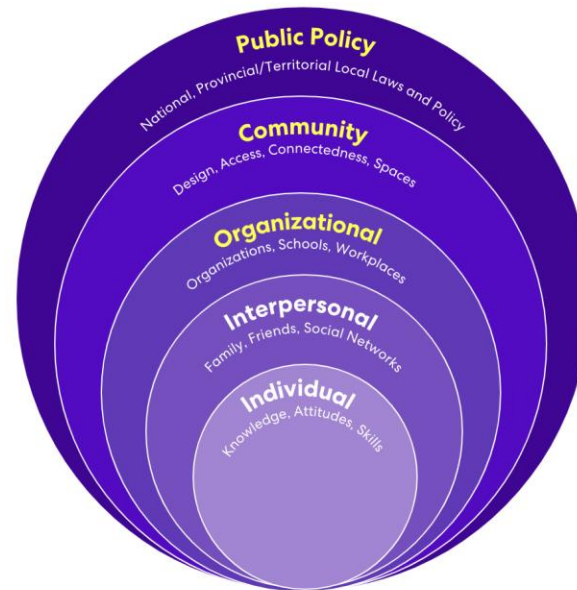
COLLABORATIVE

At the heart of learning is collaboration, human connection, and engagement. Developing deliberate ways to collaborate is an **essential social development skill** that has implications for future job performance, building healthy relationships, and conflict resolution. Design should support deliberate, formal collaboration while also providing opportunities for spontaneous human connection. These objectives can be accomplished in nontraditional places such as hallways, breakout areas, learning pods, and co-teaching spaces, requiring an openness to nontraditional learning spaces and a different approach to adjacencies.

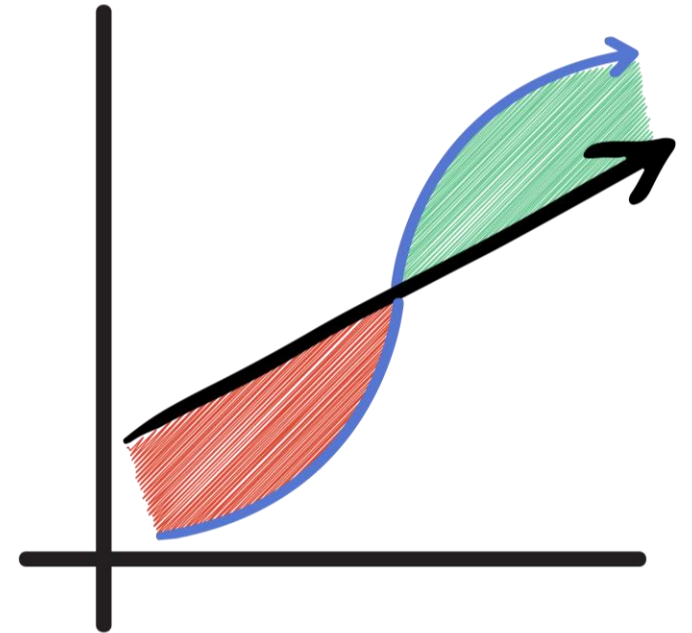
Let Your Public Health Intervention be...



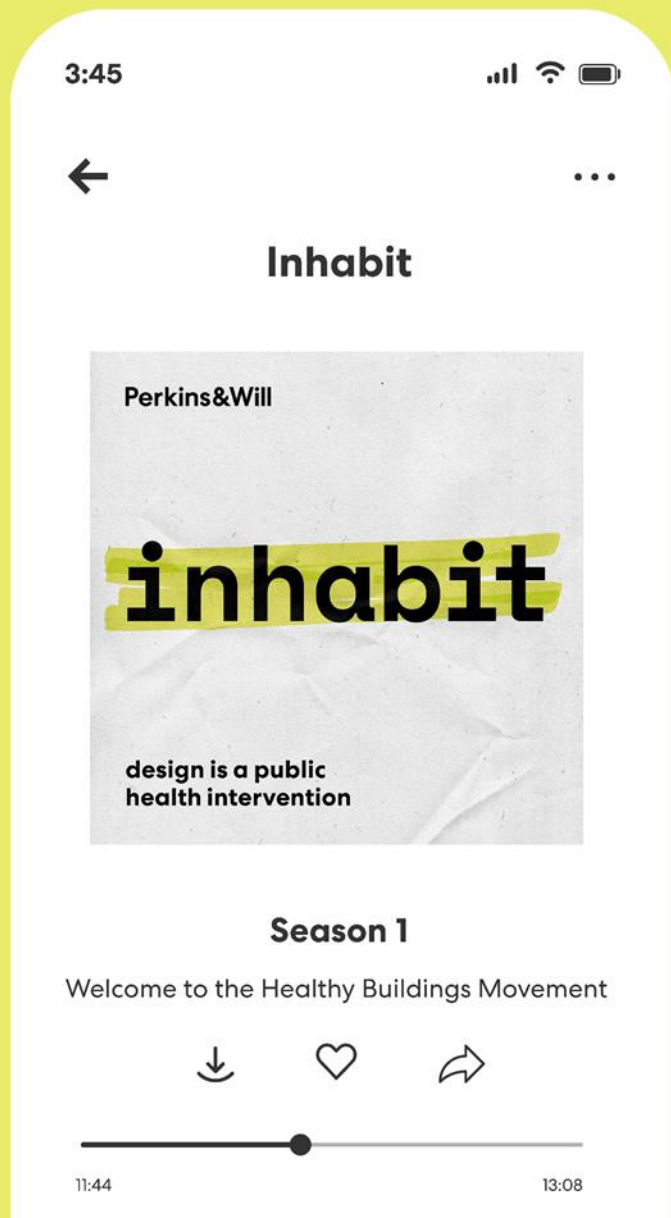
Integral



Holistic



Restorative



inhabit

“What we do in our schools is magic. It should happen in temples. It should happen in palaces.”

— Tracy Washington Enger
U.S. Environmental Protection Agency