

Mass Timber Schools— Building for Wellness

ConnectED, A4LE Washington Chapter Annual Conference

June 7, 2022



MITHŪN

UNIVERSITY of
WASHINGTON





JoAnn Hindmarsh Wilcox
AIA, Principal, Mithun

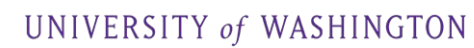


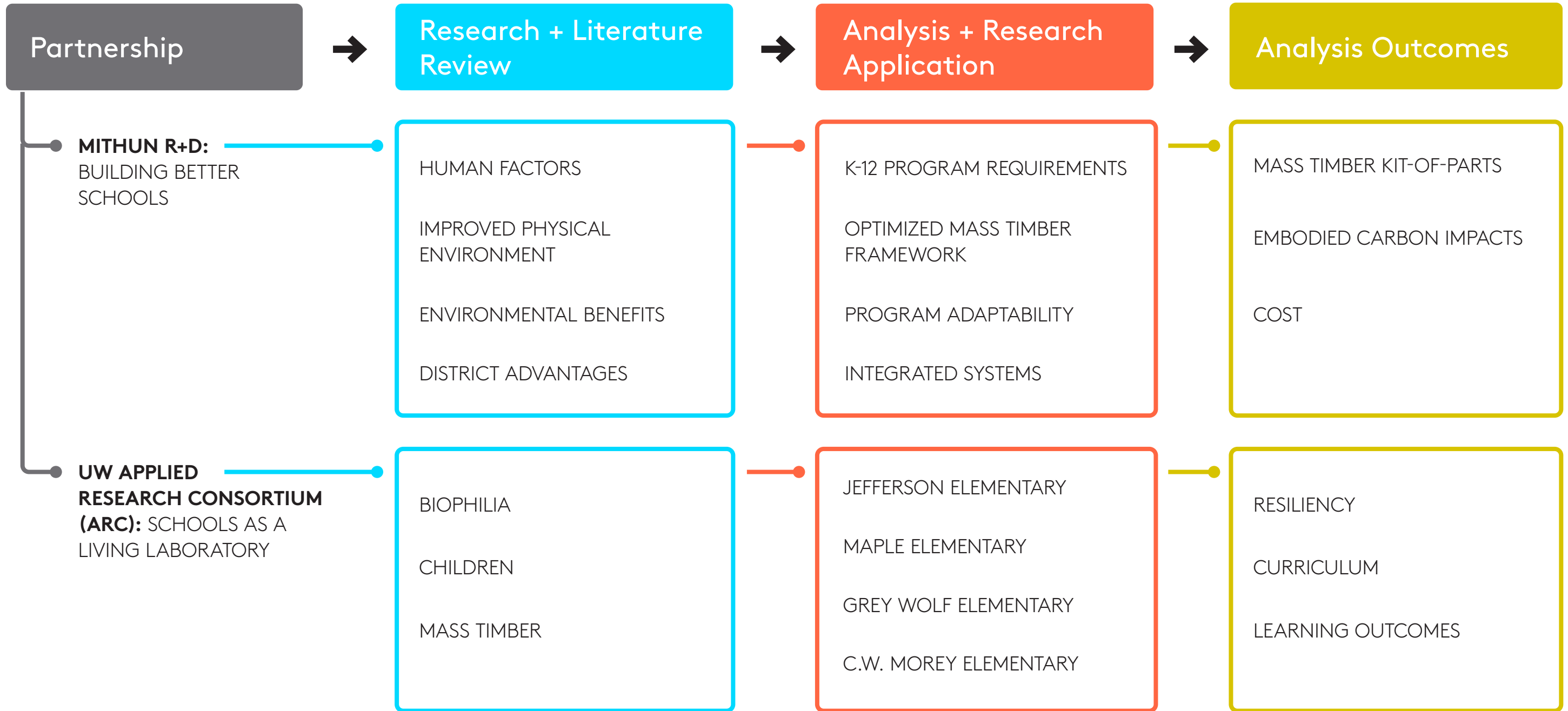
Rachel Himes
Assoc AIA, Senior Associate, Mithun



Noor Awad
ARC Fellow, University of Washington

Research Partners







On a scale of 1-5, how big
of a concern is stress and
anxiety for students in
your schools?



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Do your schools use biophilic design strategies?





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Do your schools use biophilic design strategies?



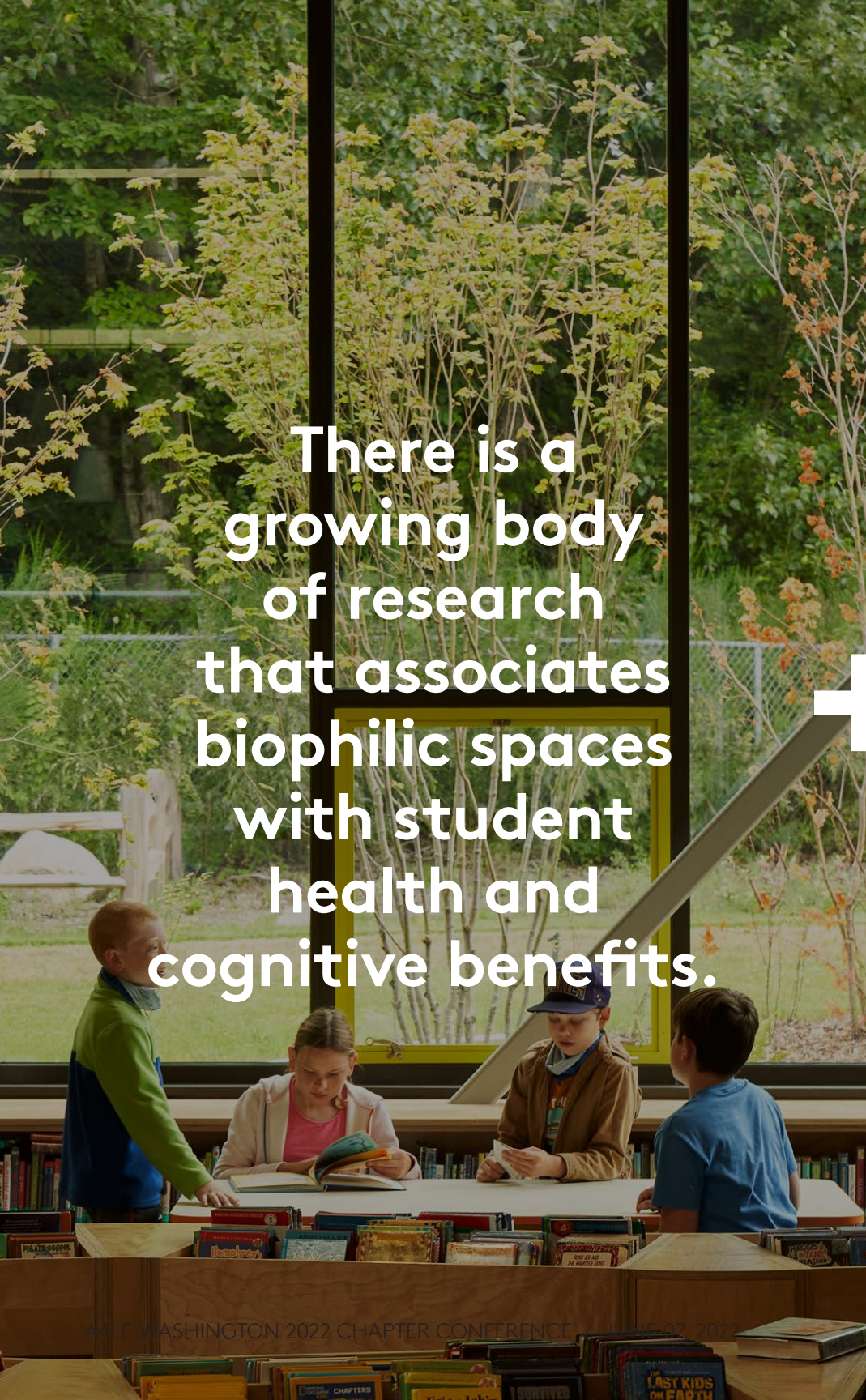
Do the biophilic strategies include wood or mass timber as a primary element?

A photograph of a modern school courtyard. The buildings are constructed with dark vertical slats and light-colored wood paneling. Large windows are visible on the right side. In the foreground, a woman in a white uniform and mask is looking at her phone. In the middle ground, several children are sitting on wooden benches, some reading. In the background, more children are playing near a small tree. The sky is blue with light clouds.

Our future rests upon the education of our children.
What if the built environment could enhance
cognitive function – learning, memory, emotion,
communication, and social intelligence – in a
developing child?

Mithun R+D:

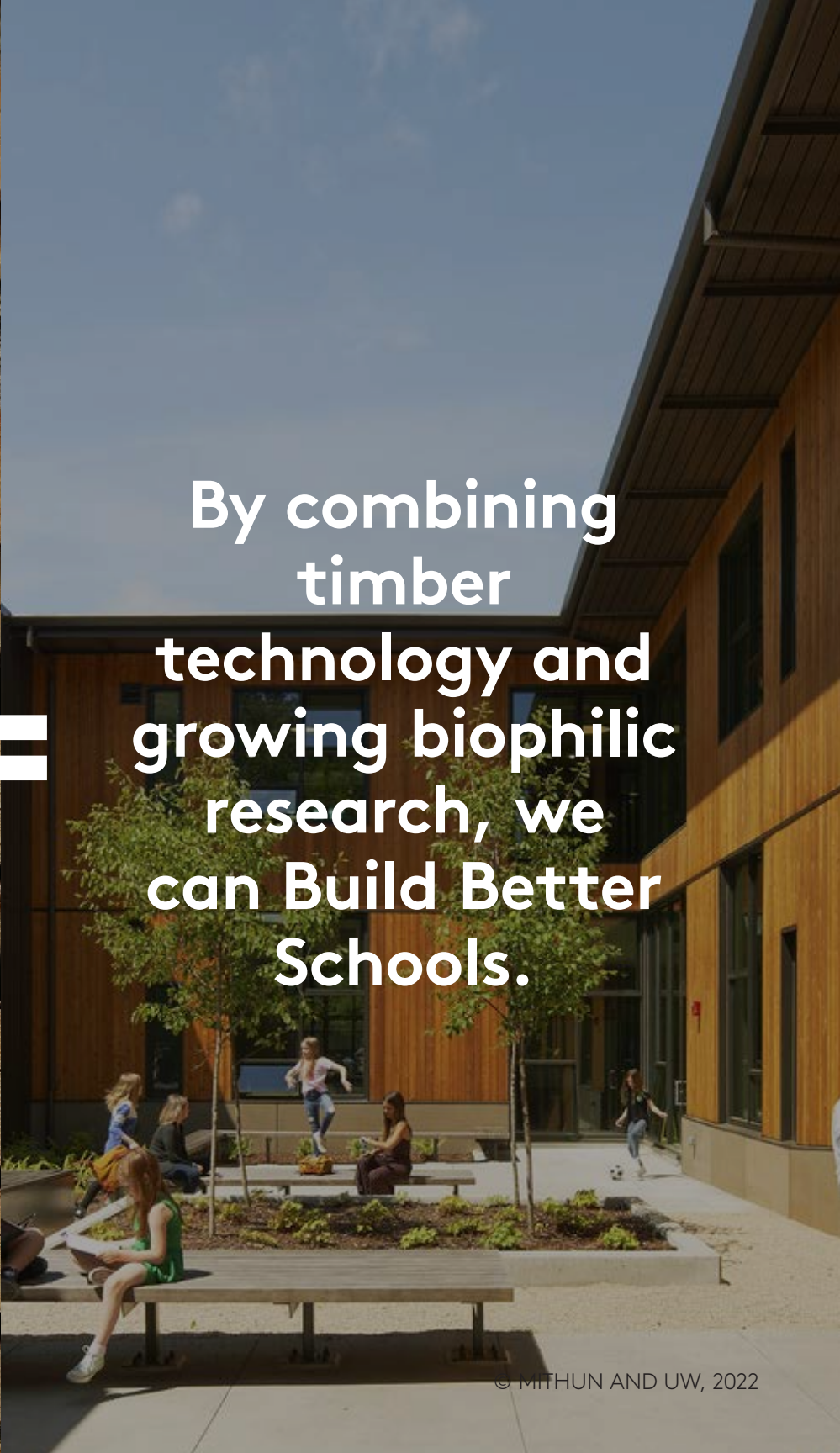
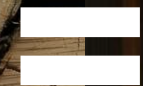
Building Better Schools Research



There is a growing body of research that associates biophilic spaces with student health and cognitive benefits.



Emerging mass timber technology is positively impacting the way we design and construct buildings.



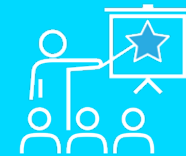
By combining timber technology and growing biophilic research, we can Build Better Schools.

Heart rate variabilities that are biologically connected to stress levels are proven to be lower by almost half in a biophilic environment. In one study, average test scores are also three times higher in a biophilic classroom.

The Human Factor

In the developed world, we spend about 90% of our time indoors. Incorporating natural elements into the built environment contributes to human wellbeing.

Well-being + Student Performance



Stress Reduction + Improved Focus and Mood



Productivity of Teachers and Staff





Air humidity fluctuation can be reduced by up to 70% in a room with untreated wood surfaces, compared to gypsum plaster. The result is a healthier classroom with reduced spread of viruses, respiratory illnesses and allergies.

Physical Environment

Wood as a living building material changes the makeup of our interior spaces, which can positively affect our physical health.

Healthier Buildings



Reduced Volatile Organic Compounds



Virus Protection + Contaminated Surfaces



When harvested responsibly from sustainably-managed forests, mass timber has a significant reduction in embodied carbon: up to about 200% compared to a steel-framed project.

Environmental Benefits

Carbon emissions from the building sector are a major contributor to the climate change equation, far larger than either the transportation or industrial sectors.

Biogenic Carbon



Embodied Carbon



Net Carbon Impact



Mass timber projects see approximately 25% savings in construction schedule. The prefabricated mass timber components yield 80% reduction in truck deliveries and 50% reduction of site staff for the building structural framing.

School District Advantages

To provide successful learning environments, School Districts need construction methods and spaces that promote new teaching opportunities, while aligning with curriculum goals.

Site Impacts + Schedule



Curriculum Alignment + Teaching Opportunities



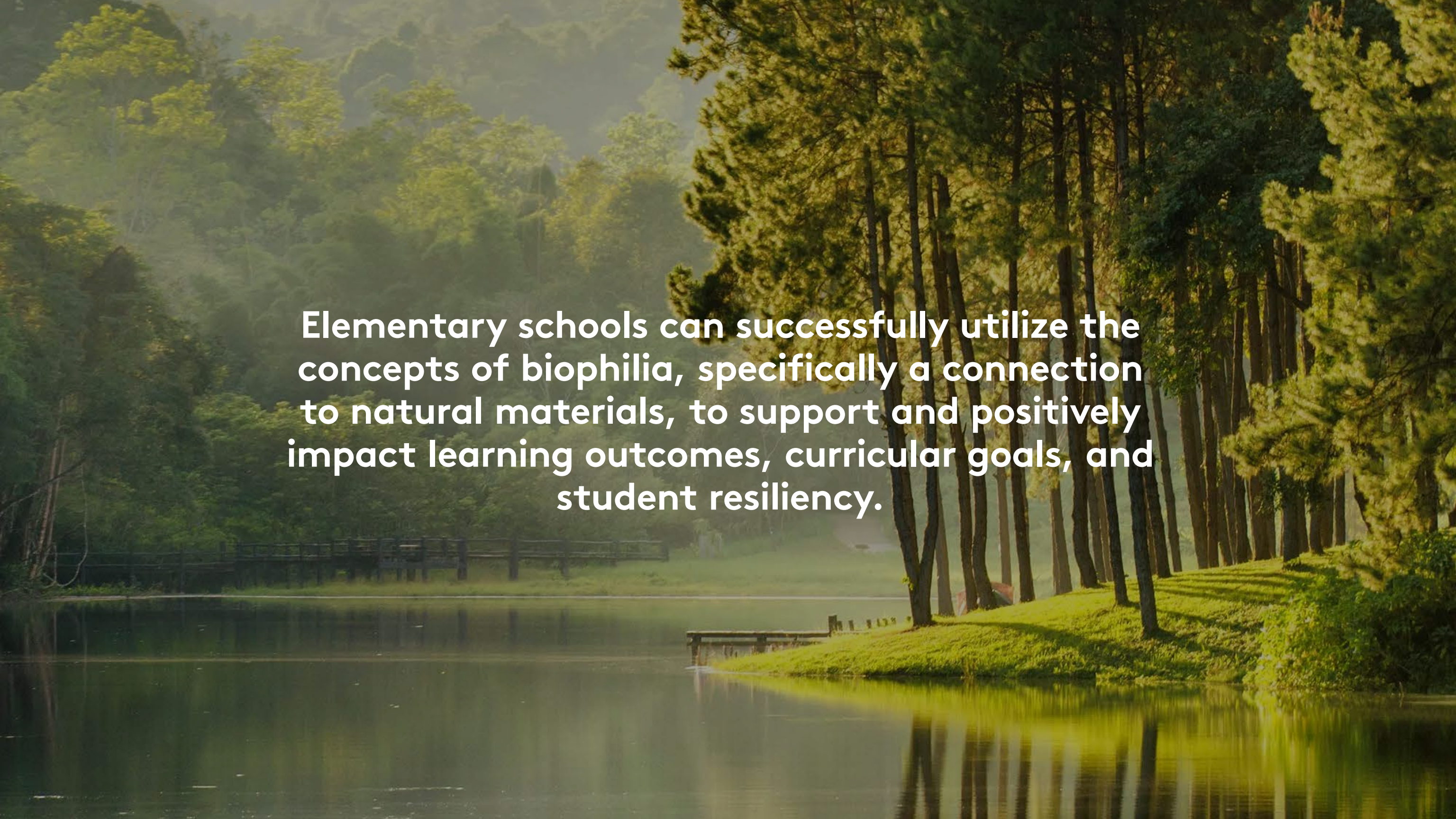
Spatial Alignment with Teaching Best Practices



University of Washington ARC:

School as Living Laboratory

Research question: Can schools constructed of mass timber support child development, curriculum, learning outcomes, long term student success, and student resiliency?

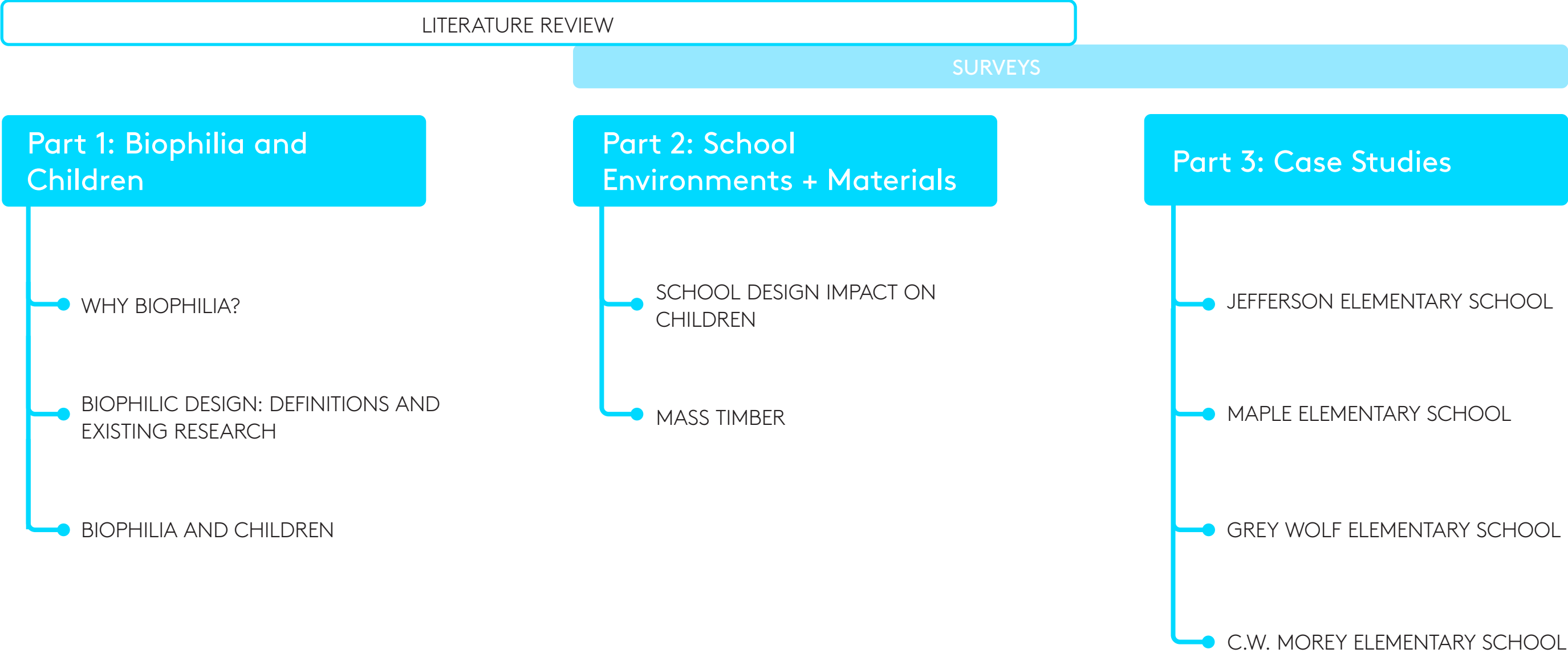
A serene landscape featuring a calm body of water in the foreground, reflecting the surrounding greenery. On the right side, a dense row of tall, slender pine trees stands on a grassy bank. In the background, a lush, forested hillside rises under a soft, hazy sky. The overall atmosphere is peaceful and natural.

Elementary schools can successfully utilize the concepts of biophilia, specifically a connection to natural materials, to support and positively impact learning outcomes, curricular goals, and student resiliency.

A person with a large backpack is walking away from the camera on a dirt path through a forest. Two children are walking alongside them, one in a purple jacket and the other in a dark jacket. The path is surrounded by tall evergreen trees and some deciduous trees with yellowing leaves. The scene is lit with soft, natural light.

This research explores questions in design methodology, provides insights on how to conduct design research, and ultimately serves to ignite a productive conversation between designers, teachers, administrators, and school stakeholders about mass timber in schools.

Research Structure



Research Topics

LEARNING OUTCOMES

Understand why children in grades K-3 are at a crucial stage in their development.

How do students apply and integrate knowledge?

is there a connection between the benefits of mass timber and stages of development?



CURRICULUM

Identify alignment between curriculum goals and mass timber.

What are the benefits of learning in a mass timber space?

What can students learn from a tree (and by extension, mass timber)?



RESILIENCY

Explore the benefits of mass timber in supporting students through stress events.

What are stress events that children might experience?


Can mass timber help students develop stress management skills?





The term 'biophilia' was coined by E.O. Wilson to label the attraction that humans feel towards living things.

Research Framework
Biophilic Design

A young girl with two braids, wearing a green denim shirt, is seen from behind, raising her right hand in a classroom. Other students' hands are also visible in the background, raised. The scene is set in front of a green chalkboard.

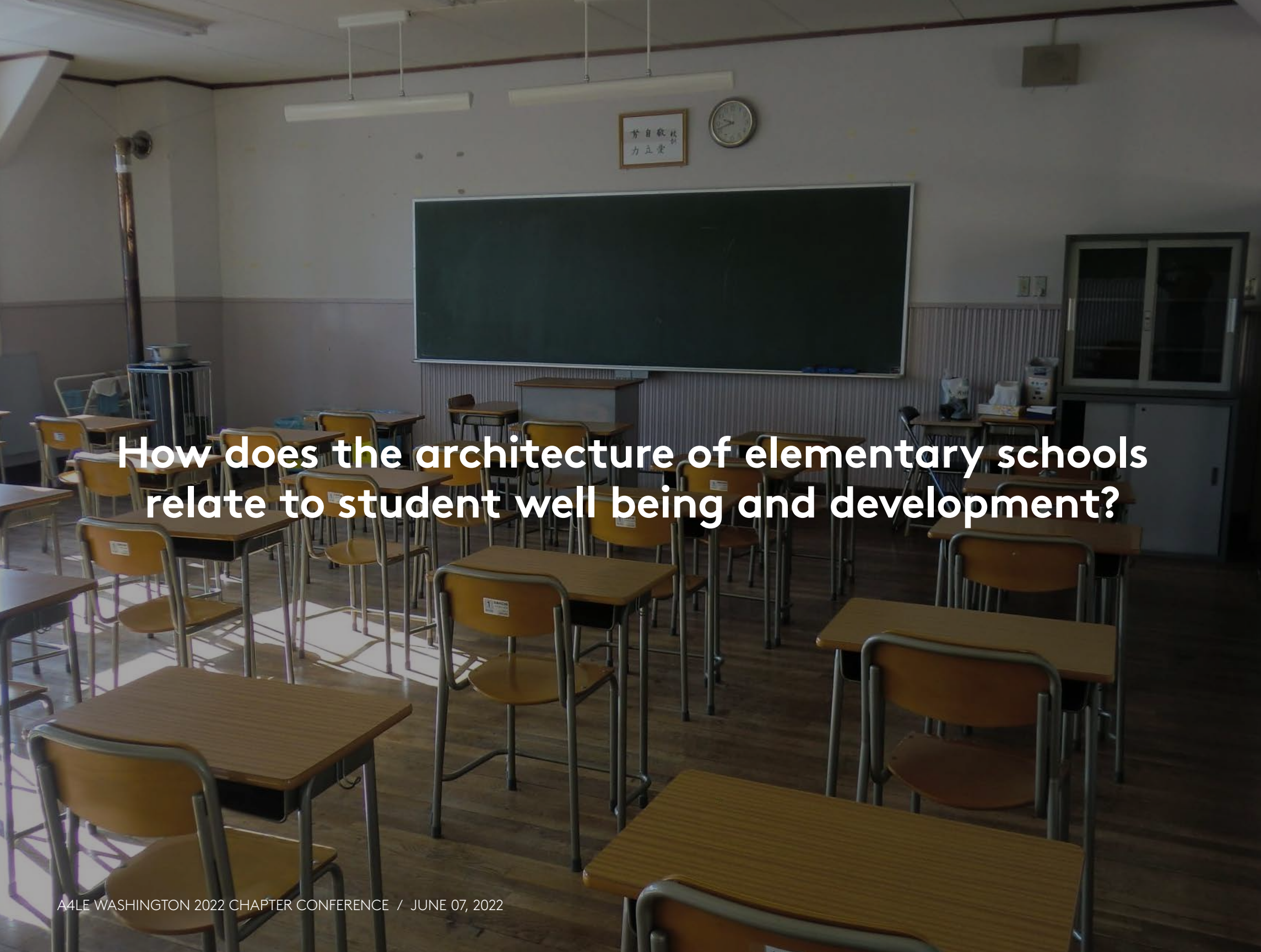
Students are better able to learn when they are less stressed, more attentive, more self-disciplined, and more engaged – all of which are qualities that can be increased from time in nature.

Research Framework
Biophilia and Children



This research focuses on children in kindergarten, first, second, and third grade between the ages of five to nine. This group is at a crucial stage in their development, particularly in relation to how they learn and experience school.

Research Framework
Demographic



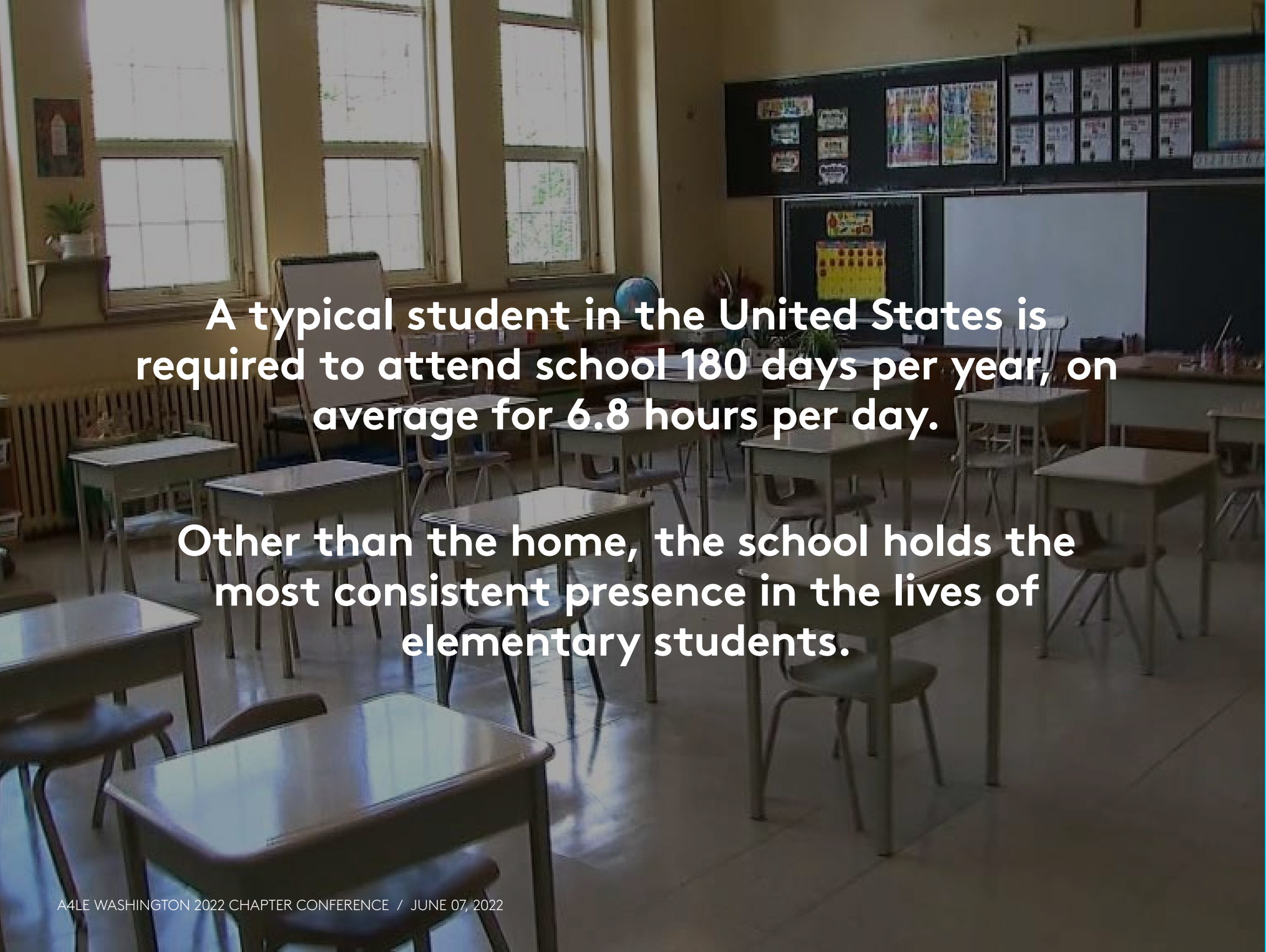
How does the architecture of elementary schools relate to student well being and development?

Research Framework
The Impact of School Design



Studies in environmental psychology prove that our environments matter and can prevent mental illness and improve mental health.

Research Framework
The Impact of School Design



A typical student in the United States is required to attend school 180 days per year, on average for 6.8 hours per day.

Other than the home, the school holds the most consistent presence in the lives of elementary students.

Research Framework
The Impact of School Design



If school environments can impact students, what is currently being done to ensure that these spaces are optimal for well being and learning?

Research Framework
The Impact of School Design

Research Framework Introduction

STAKEHOLDERS

- Students
- Teachers
- Administrators
- Staff
- Facilities
- Community

DESIGN

- Individualization/
Flexibility
- Safety/Security
- School Size
- Physical Environment
- Common/Shared space
- Technology

INFLUENCES

- Budget
- Timeline
- Building Code
- Standards
- Regulations
- Guidelines

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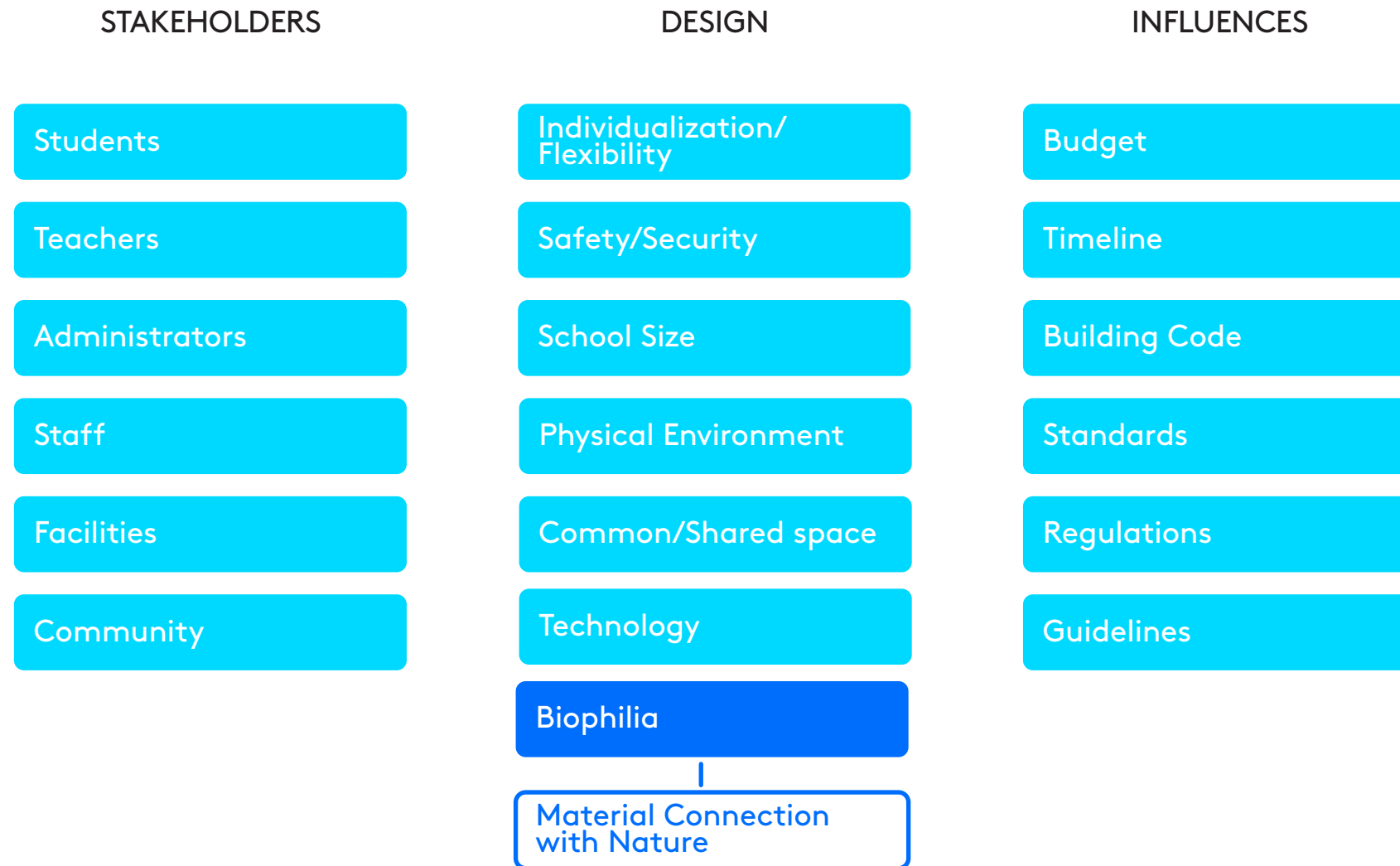
DESIGN

- Individualization/
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- School Size
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- Biophilia

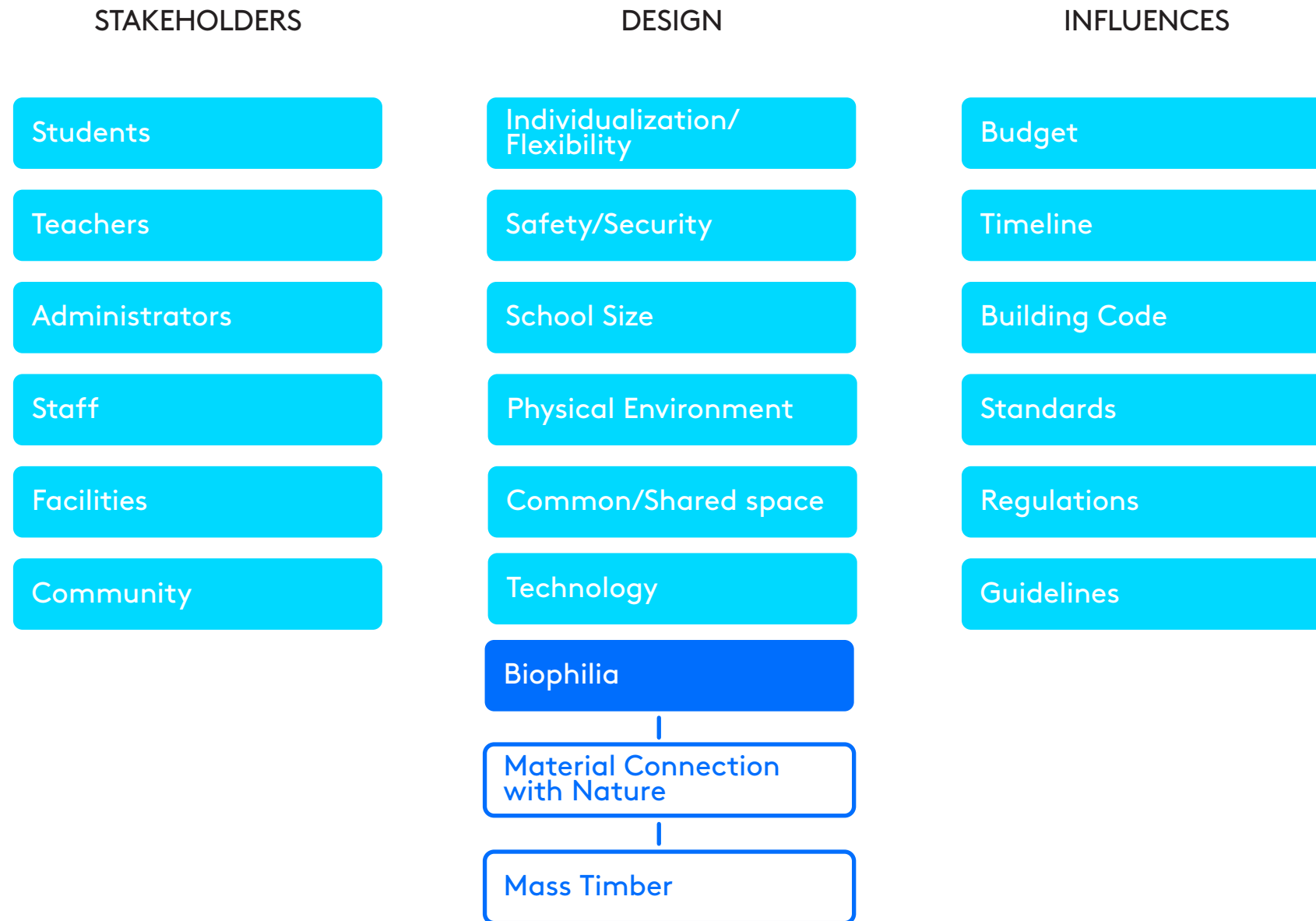
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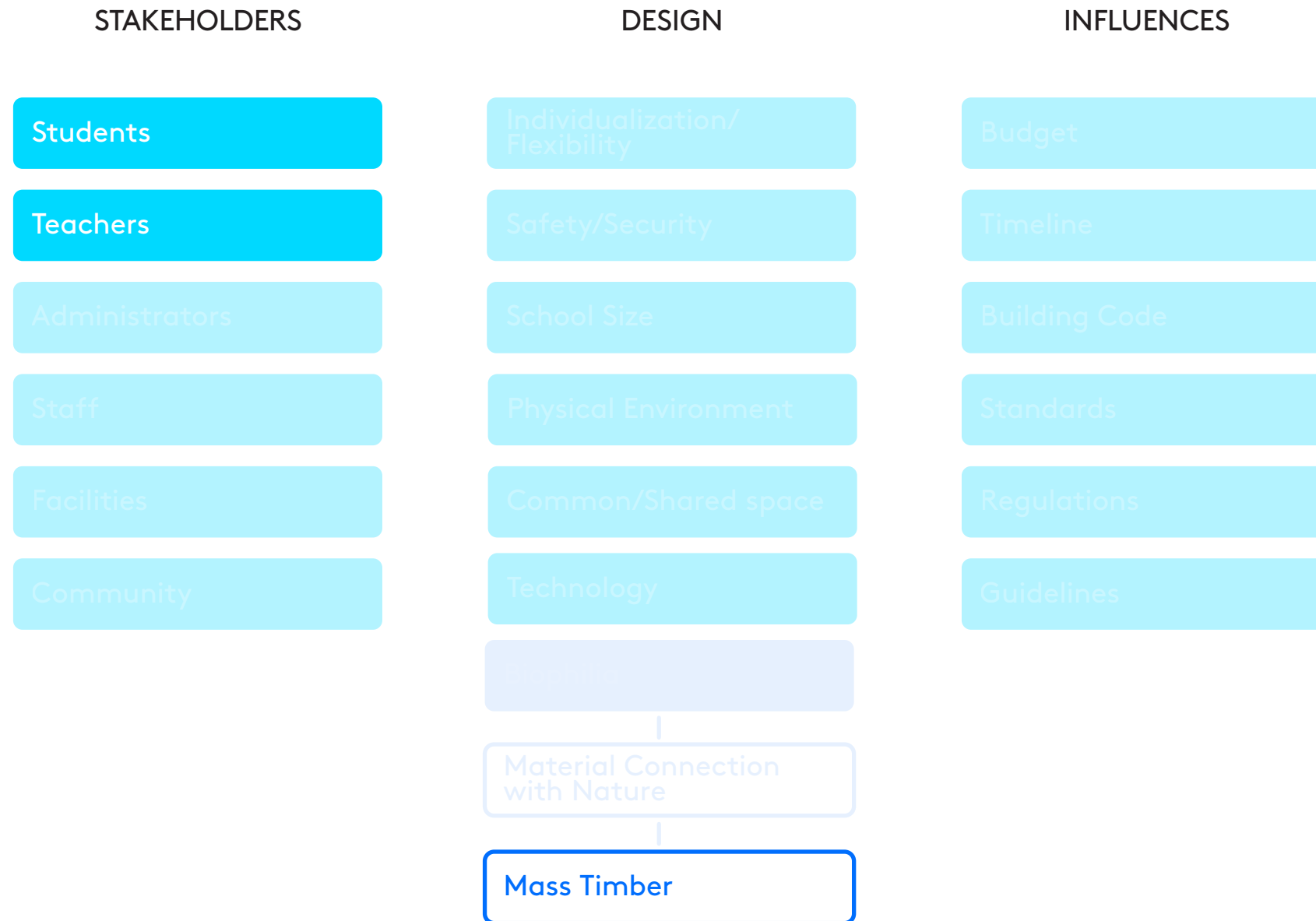
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Research Framework Introduction



Research Framework Introduction



Research Topics

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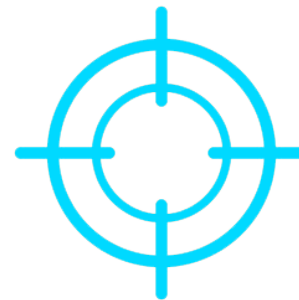


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Commitment to Learning

- Achievement Motivation:** Child is encouraged to remain curious and shows interest in academic success.
- Learning Engagement:** Child enjoys learning and is excited to go to school.
- Bonding to School:** Child feels a sense of belonging at school.

Positive Values

- Caring:** Adults help child further develop empathy, understanding, and a desire to support others.
- Equality and Social Justice:** Child is concerned about the rules and being fair to others.
- Integrity:** Child develops sense of right and wrong.
- Self-Regulation:** Child develops skills in emotional regulation and understanding the importance of healthy choices.

Positive Identity

- Personal Power:** Child develops a growing sense of influence and control over what happens.
- Self-Esteem:** Child feels an internal sense of value and feels valued by others.
- Positive view of Personal future:** Child has a growing curiosity about the world and their place in it.

Literature + Existing Research Learning Outcomes

The following developmental assets are adapted from the Search Institute’s building blocks for healthy development for children between the ages of five to nine. These assets are thought to help children become responsible, healthy, and caring adults.

The assets included are those that may be supported by biophilic design and mass timber.



Kindergarten

Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live.

Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.

1st Grade

Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.

Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

2nd Grade

Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties

Literature + Existing Research Curriculum

Next Generation Science Standards



Health

Increased comfort
Decreased blood pressure and heart rate
Reduced Stress
Quicker stress recovery

Mood

Positive emotions such as warmth, comfort,
and relaxation

Long Term Impact

80 percent of Ocean Discovery Institute students
who have participated in the after-school or
summer program have attended a four-year
college or university.

Stress during childhood can lead to mental
disorders later in life. School is one of the major
stressors of children, so reducing stress in school
may lead to healthier adults.

Literature + Existing Research *Resiliency*

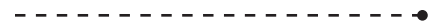


University of Washington ARC:

School as Living Laboratory

Surveys Overview

Teachers: Preferences



“Connections to nature in an urban atmosphere is even more imperative when thinking about design. I think it is as important to the soul as universal design is to the needs to the body.”

-Grade 3 Teacher, MA

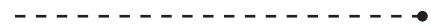
Teachers: Observation



28.6% of teachers reported that students in a wood rich classroom focus easily, in comparison to 7.1% of students in a classroom that is not wood rich.



Students



“I think wood is peaceful and I like nature so wood makes me calm peaceful, and happy.”

- Grade 3 student, WA



Surveys

Jefferson Elementary School - Mount Vernon, WA

Maple Elementary School - Seattle, WA

Grey Wolf Elementary School - Sequim, WA

C.W. Morey Elementary School - Lowell, MA

University of Washington ARC:

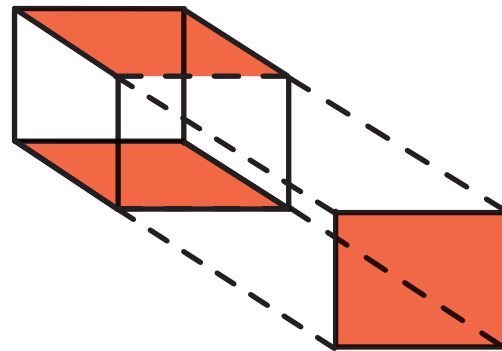
School as Living Laboratory

Teacher Surveys

Teacher Survey Groups

WOOD RICH CLASSROOM

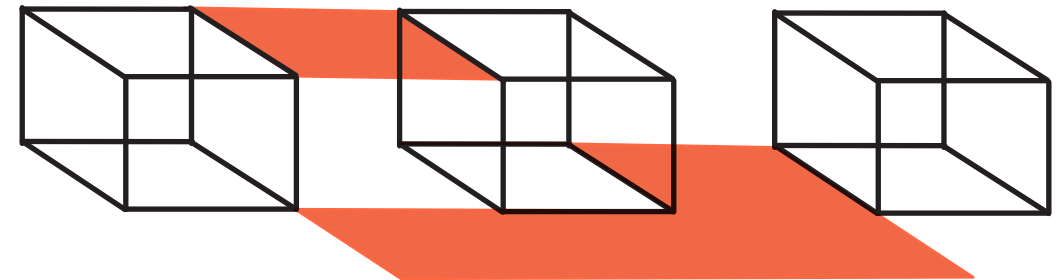
Exposed wood elements include:
ceiling and wall(s) in classrooms



Maple Elementary School- Seattle, WA
Jefferson Elementary School - Mt. Vernon, WA
Grey Wolf Elementary School - Sequim, WA
C.W. Morey Elementary School- Lowell, MA

WOOD RICH SCHOOL

Exposed wood elements include:
beams and ceilings in common spaces



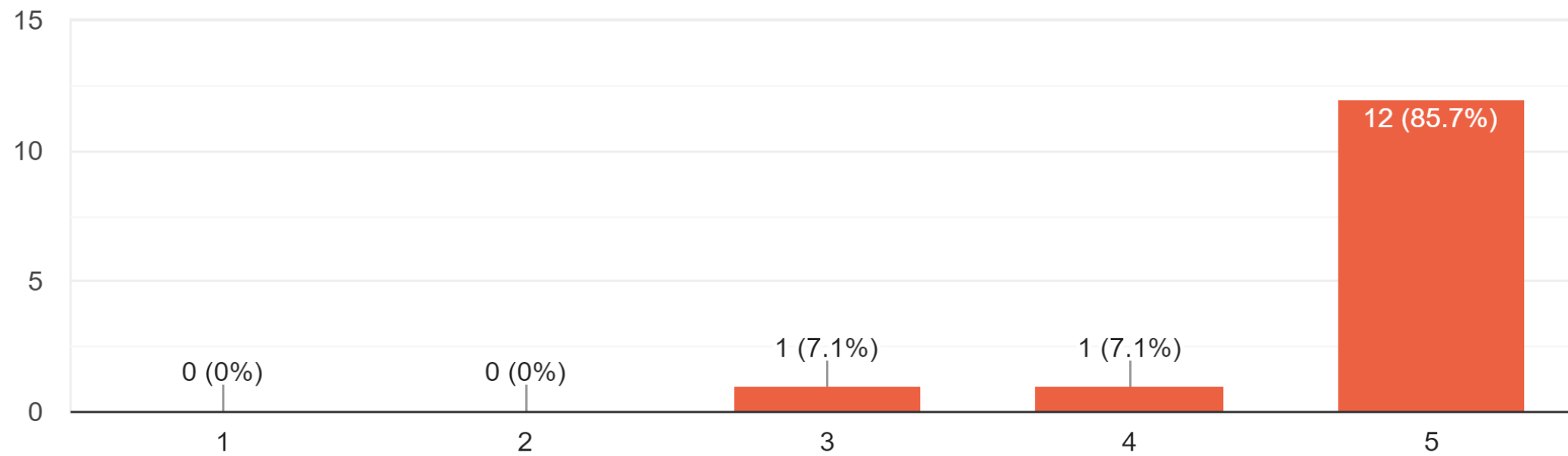
C.W. Morey Elementary School- Lowell, MA

Information is gathered from teachers who are in wood rich schools and/or classrooms to understand how their experience differs from teaching experiences in a standard classroom.

Teachers - Preferences

I care about the way my classroom looks.

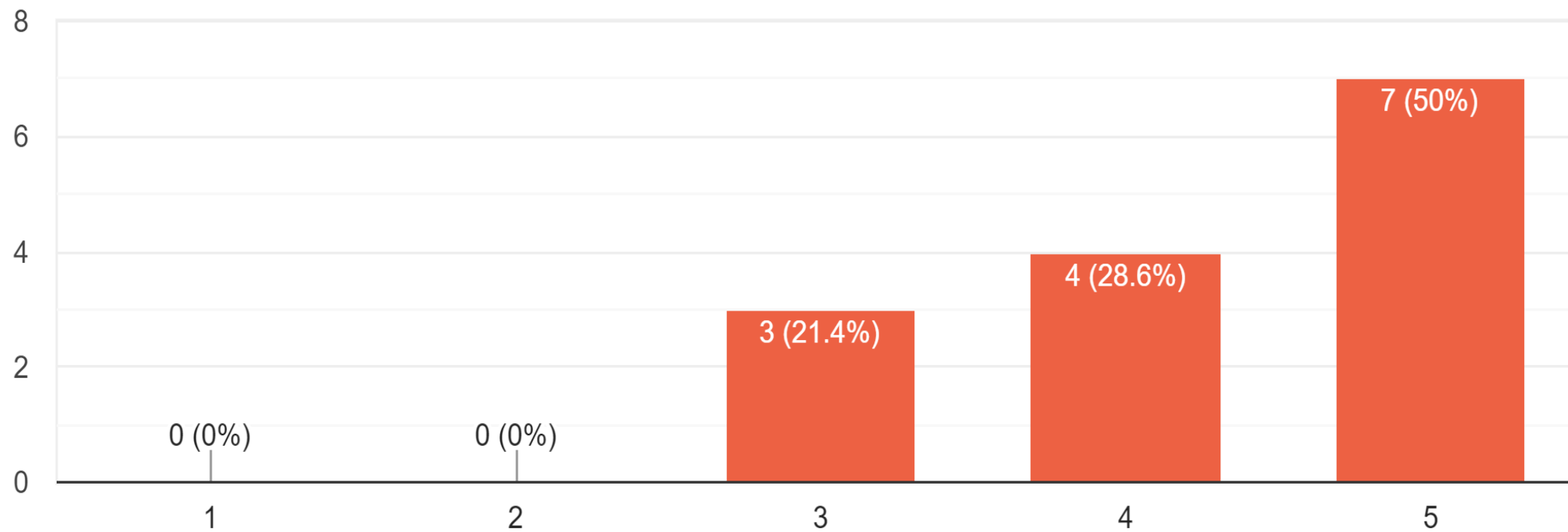
14 responses



Teachers - Preferences

I care about the architectural finishes/materials in my classroom.

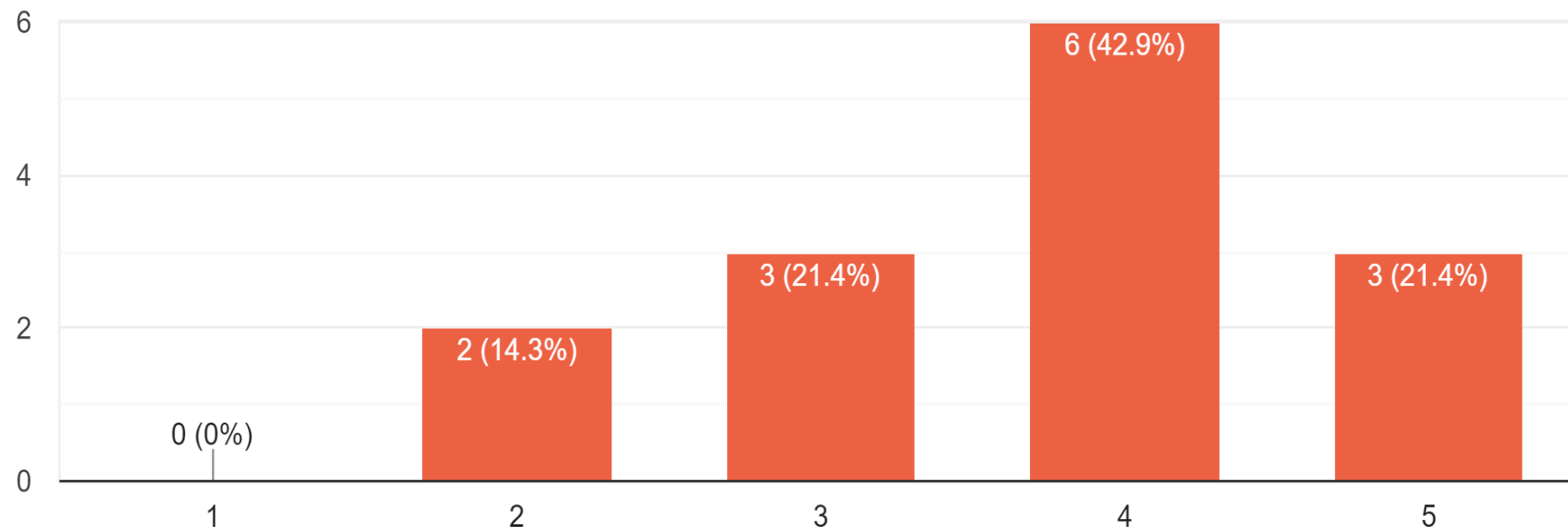
14 responses



Teachers - Preferences

The construction materials used in my classroom make a difference in the way I feel when I teach.

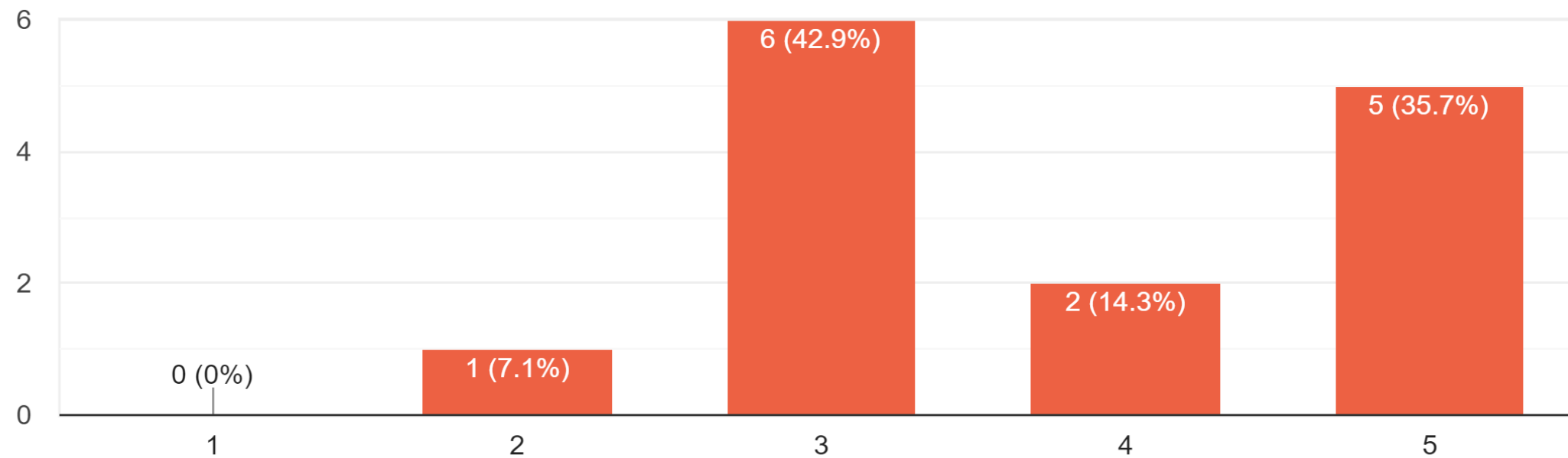
14 responses



Teachers - Preferences

I prefer teaching in a classroom with exposed wood features.

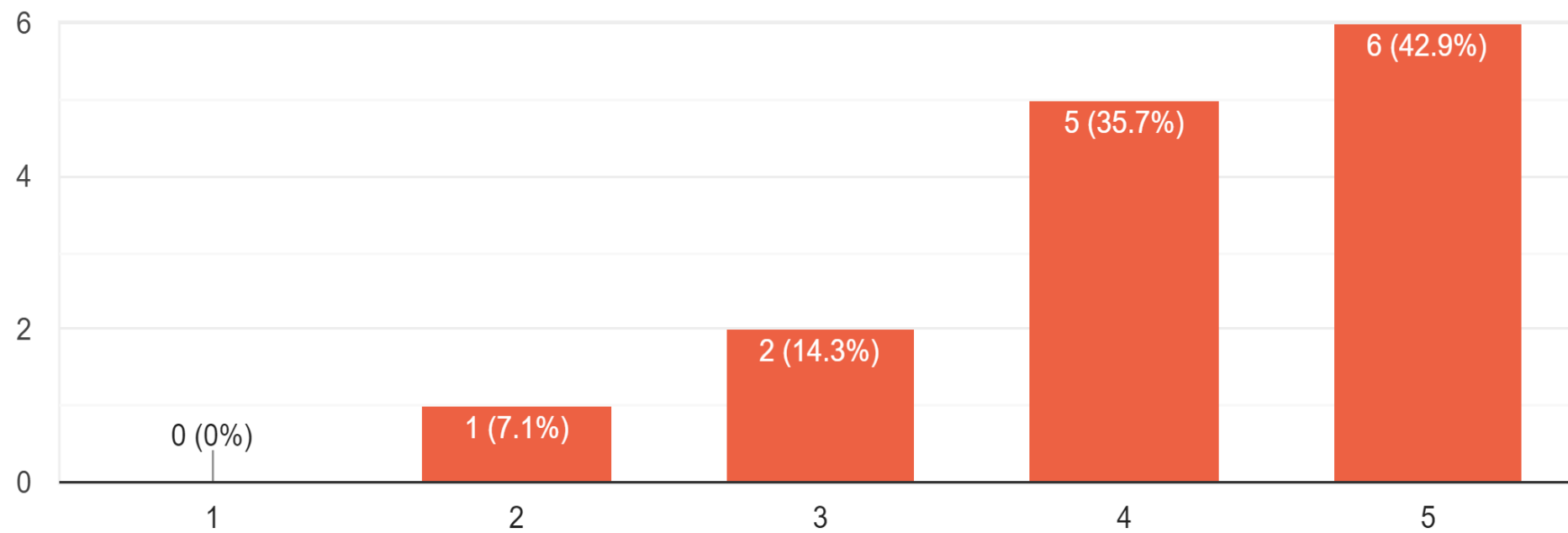
14 responses



Teachers - Preferences

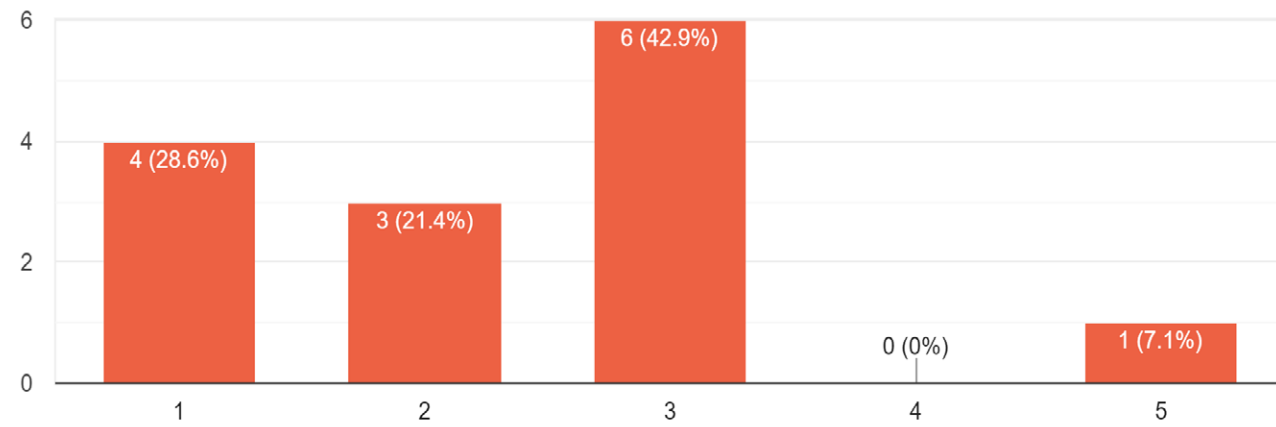
I enjoy having wood in my classroom.

14 responses



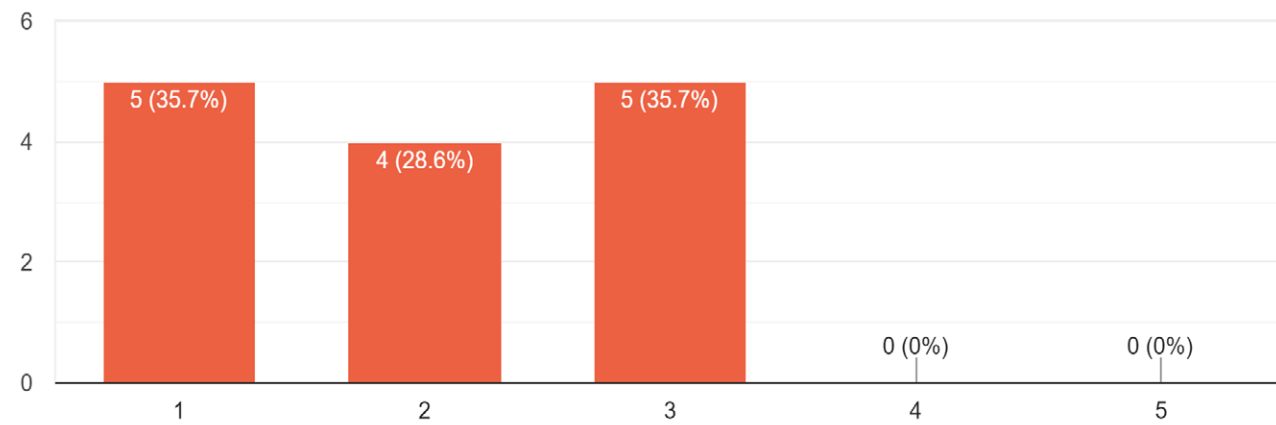
Students notice the wood in their surroundings

14 responses



Students interact with the wood in their surroundings

14 responses



Teachers - Observations *Learning Outcomes*

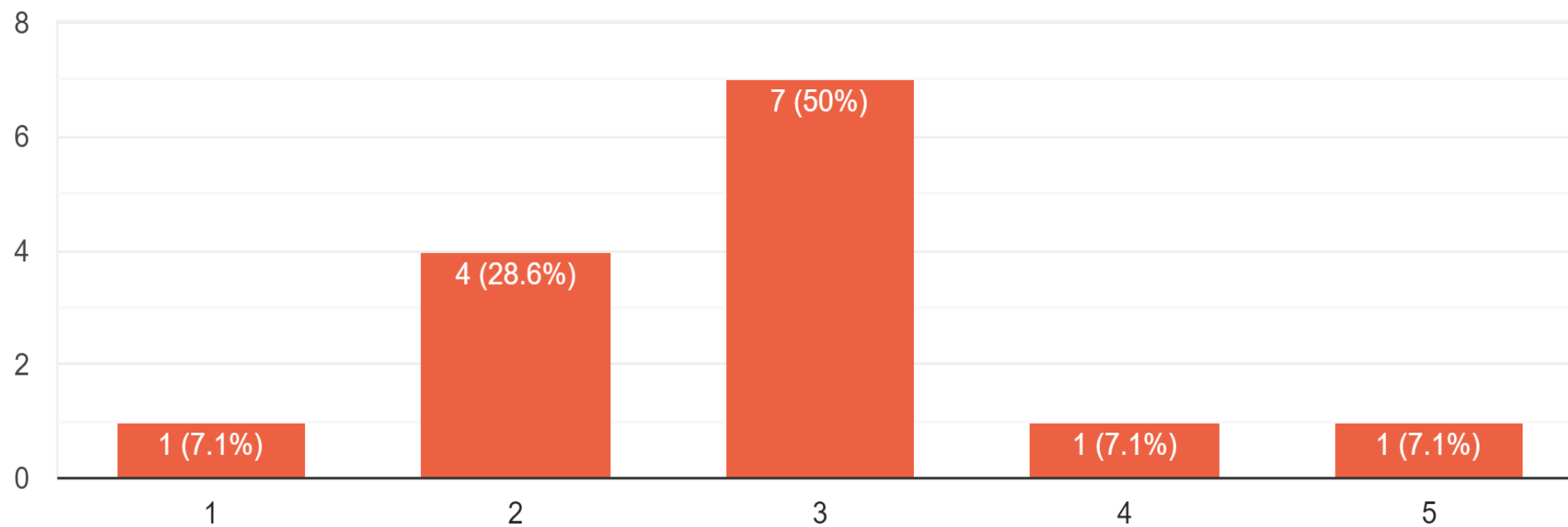


Teachers - Observations *Curriculum*



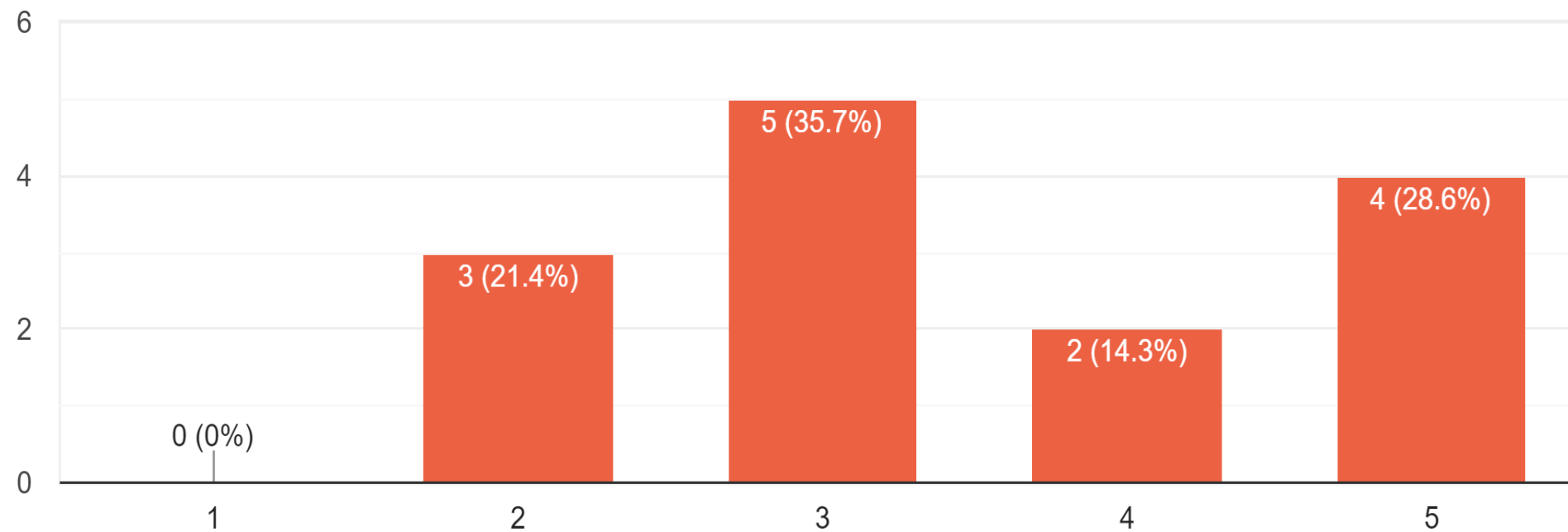
Buildings with wood elements provide ecological learning opportunities:

14 responses



Students can implicitly learn lessons from their surroundings

14 responses



Teachers - Observations *Curriculum*



University of Washington ARC:

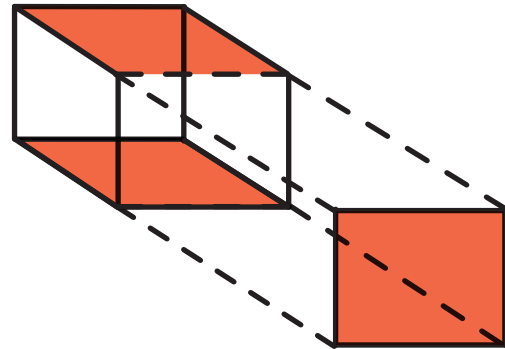
School as Living Laboratory

Student Surveys

Student Survey Groups

WOOD RICH CLASSROOM

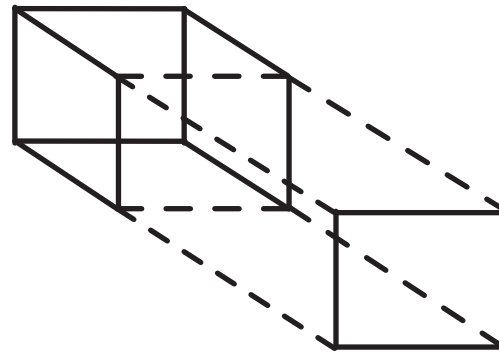
Exposed wood elements include:
ceiling and wall(s) in classrooms



Maple Elementary School- Seattle, WA
C.W. Morey Elementary School- Lowell, MA

STANDARD CLASSROOM

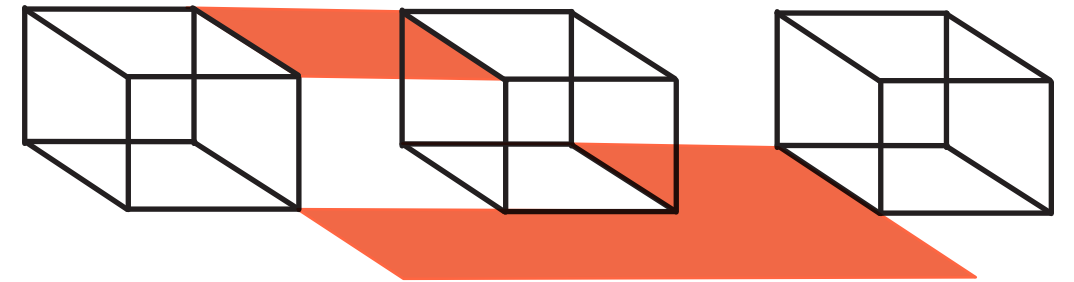
Gypsum walls and concrete, tile or
carpet floors



Maple Elementary School

WOOD RICH SCHOOL

Exposed wood elements include:
beams and ceilings in common spaces



C.W. Morey Elementary School- Lowell, MA

80 third graders exposed to varying amounts of wood in their environment were surveyed. The experience of students in all three environments was compared in order to understand the wood impacts.



“My favorite is wood because it’s cool and smooth.”

A person with a large backpack and two children are walking away from the camera on a dirt path through a forest. The person in the middle is wearing a dark jacket and has a large backpack. To their left is a child in a bright pink jacket, and to their right is a child in a dark jacket and a striped hat. The path is surrounded by tall evergreen trees, and the lighting suggests a late afternoon or early morning setting.

Being surrounded by trees makes me feel "outside with trees".

“[Wood] feels like I am in a cozy hut.”

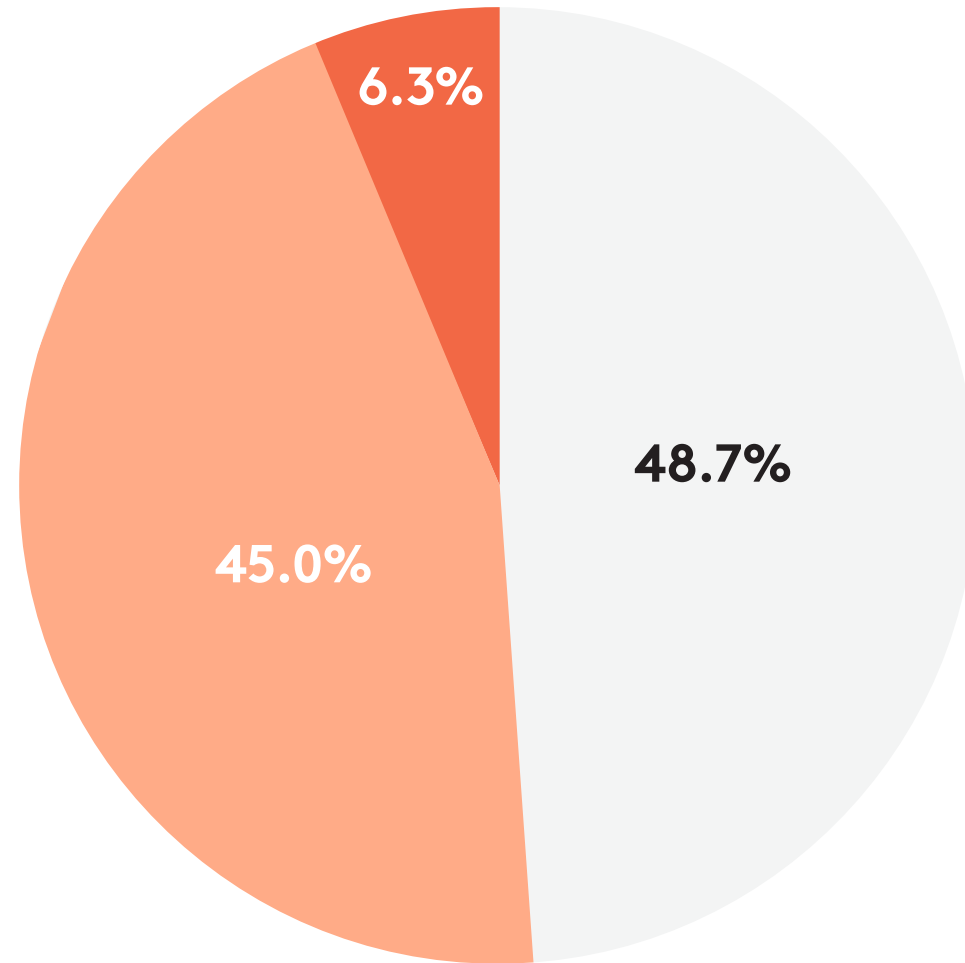


“[Wood] makes me feel at home because my house is made of wood.”



Wood is something normal.

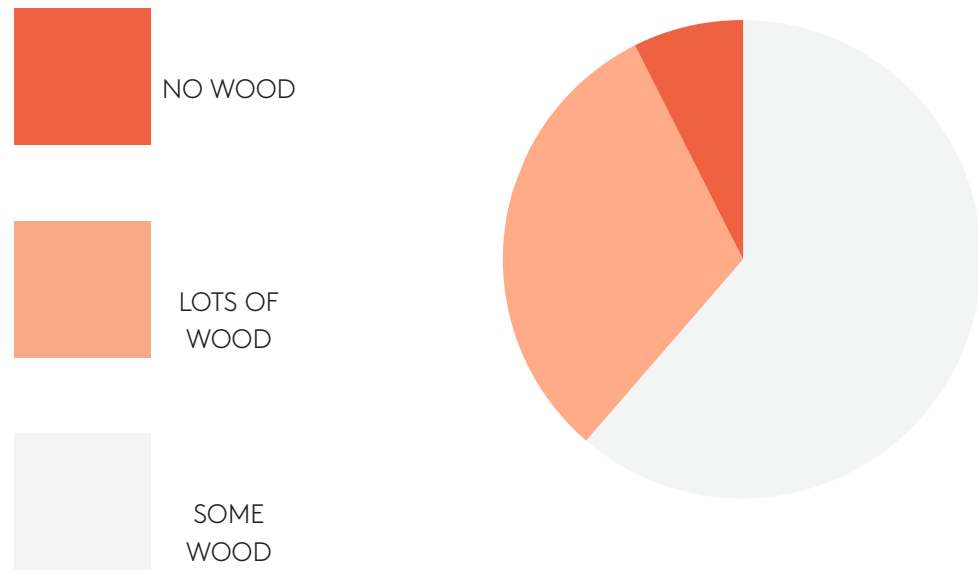
I notice when there is wood around me...



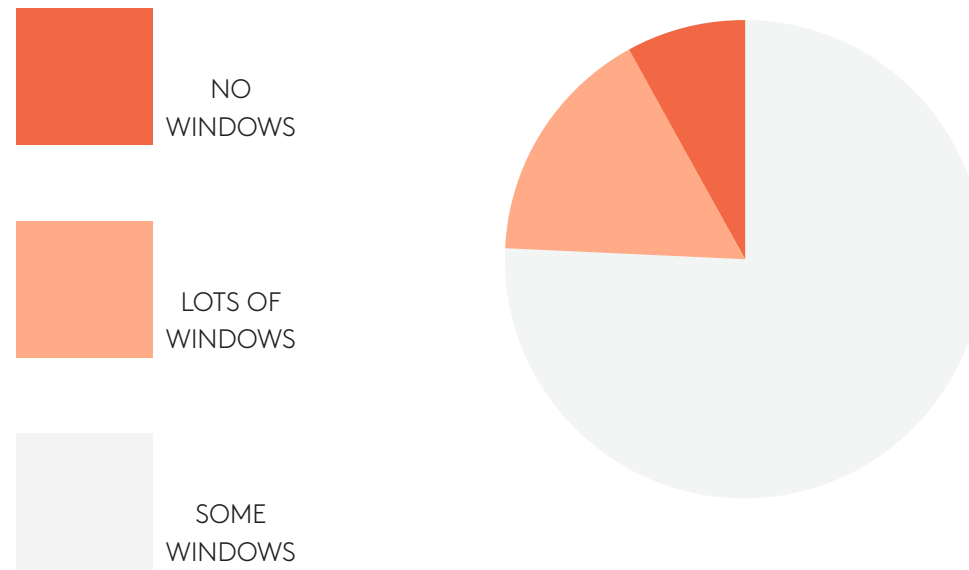
Students - Perception

Maple Elementary School - Seattle, WA
C.W. Morey Elementary School - Lowell, MA

When I think about my favorite classroom it has...



I like to learn in a classroom with...

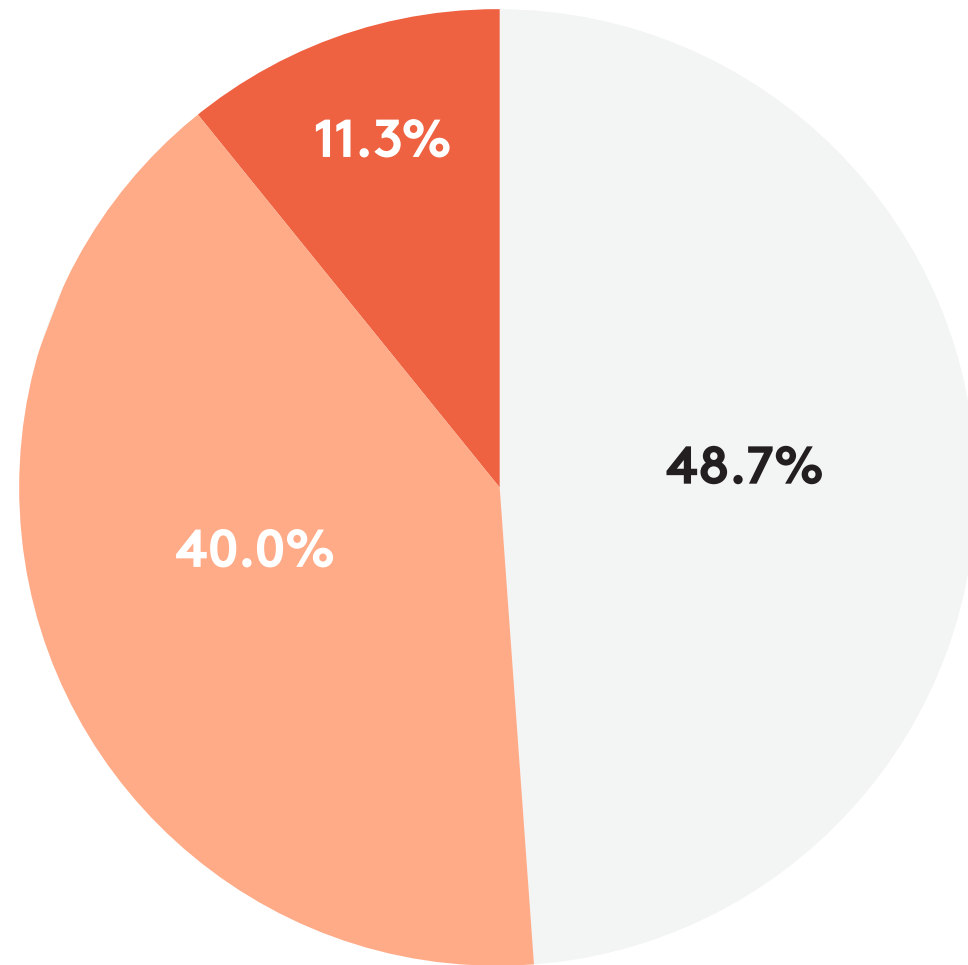


Students - Preferences

Maple Elementary School - Seattle, WA

C.W. Morey Elementary School - Lowell, MA

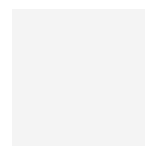
I feel more calm when I am surrounded by wood...



NO



YES



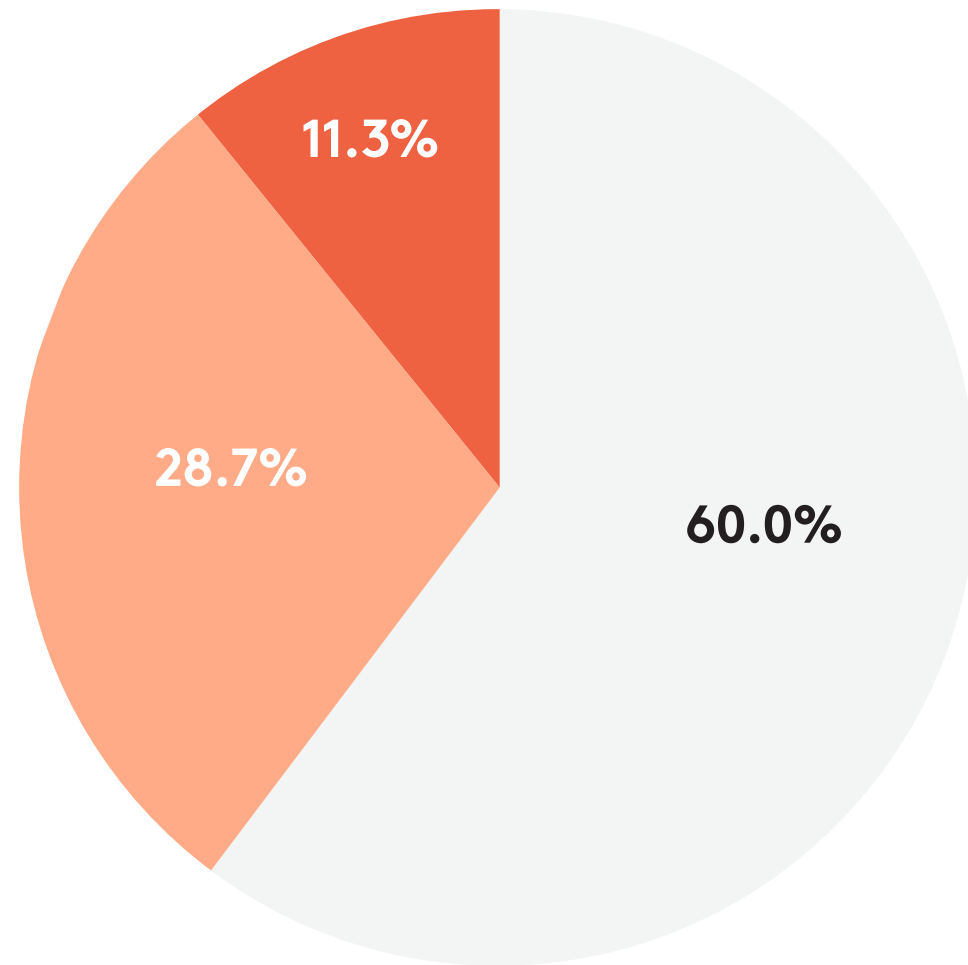
NOT SURE

Students

Maple Elementary School - Seattle, WA

C.W. Morey Elementary School - Lowell, MA

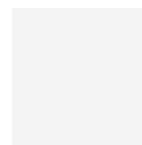
I focus better when I am surrounded by wood...



DISAGREE



AGREE



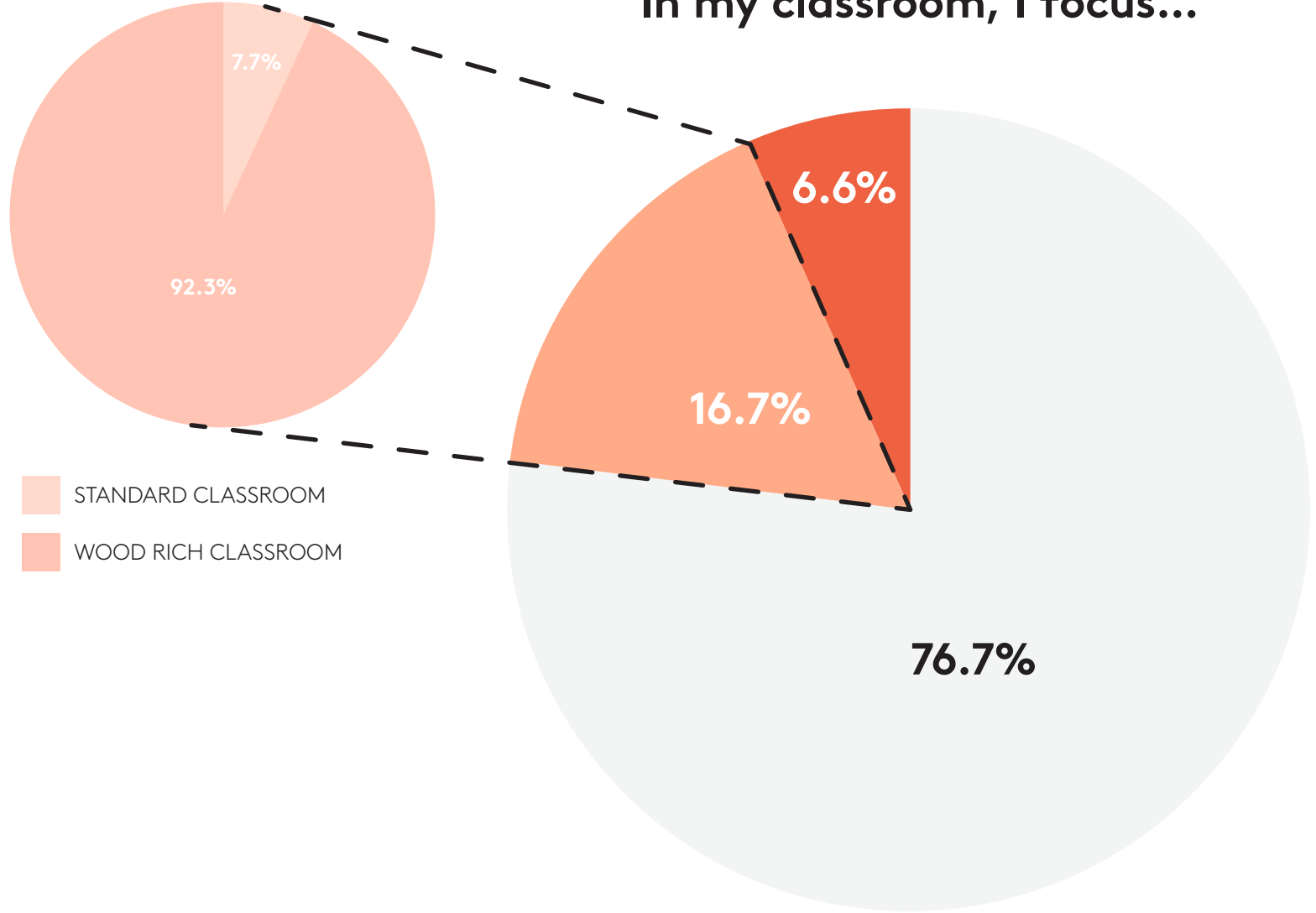
NOT SURE

Students

Maple Elementary School - Seattle, WA

C.W. Morey Elementary School - Lowell, MA

In my classroom, I focus...



STANDARD CLASSROOM
WOOD RICH CLASSROOM

WITH DIFFICULTY EASILY OKAY

Students

Maple Elementary School - Seattle, WA

University of Washington ARC:

School as Living Laboratory

The literature and research show a correlation between mass timber and learning outcomes, curriculum, and resiliency.

Teacher Responses

LEARNING OUTCOMES

Teachers observe that students may or may not notice the wood around them.



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LEARNING OUTCOMES

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CURRICULUM

28.6% of teachers reported that students in a wood rich classroom focus easily, in comparison to 7.1% of students in a classroom that is not wood rich.



Teacher Responses

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RESILIENCY

Teachers care about the way their classroom looks, including the architectural finishes. Wood is not necessarily a preference for teachers, but it is positively received when present.



Student Responses

LEARNING OUTCOMES

Student responses convey a connection between mass timber and encouraging curiosity.

Curiosity is a major component of developmental assets.



Student Responses

LEARNING OUTCOMES

Student responses convey a connection between mass timber and encouraging curiosity.

Curiosity is a major component of developmental assets.



CURRICULUM

18% of students in a wood classroom report focusing easily versus 11% of students in a non-wood classroom



Student Responses

LEARNING OUTCOMES

Developmental assets can be supported by wood rich environments



CURRICULUM

Students focus better when surrounded by wood

Teachers may be open to using their surroundings as a teaching opportunity

Teachers do not want to compromise the ability to pin up on the walls



RESILIENCY

When asked to describe the feeling of being surrounded by wood...

26% of students included the word "calm" in their response

11% of students included the word "happy" in their response



Responses Summary

LEARNING OUTCOMES

Student responses convey a connection between mass timber and encouraging curiosity.

Curiosity is a major component of developmental assets.



CURRICULUM

18% of students in a wood classroom report focusing easily versus 11% of students in a non-wood classroom



RESILIENCY

Students' mood is positively impacted by wood in their environments

Wood spaces are familiar to students and evoke feelings of home

Some students worry about the structural integrity of wood and its ability to withstand fire



University of Washington ARC:

School as Living Laboratory

Future research

Future Questions



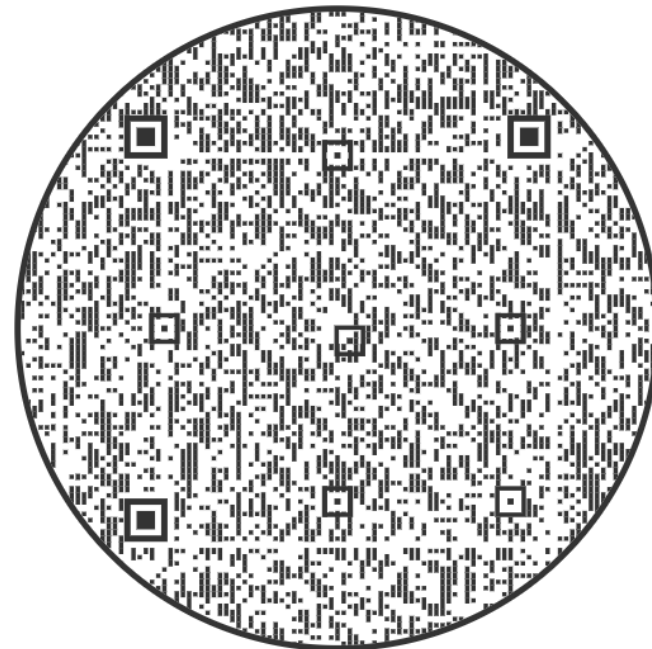
- How much surface area of mass timber is needed in the interior environment to impact students?
- Does the location of the mass timber change its impact?
- How does mass timber impact physical health?

Future Strategies

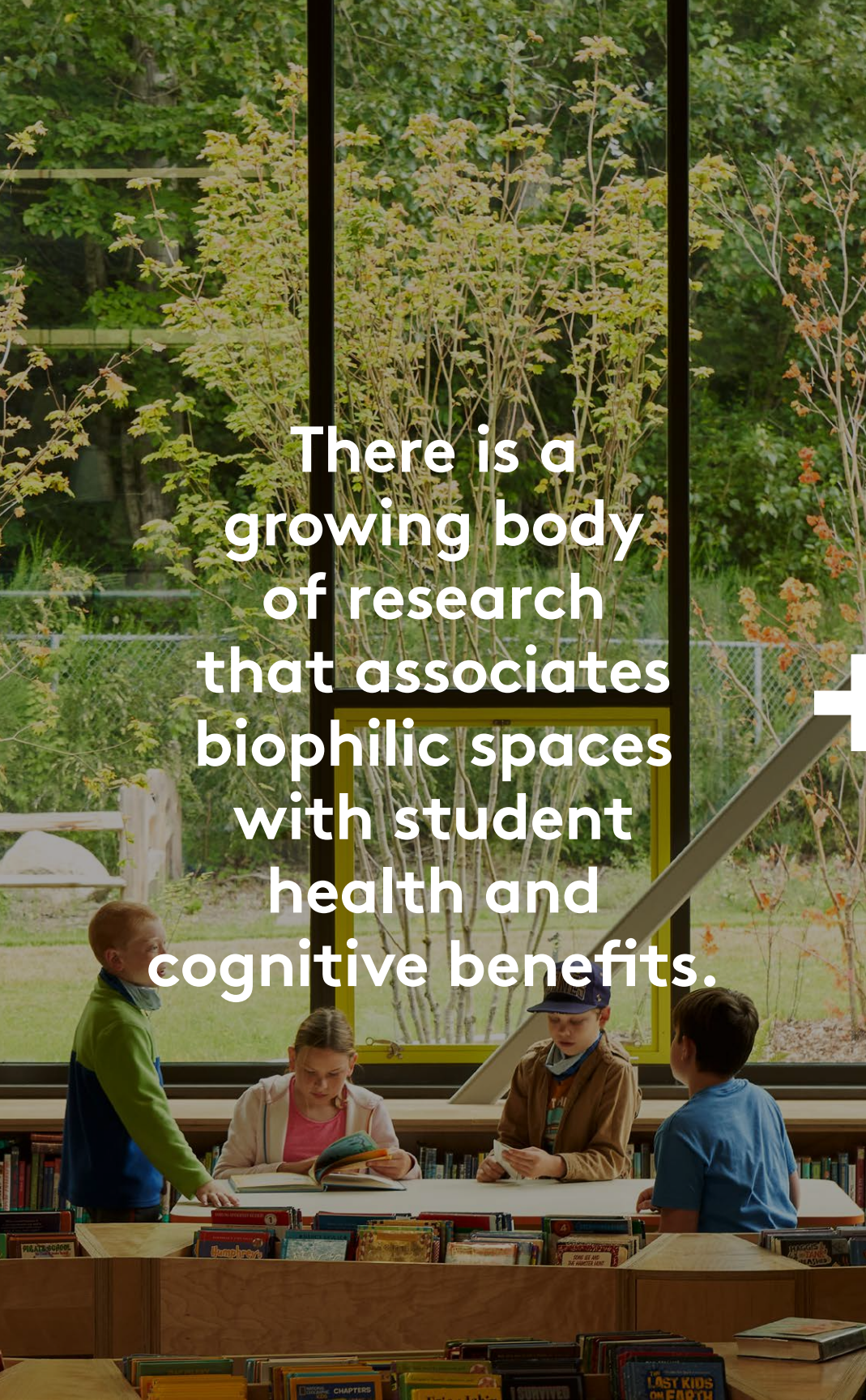


- Use biometric markers to understand how stress and focus is impacted by mass timber.
- Develop a guide that ties mass timber to curriculum.

Future Surveys / Studies



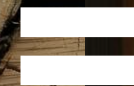
Future Research



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By combining timber technology and growing biophilic research, we can Build Better Schools.

Mithun R+D:

Building Better Schools

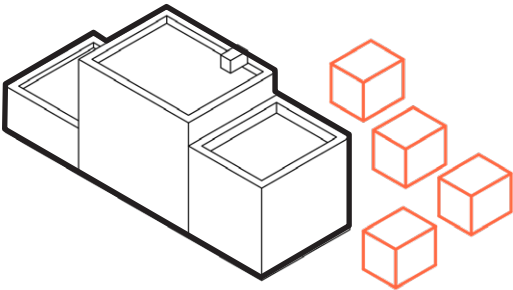
Our research findings led us to analyze four major design drivers: K-12 program components, an optimized mass timber framework, framework adaptability, and an integrated systems approach.

Education Applications



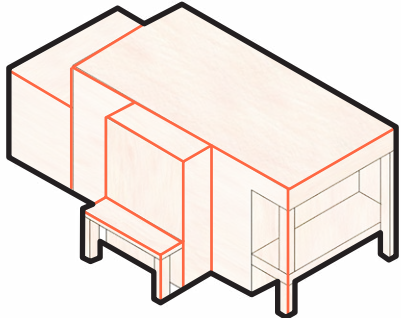
PORTABLE REPLACEMENT

Replacement of exterior portables put in place as temporary structures.



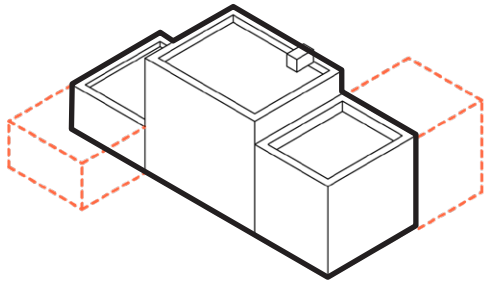
GROUND-UP CONSTRUCTION

New construction of a school including all standard program spaces.

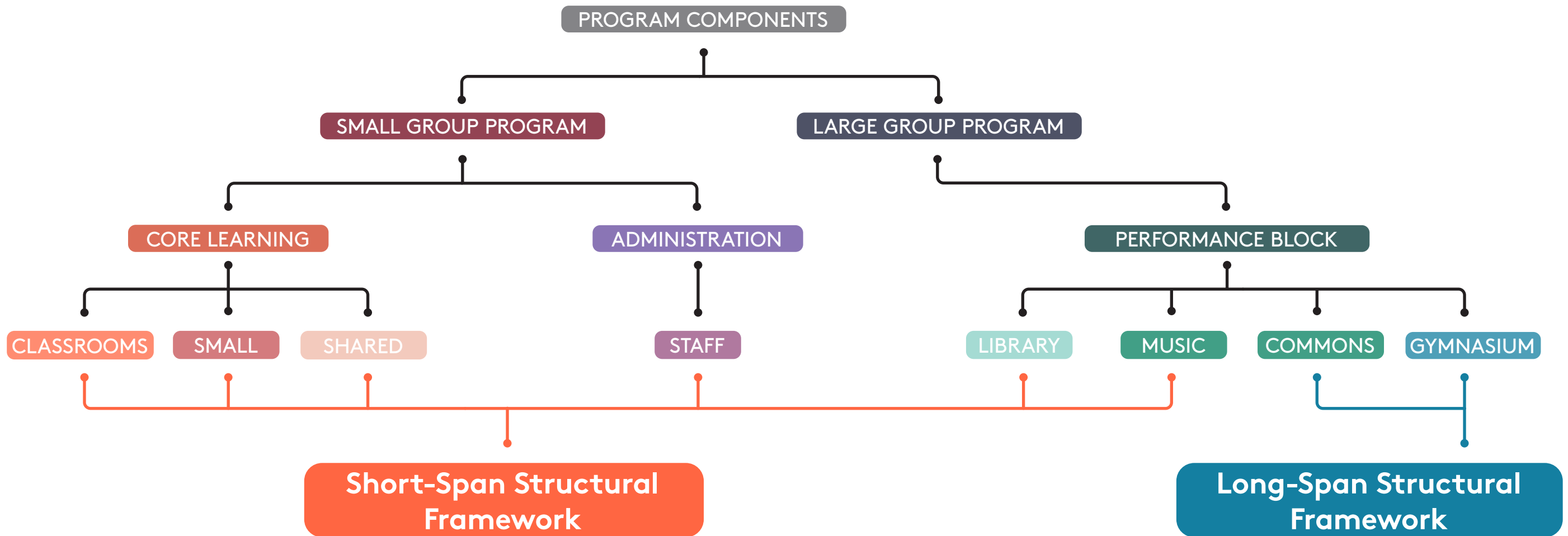


EXPANSION

An addition to an existing school that requires additional learning space due to rapid district growth.



School districts must respond to the growing population and community expansions. The systems we use to build our schools must also be able to adapt and customized to various school district needs.

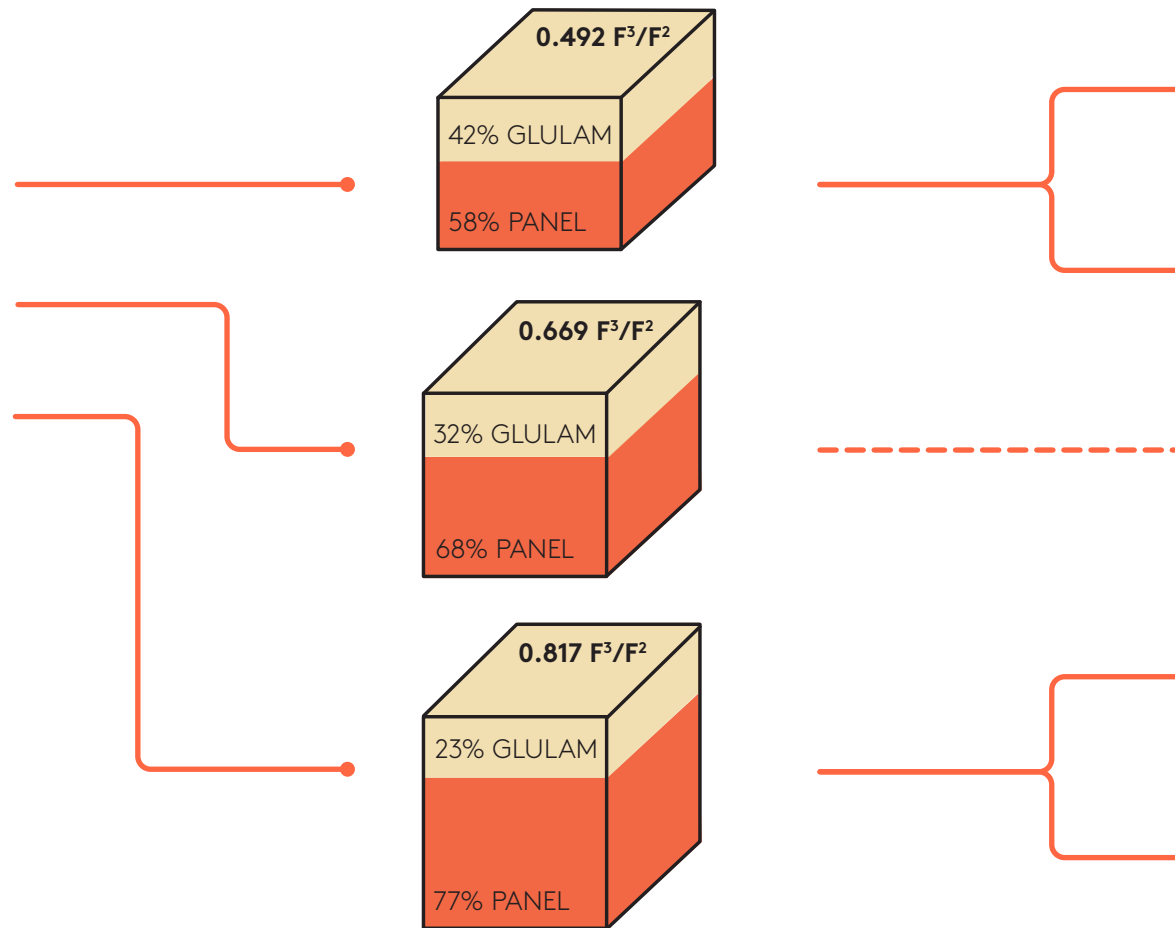


Mass timber's inherent structural properties inform a mass timber grid framework to achieve an optimal wood fiber volume efficiency. It responds to programmatic spatial requirements through either a short-span or long-span framework.

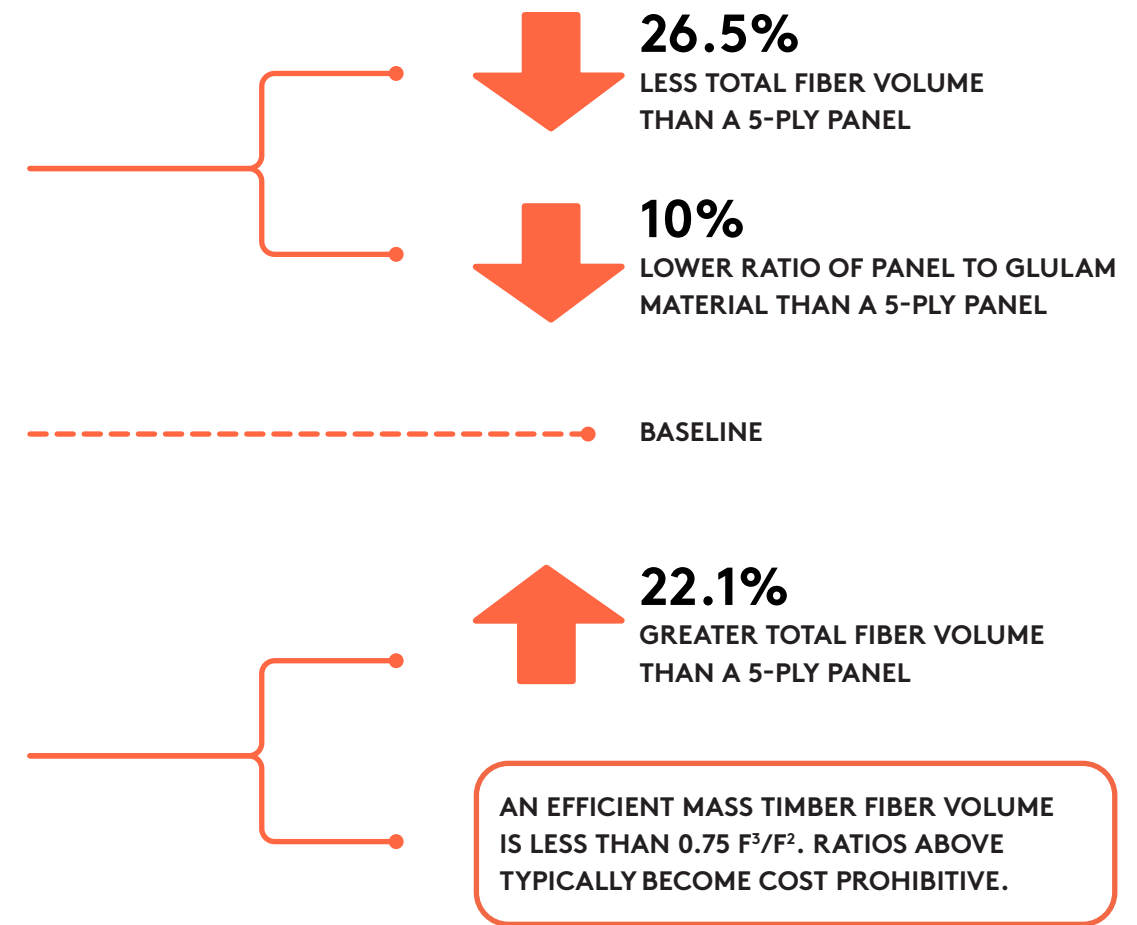
PANEL THICKNESS DRIVERS

PANEL TYPE	SPAN LIMITATIONS	FRR
3-PLY CLT	12 FEET	0 HR
5-PLY CLT	14-17 FEET	1-2 HR
7-PLY CLT	17-21 FEET	2 HR
2X4 NLT OR DLT	12 FEET	0 HR
2X6 NLT OR DLT	10-17 FEET	1-2 HR
2X8 NLT OR DLT	14-21 FEET	2 HR
5" MPP	10-15 FEET	0 HR

WOOD FIBER VOLUME OF A SINGLE STRUCTURAL BAY

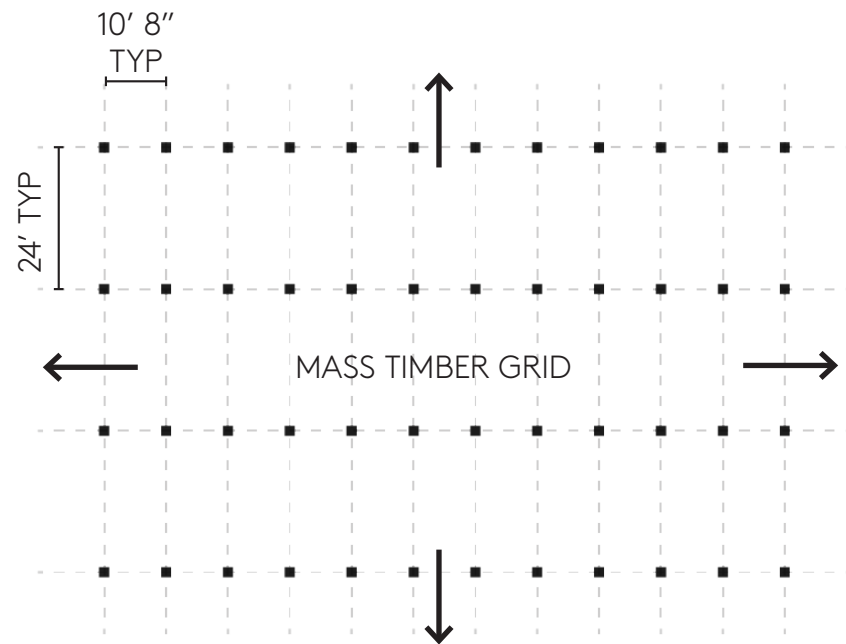


MATERIAL REDUCTION

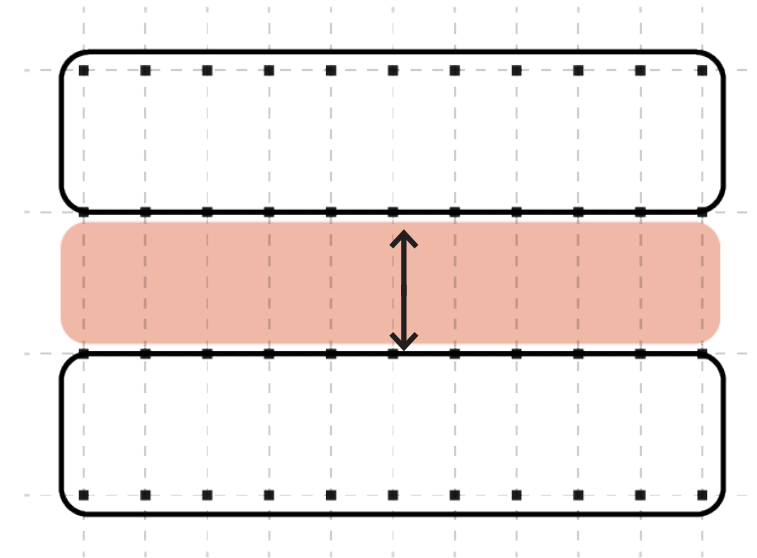


The timber panel volume is typically 65-80% of the total mass timber package volume. Thus, reducing the thickness of the floor panels has the most impact to reduce overall material costs.

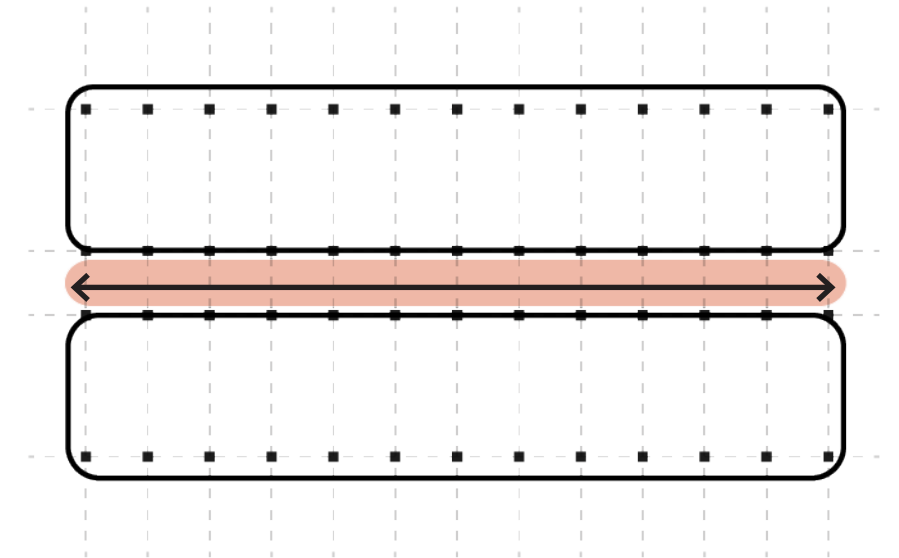
A SYSTEMS-BASED FRAMEWORK



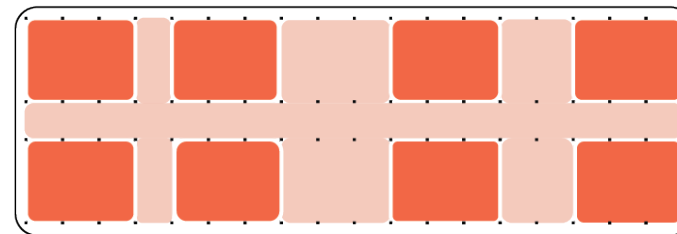
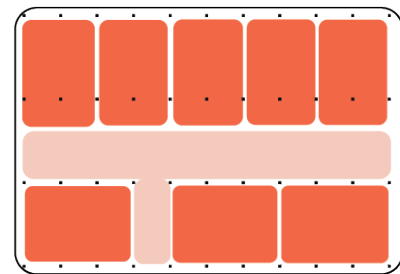
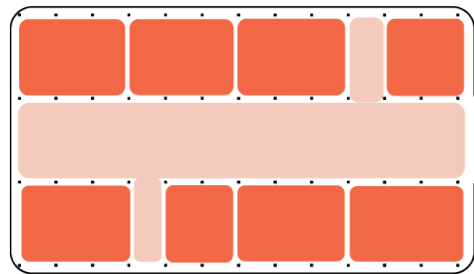
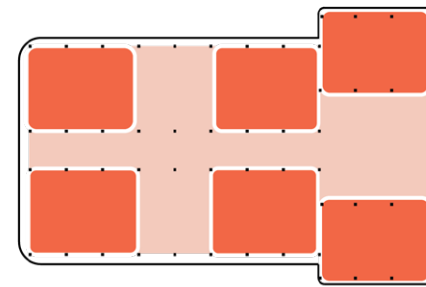
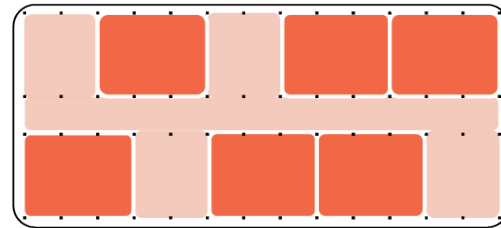
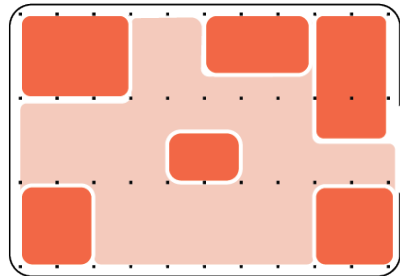
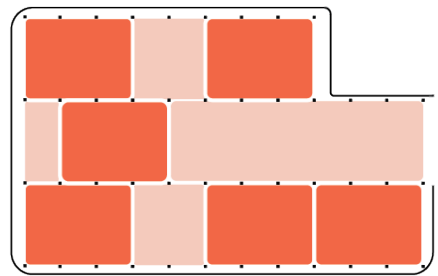
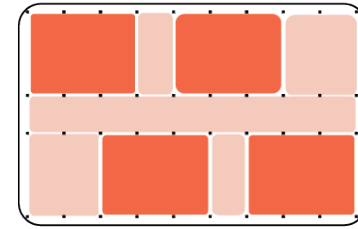
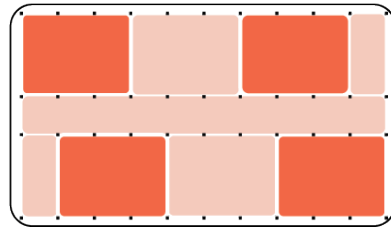
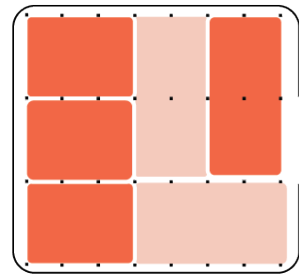
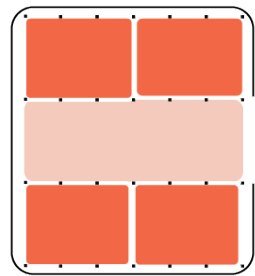
EXPANDED LEARNING



LENGTHENED LEARNING



Customization is embedded into the structural framework through a 'flexible' learning core that lengthens or expands while maintaining a comparable total learning area.

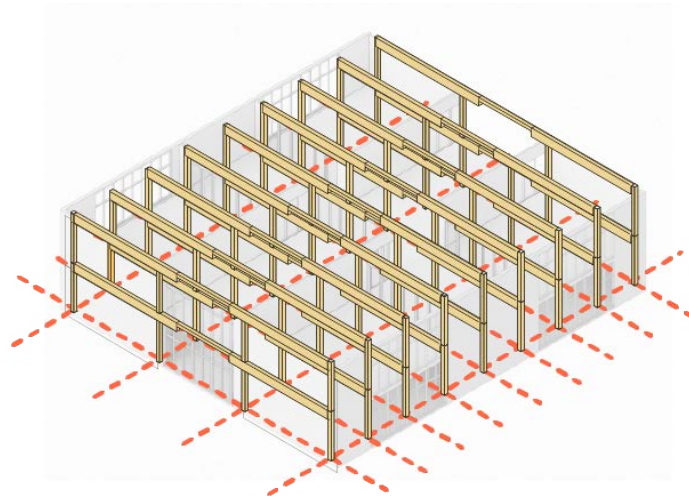


Adaptability Modeling

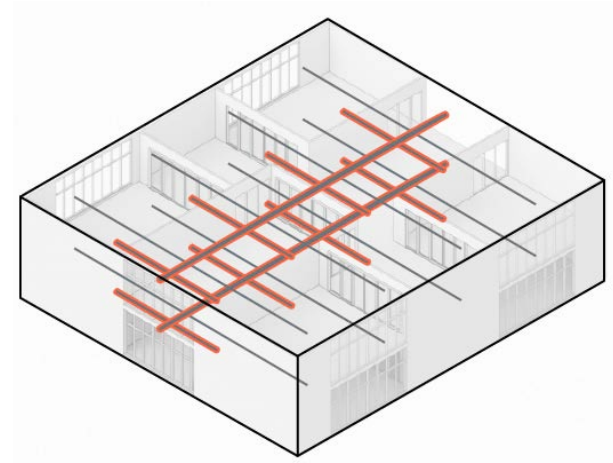
No two school districts have the same learning needs. To maximize adaptability, the mass timber framework explores ways in which the system can accommodate a range of classroom quantities, teaching pedagogies and learning area needs.

- CORE LEARNING SPACE
- SHARED LEARNING
- EXTERIOR WALL BOUNDARY

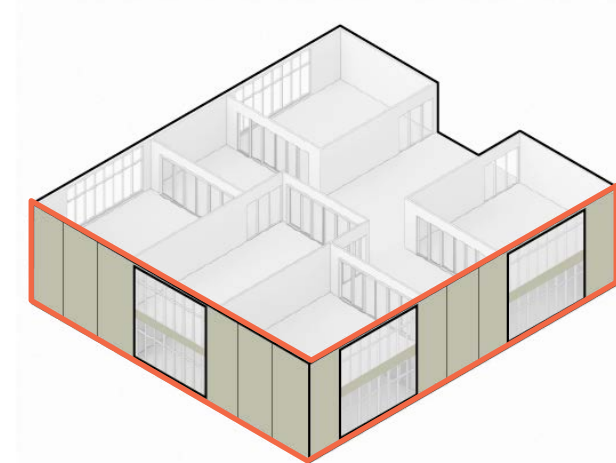
STRUCTURAL "BONES"



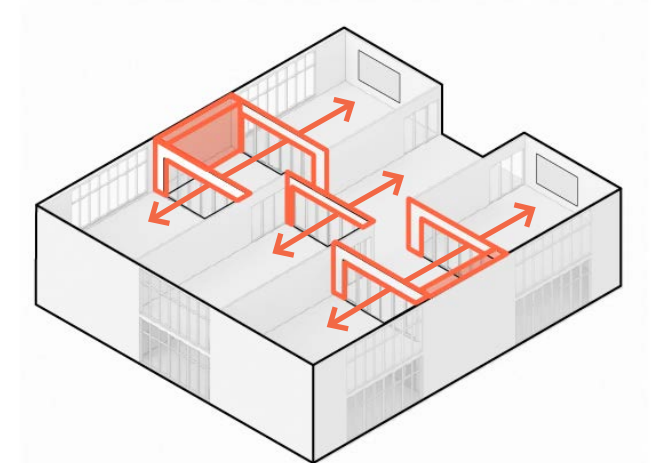
MECHANICAL SYSTEM



EXTERIOR ENCLOSURE



INTERIOR FLEXIBILITY

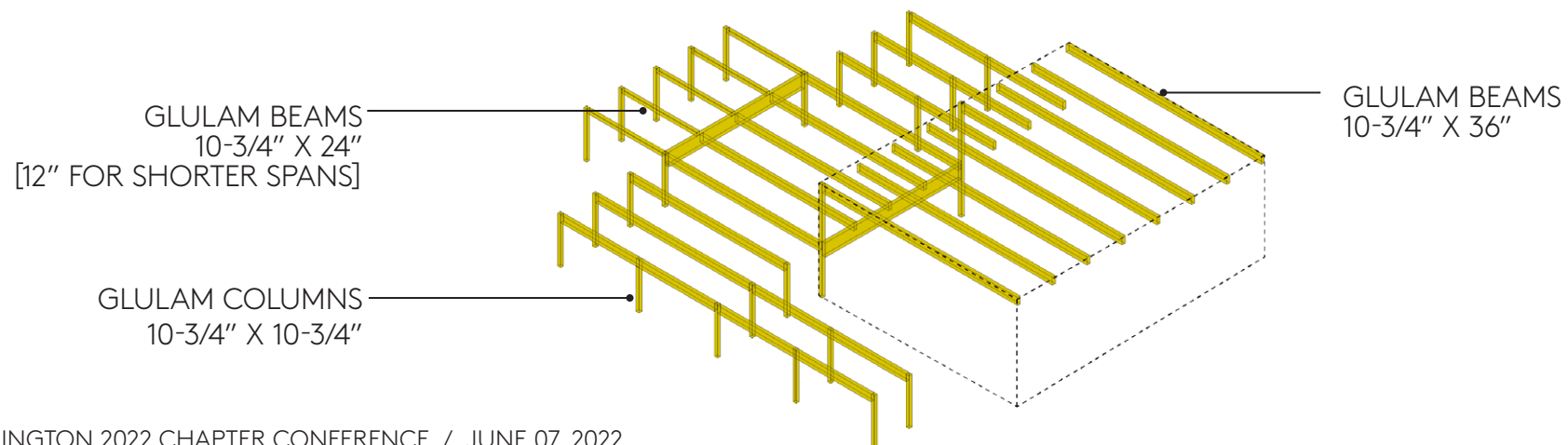
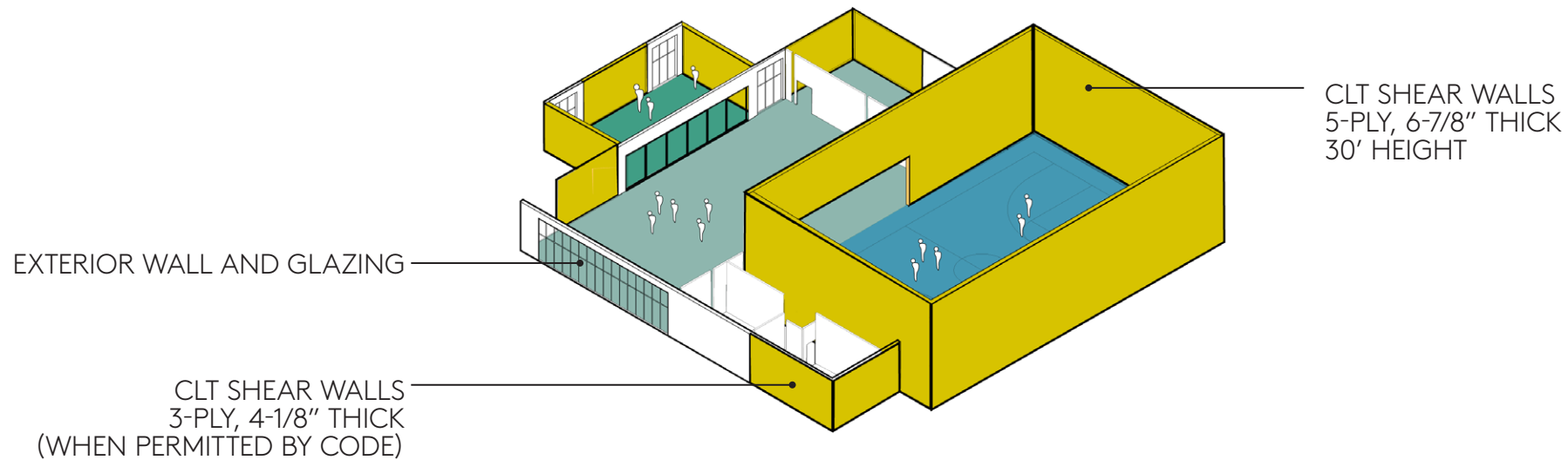
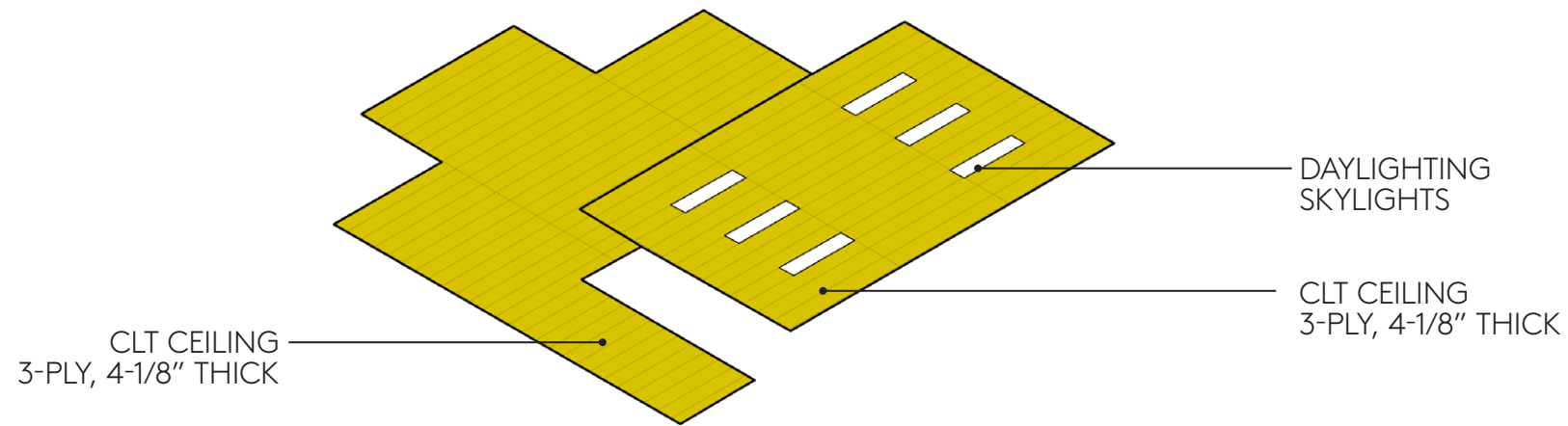


An integrated systems-based approach is important to promote flexibility, economy, and school district customization. The systems are studied concurrently to optimize intersections and improve the interior learning environment.

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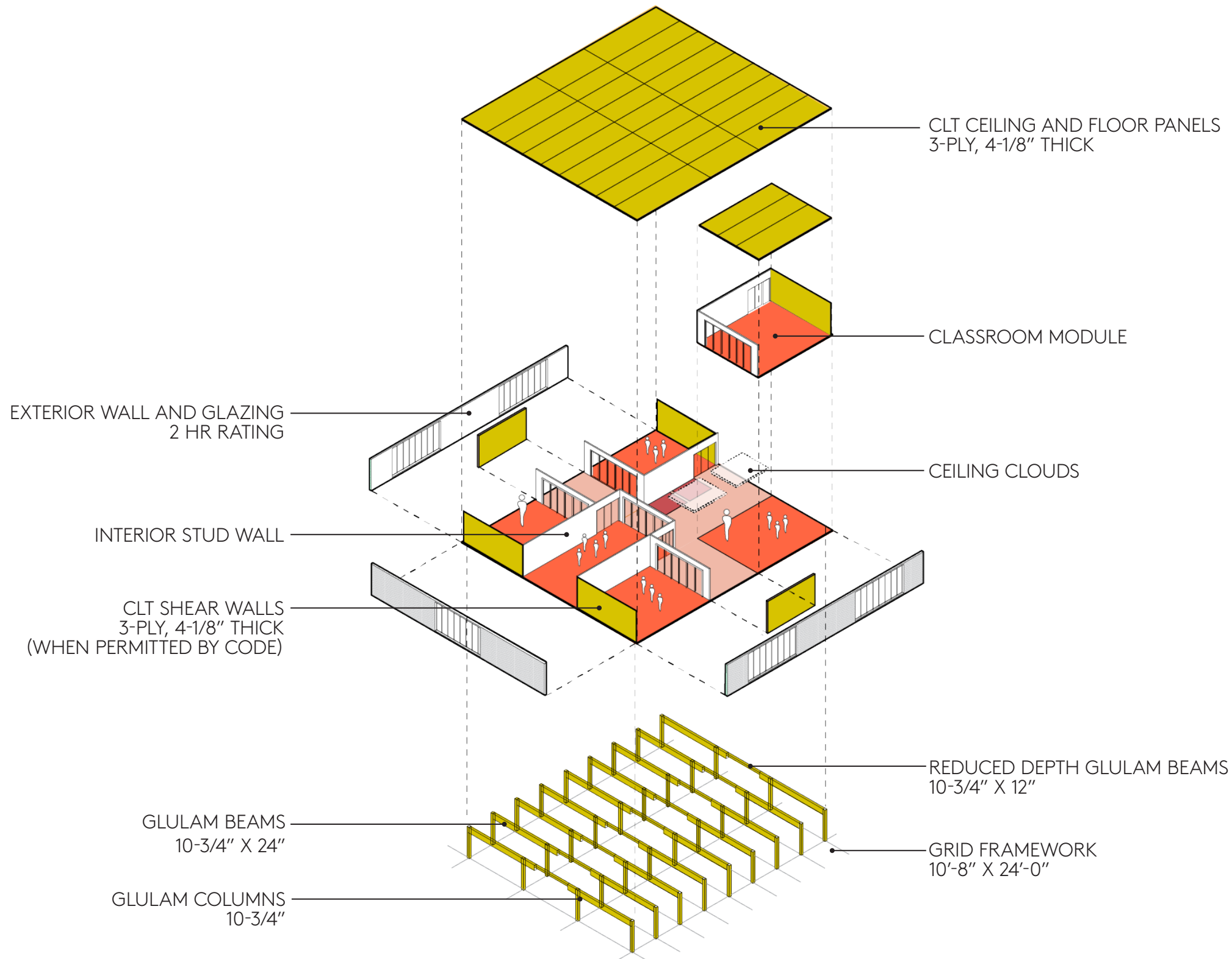
Building Better Schools

As a result, a mass timber kit-of-parts is deployed as a mechanism to improve interior learning environments for children, reduce carbon emissions and shorten construction schedules.



Kit-of-Parts Long Span

The mass timber kit-of-parts for performance block areas is similar to the core learning components, with the exception of the gymnasium which requires a long span structural framework. Together, these elements function collectively to create seamless large group gathering areas and embrace the structure and wood material. The commons, library, and music program spaces are designed on the same short span framework, however, where free span spaces are desirable, girders can be added to effectively eliminate columns and allow for column-free zones.

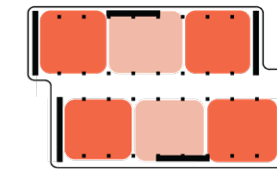


Kit-of-Parts Short Span

The mass timber kit-of-parts is conceptualized around a structural grid framework that optimizes the amount of wood fiber used on the project for cost and material efficiency. It is comprised of a series of elements including columns, beam, floors, ceilings, and walls that are adaptable to district needs.



The kit-of-parts integrates wood's biophilic properties into the building's core structure. It optimizes systems to maximize daylight and provide learning environments that improve student health and cognitive function.



Learning Environment Agility Plan Studies

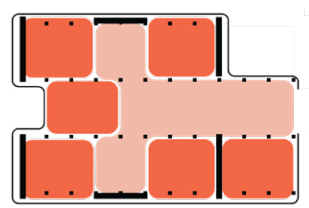
While there are an infinite number of classroom solutions, three examples are designed in more detail to illustrate the adaptability of the kit-of-parts. Each provides different opportunities for learning configuration access to the exterior and circulation to demonstrate design agility.

This 4-Up classroom design displays a traditional double loaded corridor model approach to core learning layouts. Each pair of classrooms has the ability to expand into a paired shared learning space.





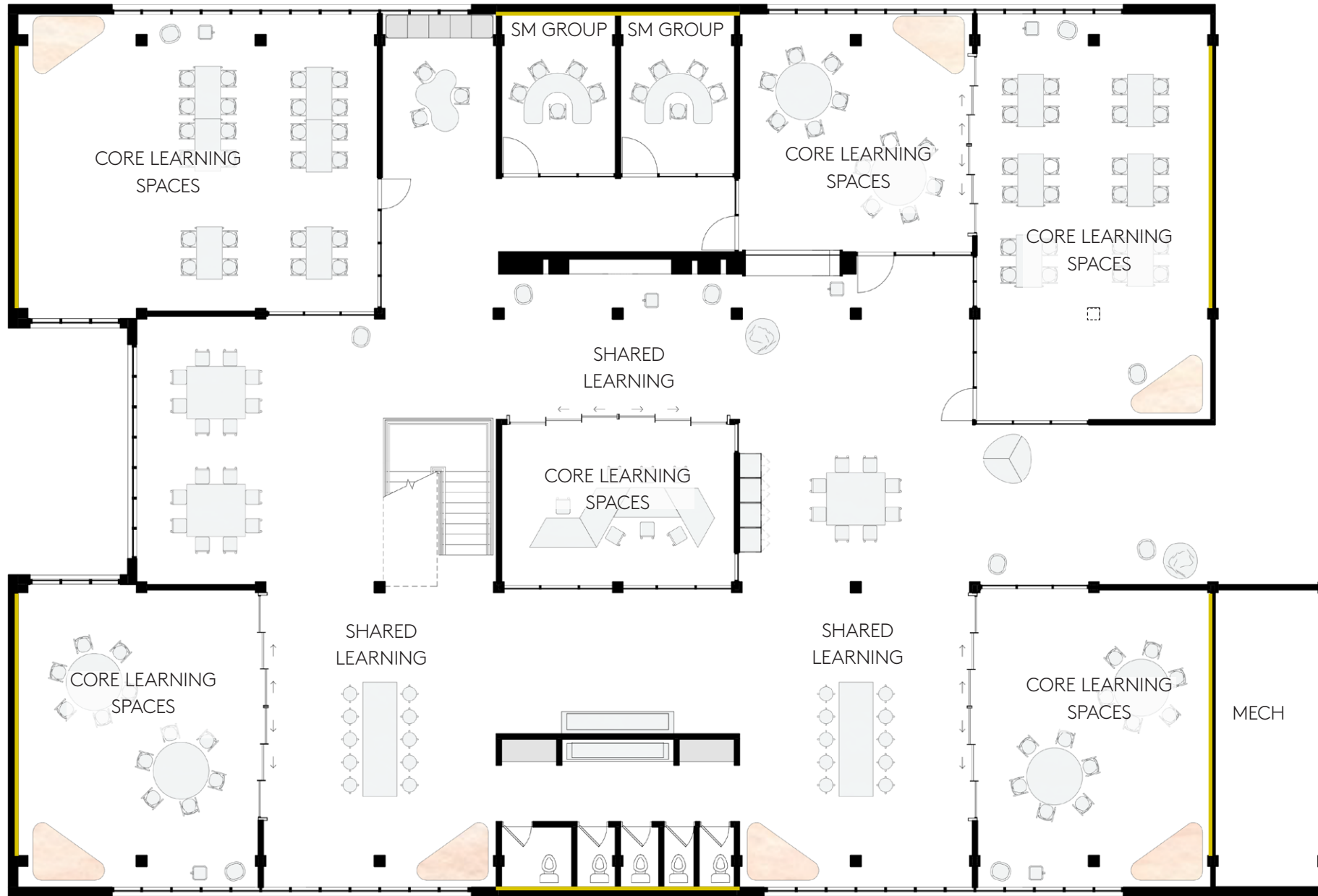
Central Learning Hub



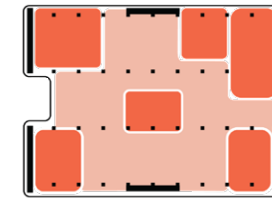
Learning Environment Agility Plan Studies

This 6-Up classroom design leverages the expanded learning core, by allowing all classrooms to have visual access to a central learning space that integrates small group rooms and shared furniture adjacent to an active circulation stair. Additional secluded shared learning and restrooms are designed to be shared between two classrooms.





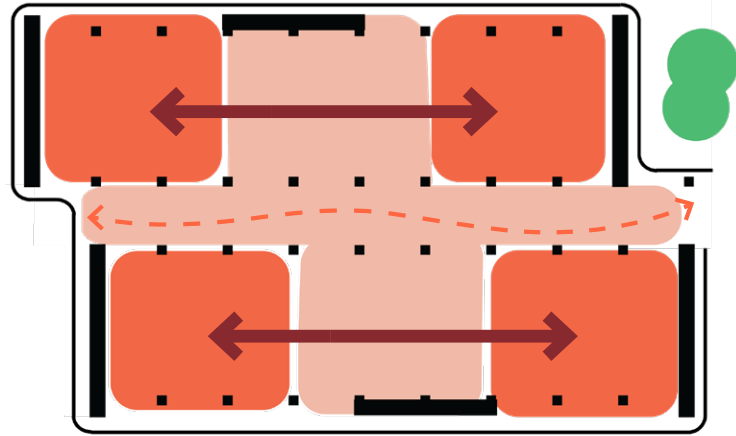
Variable Learning Blocks



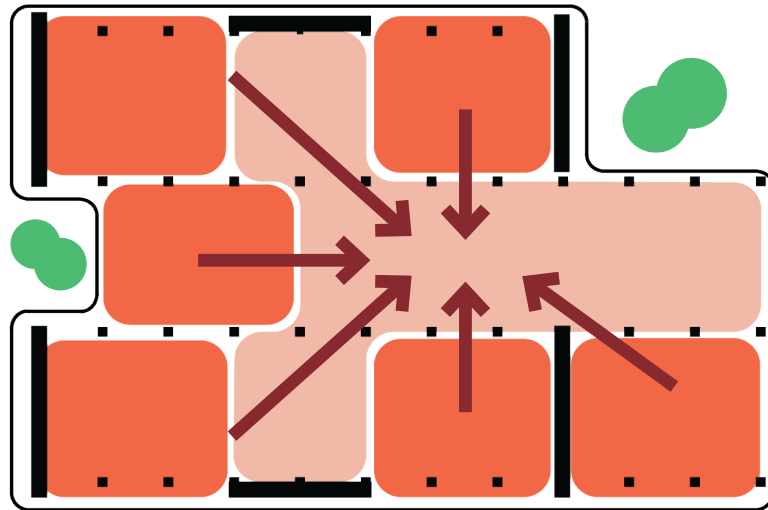
Learning Environment Agility Plan Studies

This 6-Up classroom layout offers opportunity for a different type of pedagogy. Smaller enclosed core learning spaces and greater communal shared learning area allow for increased interaction between students and teachers.

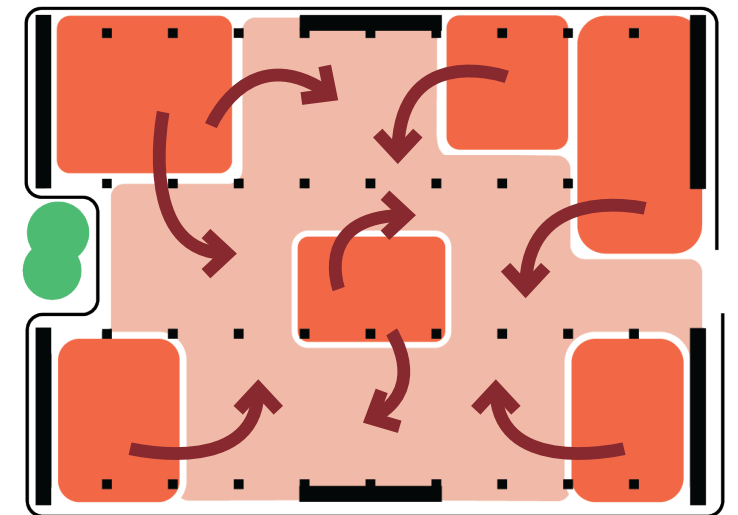




Paired Learning Partners



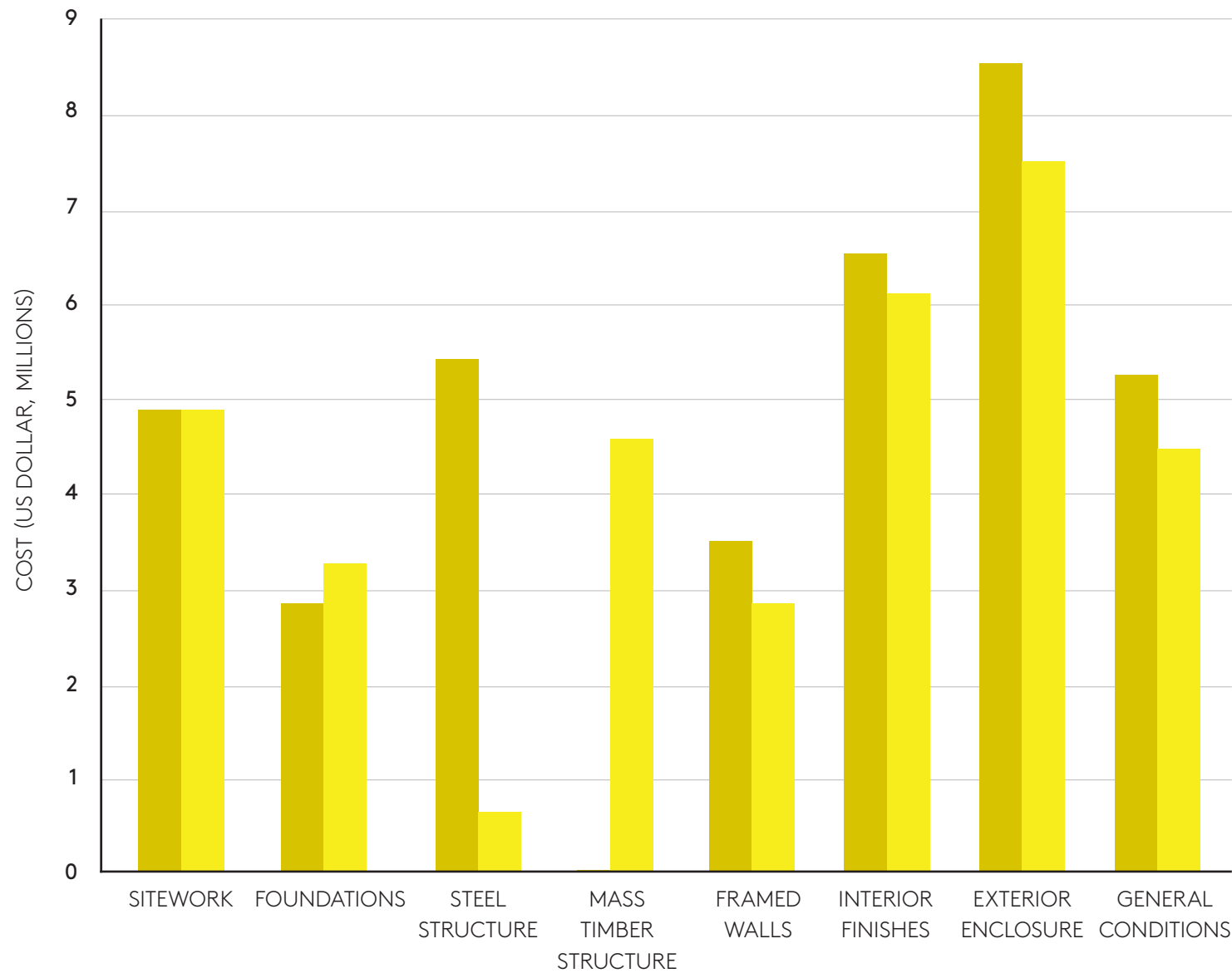
Central Learning Hub



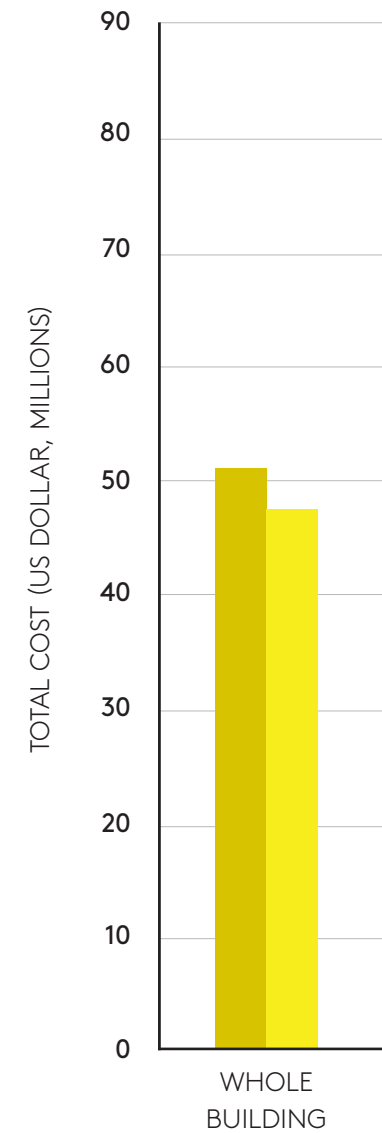
Variable Learning Blocks



BUILDING MATERIAL COSTS STEEL SCHOOL VS 3-PLY MASS TIMBER SCHOOL



TOTAL BUILDING COST



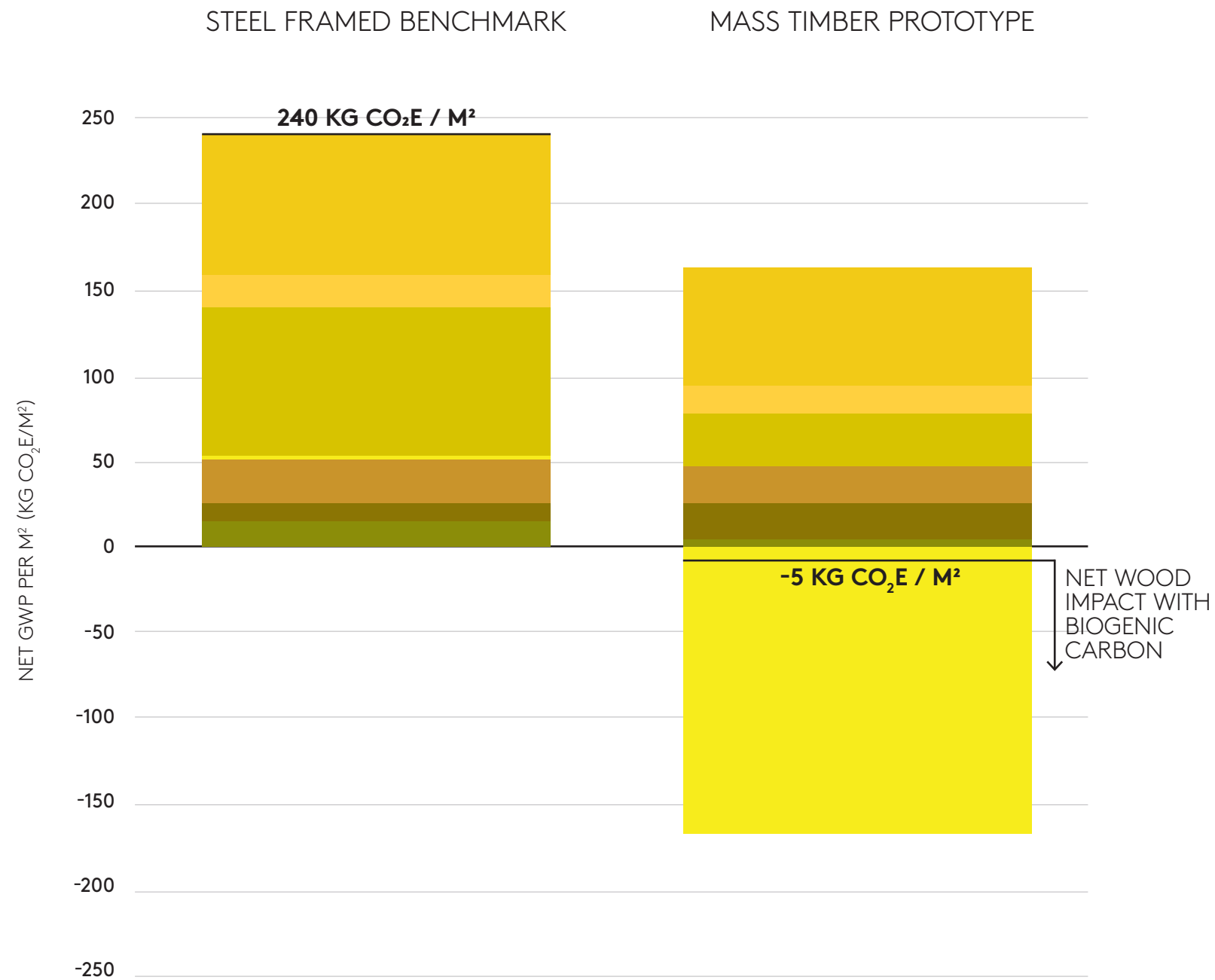
Cost Considerations

Mass timber as a primary building material is proven to have many advantages including environmental benefits, less impact on a school campus and most importantly, positive impact to students. As an added bonus, mass timber can be cost competitive with more traditional construction methods.

Our mass timber kit of parts is designed to minimize material costs by using shorter structural spans to reduce the thickness of CLT panels and reduced floor to floor height resulting in less exterior building enclosure. In addition, one must consider the reduction of contractor general conditions, resulting from faster construction and less temporary facility costs for the District.

SCHOOL CONSTRUCTION TYPE

- STEEL
- MASS TIMBER (3-PLY)



Embodied Carbon Impact

The structural system of a building comprises up to 80% of the embodied carbon footprint of a building, due to the carbon intensity of structural materials like steel and concrete. Using mass timber can offset all emissions incurred during manufacturing and production, reducing GWP by almost 200% compared to a steel-framed benchmark.

MATERIALS

- CONCRETE
- MASONRY
- METALS
- WOOD/PLASTICS/COMPOSITES
- THERMAL AND MOISTURE PRO
- OPENINGS AND GLAZING
- FINISHES

An architectural rendering of a modern school interior. The space features a high ceiling with a complex, geometric pattern of wooden slats. On the left, there is a long wall of green bookshelves. In the center, a group of children are sitting at a wooden table. To the right, more children are playing on the floor. The overall atmosphere is bright and open, with large windows in the background.

The Building Better Schools comprehensive report is located on the Mithun R+D web page. The UW ARC research is ongoing, however, progress will be posted to the Mithun R+D web page and to the UW ARC website this summer.