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SCHOOL AS LIVING LABORATORY

MASS TIMBER IN ELEMENTARY SCHOOLS

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Land Acknowledgment

This research was conducted on the traditional and present land that touches the shared waters of the Duwamish, Puyallup, Suquamish, Tulalip, and Muckleshoot Nations, who have stewarded the land and waters since time immemorial. I gratefully honor the Indigenous communities of this land, stolen through colonial violence.

Abstract

The physical built environment of elementary schools often does not adequately address or support the wellbeing of students. This report makes the claim that elementary schools should consider utilizing the ideas of biophilia, specifically a material connection to nature that is accomplished through the use of mass timber, to support the health and wellbeing of students. This report begins by exploring secondary sources related to the impact of biophilic design on student physical and mental health and wellbeing to identify areas of design, such as lights, daylight, materials, and ventilation, that significantly impact students. These design considerations and biophilic strategies are then connected to specific developmental goals in the K-3 age range. Teachers and students were surveyed to further investigate how wood environments might impact student learning and resiliency. Future research should include a more robust study range of schools, including exploring the difference in architecture in low-income elementary schools, to understand the role of justice, equity, diversity, and inclusion within the work.

How to Use this Report

A core goal of this research is to share the findings widely and legibly for those involved in the design of schools, including educators, administrators, and facility directors. Designers and architects will also be able to use this research to start conversations when designing elementary schools.

This report is best viewed online as two page spreads.

Chapter Overviews

Chapter 1: An exploration of why school design is important, particularly for children in grades K-3. A look at traditional school design considerations is also included to understand the foundations of existing schools.

Chapter 2: A deep dive into how traditional school design might be improved through the implementation of biophilic design strategies.

Chapter 3: A literature review that analyzes the connection between mass timber, learning, and resiliency.

Chapter 4: An analysis of surveys conducted that ask how wood environments impact student learning and resiliency. Conclusions and future research is included here.

TABLE OF CONTENTS

LITERATURE REVIEW: CHILDREN AND SCHOOL S

GRADES K-3

Overview

This research focuses on children in kindergarten, first, second, and third grade between the ages of five to eight. This group is at a crucial stage in their development, particularly in relation to how they learn and experience school (McLean). In order to understand how the design of their classroom impacts their wellbeing and academic achievement, it is first important to explore what is typically expected of children at this age developmentally, from social, physical, and cognitive lenses.

Developmental Milestones

Doctor Sara McLean sheds light on the crucial stages of development for children ages five through eight in her report "Understanding child development: Ages 5-8 years". Ages five through eight may be referred to as “middle childhood”. During this stage, children become far more curious about the world around them and their role in it. They begin to develop a sense of consciousness or consideration of what is right and wrong (McLean).

They are generally more social beings, interested in friendships, and able to practice sharing. Play is still central to their development and remains imaginative, though at this age children can distinguish between real and make believe. Their play becomes more elaborate and intricate with children assigning each other defined roles.

At this age learning adversities and difficulties start to become more prevalent. Emotional regulation also begins to emerge as an issue for many children as they learn to process big feelings. K-3 classes introduce increased social and learning expectations, as children are expected to have mastered certain fine motor and foundational skills. Given these expectations, students who experience delays in certain areas may feel frustration or anger when unable to complete certain tasks, fulfill expectations, or match their peers’ progress (McLean).

An increased capacity for complex imagination benefits play, but also may have adverse effects on children as they are able to imagine traumatic scenarios, such as loss of a loved one. Children begin to understand loss and permanence. Events at home will also impact a child and at this age it is likely that they will process trauma through anger, oppositional behavior, increased fearfulness, and somatic symptoms. Fears of separation from a caregiver may also cause children to need increased reassurance. Due to this fear or other traumatic events, teachers may notice that students have difficulty focusing or concentrating as they revert back to earlier behaviors in order to cope (McLean).

Developmental Assets

The report focuses on how the school environment, specifically one that features mass timber, can support student learning and resiliency. Learning in this report includes both learning inside and outside of the classroom. Resiliency is defined as how students handle stress and emotional regulation. The way students in grades K-3 learn and what impacts their resilience can be understood by first exploring development assets for children in grades K-3.

The following assets are drawn from the Search Institute's building blocks for healthy development for children between the ages of five to eight. These assets are thought to help children become responsible, healthy, and caring adults. The assets are divided into two categories: External assets which depend on the people surrounding a child, and internal assets which a child develops from within.

Considering the amount of time a child spends at school, it is imperative that these assets be present in a school environment.

Assets that relate directly to learning and resiliency and are hypothetically able to be improved through biophilic design strategies, particularly a material connection with nature, are **bolded**. These assets will be referred back to in following sections.

External Assets

Support

Family Support: Family continues to be a consistent source of support and love for a child's needs, both physical and emotional.

Positive Family Communication: Communication in family is open, frequent, and respectful. The child receives praise for accomplishments and efforts.

Other adult relationships: Child receives support from adults other than parents.

Caring Neighborhood: Neighbors are friendly and support the child's sense of belonging and growth.

Caring School Climate: Teachers, caregivers, and peers at school provide a safe and welcoming environment.

Parent Involvement in School: Parents are actively involved in the child's school success and talk about the importance of education.

Empowerment

Community Values Children: Children are included in community activities.

Children as Resources: Child has opportunities to contribute to the community and family decisions.

Service to Others: Child has opportunities to serve the community.

Safety: Adults ensure child's safety while also providing space for the child's growing sense of independence.

Boundaries and Expectations

Family Boundaries: The family always knows where the child is and has reasonable guidelines for the child's behavior.

School Boundaries: Schools have clear and consistent rules. Discipline is approached in a fair and positive way.

Neighborhood Boundaries: Neighbor help monitor the child and provide feedback to parents.

Adult role models: Adults model positive and reasonable behavior. Children are encouraged to follow their example.

Positive Peer Influence: Parents encourage child to spend time with children who are good role models or exhibit positive behavior.

High Expectations: The child is encouraged to and success is celebrated.

Constructive use of time

Creative Activities: Child participates in activities that involve creative expression weekly outside of school.

Child Programs: Child participates weekly in at least one club, organization, or sport within the school or community.

Time at Home: Child spends time at home doing positive activities with the family or playing.

Internal Assets:

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.

Homework: Child can complete homework, with the appropriate support necessary to do so.

Bonding to School: Child feels a sense of belonging at school.

Reading for Pleasure: Child reads outside of 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.

Honesty: Child develops ability to recognize and tell the truth.

Self-Regulation: Child develops skills in emotional regulation and understanding the importance of healthy choices.

Social Competencies

Planning and Decision Making: Child thinks and plans activities, with appropriate adult support.

Interpersonal Competence: Child looks to build friendships and learns about self-control.

Cultural Competence: Child learns about own identity and is encouraged to interact with children of different backgrounds.

Resistance Skills: Child is learning to recognize risky situations and seek help when needed.

Peaceful Conflict Resolution: Child learns how to resolve conflicts in a healthy and non-disruptive manner.

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 values by others.

Sense of Purpose: Child is open to new experiences and imagines future activities.

Positive view of Personal future: Child has a growing curiosity about the world and their place in it.

The Impact of School Design

Overview

The majority of the built environment is designed for adults and explored in relation to the experience of adults. Though this is the case, it is important to recognize that the built environment significantly impacts children's mental and psychological well being. The physical buildings in which they spend their time shape their perception of the world, affect their mental health, contribute to their development, and impact their ability to learn (Ismail 2). Given this, and the amount of time that children spend in schools, it is important to explore the impact of the architecture of schools. While this impact can be understood from the perspective of designers, children, and health officials, this research mainly focuses on the perspective of designers and social science researchers.

While it should be acknowledged that school design impacts the physical health of students, the scope of this section is limited to the impacts on mental and psychological health and wellbeing (Ismail 2). This includes factors such as mood, self-esteem, focus, identity, appropriate development, ability to learn, and academic success. The next section in this report explores traditional design considerations, specifically individualization/flexibility and security/ safety. This is not an exhaustive exploration of the design considerations that directly impact student health – rather it is a close examination of two considerations that relate to developmental assets tied to resiliency and learning.

Architecture & Well Being

Before exploring the impact of elementary school design on children, it is useful to have a general understanding of how architecture impacts psychological wellbeing and the current state of this research. While many different building typologies have been explored in terms of their relationship to design and mental health, the typology that is recurrent across this field of research is that of a psychiatric facility or mental hospital. Through the exploration and close analysis of the design of a space whose function is to improve the psychological wellbeing of its occupants, many conclusions can be drawn about the overall impact of architecture on mental health.

Edmund Ramsden explores this idea in "Designing for Mental Health: Psychiatry, Psychology, and the Architectural Study Project." His paper explores "the contribution of the mental hospital, as both laboratory and field site, to the development of the new field of environmental psychology which attended to the function and design of a range of city spaces to prevent mental illness and promote mental health in a period of urban crisis." (Ramsden 234). In this quote, Ramsden begins by clearly stating the contributions that studying the design of the mental hospital has made to creating a movement centered around the intersection of mental health and architecture. This research made it so that mental health would be considered in various city spaces, buildings, and designs in order to understand how physical forms can prevent mental illness or improve it. To convey the applicability of this research, he states "The understanding of territorial behavior and personal space that had been established on the psychiatric ward (and which had been informed by the zoo) could be applied to the general hospital, prison, classroom, dormitory and even family apartment." (Ramsden 233).

In addition to understanding the conception of this field of research, it is also beneficial to highlight some of the general considerations that exist when designing architecture for mental health. Oftentimes, designers consider color, material, organization/layout, daylight, air, and nature as elements that directly impact how a person feels in a space and their state of mind (Ismail). The following research examines some of the main design considerations and factors that impact elementary students and aims to propose biophilia as an additional consideration.

Schools

To understand the impact of elementary school design on children, it is imperative to have a general understanding of the influence attending school has on the average child's life between the ages of 5 through eight. According to the National Center on Education and the Economy (NCEE), a typical student in the United States is required to attend school 180 days per year, on average for 6.8 hours per day (NCEE - How Many Weeks Off?). This does not include time spent in before/after school programs, clubs, and extracurricular events. Other than the home, the school holds the most consistent presence in the lives of elementary students.

In addition to the sheer amount of time spent in school, the psychological and mental development that elementary students experience during these years of their lives cause schools to hold even greater significance. At school, many young students refine their fine motor skills and coordination (School-age Children Development Mt. Sinai Health System). As students progress through elementary school they learn to focus on tasks for greater periods of time – a skill that is important both at school and at home. Children also develop important coping strategies during elementary school. Stressors, such as bullying, workload, and learning disabilities are common during elementary school. Children must learn the proper skills to cope with such stressors since they can lead to anxiety and depression if left unaddressed (School-age Children Development Mt. Sinai Health System). Children must be allowed the space to develop these skills and behaviors properly, in a safe environment. At this age, children are highly active and often

experiment. While this activity is crucial to their development, they must be supervised in a space that is safe and hazard free. Ample room for physical activity should be provided so that students can have the space they need to develop properly (Ismail 1).

The formative development that occurs during elementary school is dependent on multiple factors, including class structure, curriculum, social relationships, and the individual capacities of each child (Barrett 21). While these factors are significant and cannot be removed completely when studying the mental and physical wellbeing of children, this report focuses on how the physical school impacts children's development and mental wellbeing.

Traditional Design Considerations

Overview

This report makes the claim that biophilic design patterns, specifically a material connection to nature accomplished through the use of mass timber, should be considered in elementary school design to support student learning and resiliency. Schools across the world already utilize and showcase biophilic patterns, both intentionally, with the benefits of biophilia in mind, and unintentionally. In order to understand how biophilic design patterns may be better incorporated into school design, it is important to first understand the major factors that currently impact school design, how they impact student well-being and success, and if these factors are compatible with biophilic design.

Major Elements of School Design

The matrix below summarizes some of the major elements that drive school design. There are three categories: stakeholders, design, influences. The stakeholders are the people involved with decision making and or impacted by school design. The design includes a list of the six top recurring design considerations found throughout the research. These design considerations are drawn from Peter Barrett and Dr. Yufan Zhang's report "Optimal Learning Spaces: Design Implications for Primary Schools" as well as Said Ismail's "Architecture for Children: Understanding Children Perception towards Built Environment". And then lastly, influences looks at anything that might impact what the stakeholders want or the design decisions made. This matrix will serve as a starting point to understand where school design currently stands and how traditional design considerations impact students. The scope of this report does not explore "influences".

While all six design considerations are impactful, this report focuses on student resiliency and learning. Thus, this chapter explores two design considerations that greatly impact student resiliency and learning: safety/security and individualization/flexibility.

Matrix of School Design Elements

STAKEHOLDERS	DESIGN	INFLUENCES
Students	Individualization/ Flexibility	Budget
Teachers	Safety/Security	Timeline
Administrators	School Size	Building Code
Staff	Physical Environment	Standards
Facilities	Common/Shared space	Regulations
Community	Technology	Guidelines

Resiliency: Security and Safety

Developmental Asset: Caring School Climate
Teachers, caregivers, and peers at school provide a safe and welcoming environment.

Developmental Asset: Personal Power
Child develops a growing sense of influence and control over what happens.

The first consideration explored in this report is safety and security, which directly impacts student resiliency.

Feeling unsafe at school can significantly impact students' peace of mind, ability to focus, and anxiety levels. Due to the increase in school shootings, designing a school that is equipped to protect students from such acts of violence is critical. Though security measures are crucial in schools, if only the physical safety of students is considered there may be adverse mental impacts that overshadow the relief and comfort that students feel in a well-equipped and protected school. Schools can quickly begin to feel like a prison if security measures are installed heavy handedly and without thoughtful consideration for the mental wellbeing of students. While security measures such as double locking entry doors, bullet proof glass, and security/police are effective, they may not be the best option for students' mental health as they can perpetuate "prejudices as well as harmful paranoia and anxiety." (Flynn)

Nicki Cole sheds light on this correlation in her essay "Understanding the School-to-Prison Pipeline." Cole states that "the school-to-prison pipeline is a process through which students are pushed out of schools and into prisons. In other words, it is a process of criminalizing youth that is carried out by disciplinary policies and practices within schools that put students into contact with law enforcement." (Cole 1). While this process emphasizes factors such as school correctional policies, many of the ideas and impacts of this pipeline are applicable to the design of a school. Cole explains the sociological theory of deviance, also known as labeling theory, which states that "people come to identify and behave in ways that reflect how others label them." (Cole 3). Cole applies this theory directly to the school to prison pipeline, explaining that "being labeled as a "bad" kid by school authorities or student resource officers, and being treated in a way that reflects that label (punitively), ultimately leads kids to internalize the label and behave in ways that make it real through action. In other words, it is a self-fulfilling prophecy." (Cole 3). Cole also references a study that showed how "increased surveillance and attempts at controlling "at-risk" or deviant youth ultimately foster the very criminal behavior they are intended to prevent." (Cole 4). This concept is eye opening as it can be directly applied to school designs with overt security measures. Students who see metal detectors and police presence may begin to subconsciously label themselves as dangerous or problematic, leading to negative feelings and low self-esteem. This also often leads to behavioral issues as students begin to act in ways that reflect their environment. Proven impacts of the school-to-prison pipeline show that designers must consider how to protect students in a way that does not harm their mental health or lead to additional issues (Cole 3).

In addition to major public safety issues, architects must consider the safety of students on an average day. Designing to minimize opportunities for bullying is significant in improving and protecting the mental health of students as bullying has severe and long-lasting negative impacts. According to Violence Prevention Works, students who are bullied as children are more likely to struggle with depression and low self-esteem throughout their life (Violence Prevention Works). In addition, in schools in which bullying is common, students generally feel unsafe, insecure, and dislike school. School bullies often target students in secluded areas of a school, such as the hallways and stairwells. Allowing for more visibility within classrooms and clear connections between

classrooms reduces the number of places where students are vulnerable and may be targeted (Violence Prevention Works). By designing to prevent bullying, the school as a whole becomes a more welcoming and safe space in which students are able to develop appropriately and protect their mental health.

The last major component of safety and security is adult supervision, specifically regarding the balance between supervision and independence. The need to be independent plays a large role in the development of students, therefore design for safety must consider both the physical wellbeing of students as well as their psychological needs. Tom Dobbins explores this idea in his article "Shaping the Future: What to Consider When Designing for Children". Dobbins explains that as children begin to develop a strong desire to be independent and use the new skills they are learning, it is important that school design encourages liberation and independent exploration (Dobbins). This can be accomplished through spaces that are tailored to the children and can be navigated without the assistance of adults. While adult supervision and access is necessary, children are free to exercise their growing desire to be independent. This type of design might be executed in the playground of schools. If schools are designed in a way that allows for teachers to supervise without students feeling too heavily monitored or confined, this can positively contribute to their development of self-confidence and independence (Dobbins).

Learning: Individualization/Flexibility

Developmental Asset: Learning Engagement
Child enjoys learning and is excited to go to school.

Developmental Asset: Bonding to School
Child feels a sense of belonging at school.

The next consideration that will be explored is individualization, which directly impacts students' ability to learn in the classroom. Peter Barrett and Dr. Yufan Zhang explore the concept of individualization in "Optimal Learning Spaces: Design Implications for Primary Schools".

> *"As an individual matures their brain builds a very personal set of connections between primary reinforces (basic needs) and complex representations of secondary reinforces (features in the world). Taken together with the situated nature of memory, these personal value pro- files lead to highly individual responses to space. This provides a sound basis to raise the potential importance of 'individualisation' as an additional, key, underlying design principle."* (Barrett 22).

It is clear that individualization is crucial as children are building complex and personal connections at their own pace, furthering their mental development. Individualization consists of two components: personalization and particularization. Personalization "concerns an individual's preferences owing to their personal life experiences of spaces" while particularization "concerns accommodating the functional needs of very specific types of users, for example learning and way finding in the context of age and physical requirements" (Barrett 22). Both aspects of individualization are significant in designing a space that supports student growth. Without individualization, students may not be able to develop properly and at their own pace, which could lead to mental and psychological issues.

Designs that allow for choice are crucial in regards to personalization. "Physiology and psychology research indicates that personalization of space is an important factor in the formation of an individual's identity and sense of self-worth." (Barrett 23). A similar concept in the adult word is the desire of working professionals to customize their office or cubicle to make it their own. This type of personalization cultivates a positive sense of self, pride, and ownership. In school design, personalization may look like providing multiple intimate and smaller scales spaces within the larger classroom so that students can choose where to read, play, or nap, as well as have a space that they feel is their own. It may also look like providing plain desks and cubbies to students that they can decorate and design to their liking (Barrett 23).

Flexibility is also significant in supporting particularization as it allows for students to develop both independently and as a group as they move up grade levels. Considering that students, even those among the same age group, develop at their own pace, it is imperative that schools can accommodate a wide range of student capacities. In addition, students learn in different ways and different lessons require different settings. The classroom is where students spend the most time in school, "Therefore, it is required to provide opportunities for the greatest flexibility to anticipate changes in pedagogical goals and educational programmes" (Barrett 25). One way that design can accommodate flexibility is through furniture that students and teachers can move as they see fit. This also contributes to the development of student's independence as they can further personalize the classroom to their own liking. Large classrooms with multi-use spaces also support flexibility (Barrett 25). While Barrett and Zhang emphasize particularization in relation to flexible classrooms, it is also important to recognize that flexibility leads to personalization as well.

Though Barrett and Zhang did not cover this idea, it should be acknowledged that flexibility supports students with special needs, such as those who are autistic or have faced trauma (Dobbins). Social Sensory Architectures is a research project that explores how variations of tactile architecture can be therapeutic to children with autism. Also, Catalytic Action works with refugee children to provide play structures that children have control over, creating a sense of ownership and belonging (Dobbins). These two examples show how flexible spaces are significant for a range of abilities and emotional states – one size does not fit all in elementary school design.

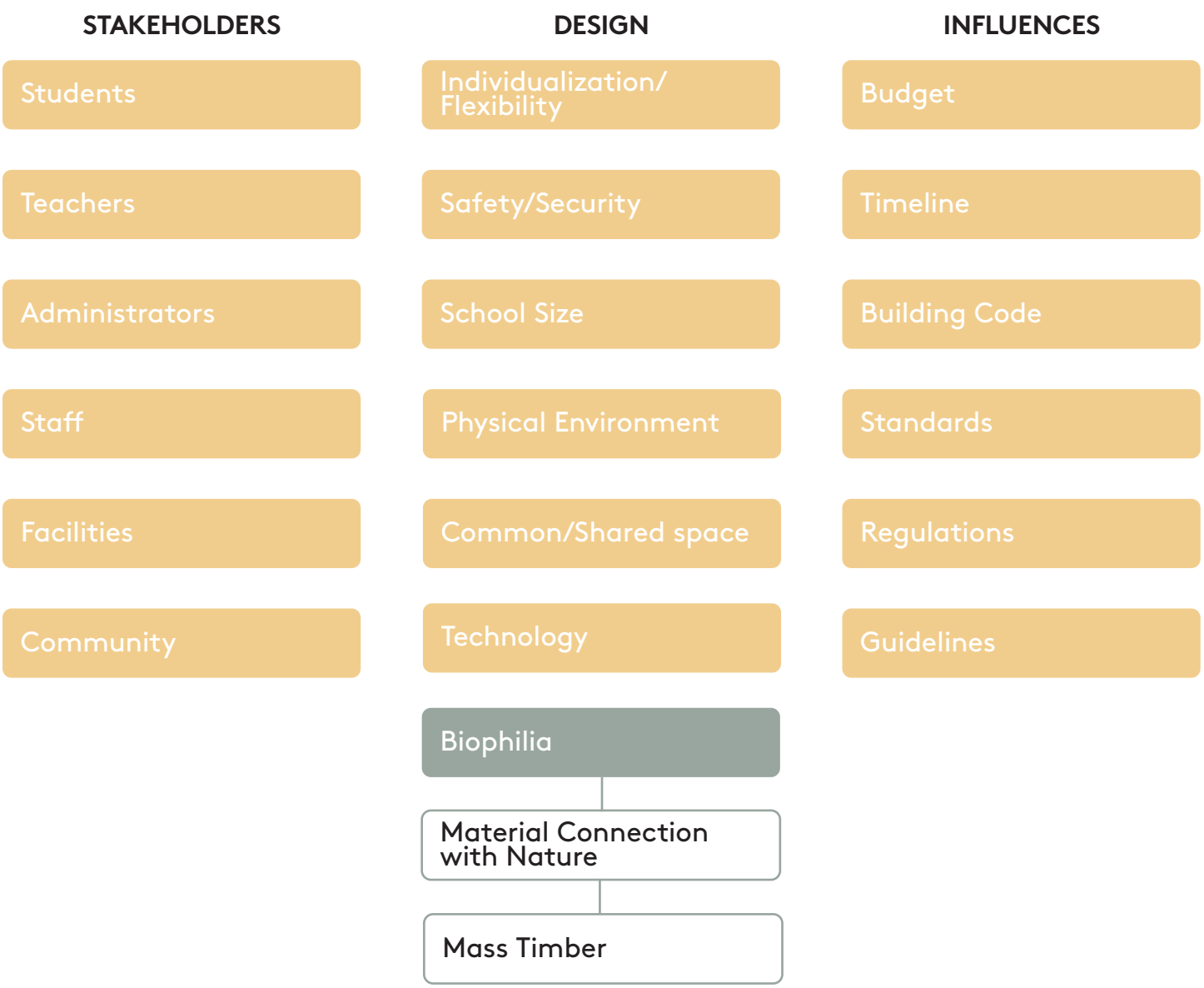
Summary

In considering the future of how design can impact student resiliency and learning, it is imperative to understand the current state of design.

The following sections will uncover how biophilic design can support student resiliency, which is necessary considering the negative impacts of certain safety/security design strategies. In addition, biophilic design can be achieved through many strategies which ties to the needs of individualization and flexibility in the classroom. Biophilia is a consideration that can support and improve existing design considerations.

This report proposes that biophilia, specifically a material connection with nature established through the use of mass timber, should be added as a design consideration to further support student resiliency and learning.

Proposed Matrix of School Design Elements



LITERATURE REVIEW: BIOPHILIA

Section Overview

Overview

The first section of this report explores why children in grades K-3 are at a crucial stage in their development as well as how the current design of schools impacts them. This chapter considers how biophilia in school can positively impact student learning and resiliency. The main research that guides the report is based on existing theories and findings surrounding the intersection of biophilia in design and student wellbeing.

There are several key theories and ideas that are important to understand when exploring biophilic design.

Attention Restoration Theory

Attention Restoration Theory (ART) suggests that exposure to nature allows the brain to concentrate or refocus, especially after mental fatigue (Heather 305). There is a limit to how long the brain can focus on a specific task before experiencing mental fatigue. ART is one theory that connects time in nature to academic success as students often focus on tasks in the classroom for extended periods of time.

Nature-Deficit Disorder

This term was coined by Richard Louv to describe the consequences of humans being removed from nature as the world becomes more urbanized (Louv).

It is clear in existing theories that there is a correlation between human wellbeing and exposure to nature. This report uses these claims to support the call for biophilia based design considerations in all elementary schools.

Biophilia and Children

Literature Review Summary

Nature plays a significant role in students' learning ability and health. Before exploring the impact of nature on elementary students directly, it is helpful to understand how the outdoors generally impact mental health. Ed Decker explores this topic in his article "How the Great Outdoors Improves Mental Health." Studies have shown that people who are more connected to nature tend to be happier overall. The term 'biophilia' was coined by E. O Wilson to label the attraction that humans feel towards living things. While in the past, a connection with nature was related closely to survival, nowadays the connection is more about pleasure and enjoyment. Though humans may look to nature first for enjoyment, the positive mental and wellbeing impacts that stem from time in nature cannot be overlooked. Some of the major benefits from time spent in nature include boosted mood, reduced stress, and increased resilience. Additionally, time in nature is very restorative and grounding. It provides a break from the hustle of daily life and allows for peaceful contemplation – a practice which has been shown to reduce impulsive decision making and anxiety (Decker).

The following theories address how time in nature or biophilia impact student resiliency and learning.

Attention Restoration Theory

Ming Kuo explores the impact of nature on children's learning ability and mental wellbeing in "Do Experiences with Nature Promote Learning? Converging Evidence of a Cause and Effect Relationship". Kuo argues that 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 (Kuo 2). Each of these factors is specifically explored in the work to fully convey this correlation. Beginning with stress levels, Kuo explains that nature has been shown to reduce stress levels in children, proven through self-reported data and physiological measures. In terms of engagement and attention, teachers report that students who are either learning in nature or connected to nature in the classroom are better able to focus on the course and seem to be intrinsically motivated to do so, possibly due to nature's restorative qualities. Lastly, Kuo explores the self-discipline that students develop through time in nature,

especially in regards to students with ADHD. Kuo uses the positive psychological benefits of nature to make a compelling argument for why nature must be considered in the design of schools (Kuo 3).

Nature Deficit Disorder

In his article "Do Our Kids have Nature Deficit Disorder?" Richard Louv also looks at the impact of nature and argues that access to nature is important for children's ability to learn and their mental health. He argues that the gap between children and nature results in health and wellbeing complications, a phenomenon he calls the "nature-deficit disorder". To support this claim he cites various studies in which students who studied outside experienced significant improvements in their learning and behavior, pointing to the mental benefits of connecting students to nature. One study that Louv cites is from the American Institutes for Research in which students involved in outdoor science programs improved their test results by 27% (Louv). Also important to note is that students in elementary school showed a reduction in attention deficit/hyperactivity symptoms when they were engaged with nature.

After making his claim that students should be exposed to nature more significantly in schools, Louv turns to examine a troubling trend in schools. In the 1970s, the design of schools became more inward focused. Many schools began to focus on the enclosed classroom, windowless hallways, and generally enclosed structure. Louv argues that we must move away from this trend as nature is the preferred classroom (Louv).

Louv concludes his work with a call for action through the proposal of several strategies that will increase student connection with nature. Some of his ideas include bringing nature into the classroom and green shared spaces in schools (Louv). While his ideas are open ended, Louv makes a compelling argument for why schools must integrate nature in order to support the wellbeing of children.

Ed Decker also explores the impact of nature, focusing on how access to nature impacts students' ability to learn in his article "How Time in Nature Boosts Learning in the Classroom". He focuses on daylight and how natural daylight positively impacts students' ability to learn math and reading. In one study, students in a school district with the sunniest classroom improved 26% faster in reading and 20% in math than students with less daylight (Decker). This makes a strong case for why students need access to natural daylight in order to most effectively learn.

The information in this section points towards the need for nature to be incorporated into elementary school design. Though it may be tempting to fully transition all elementary schools to outdoor programs, this is not feasible in many cases and not necessary. Rather, it is significant that students have access to nature, whether through large windows that look out to vegetation, courtyards, or green spaces in/around the school.

Key findings

Developmental Asset: Self-Regulation
Child develops skills in emotional regulation

- Time in nature boosts mood, reduces stress, and increases engagement (Decker).
- Time in nature is restorative and grounding (Decker).

Developmental Asset: Achievement Motivation
Child is encouraged to remain curious

Developmental Asset: Learning Engagement
Child enjoys learning and is excited to go to school.

- Children who study in or around nature focus better and seem intrinsically motivated to do so (Kuo).

Developmental Asset: Caring School Climate
Teachers, caregivers, and peers at school provide a safe and welcoming environment.

Developmental Asset: Bonding to School
Child feels a sense of belonging at school.

- Human have an inherent attraction to nature (Decker).

Biophilic Design

Overview

Given the impact that school design has on students and the positive impact that biophilia has on children, it is crucial to explore how biophilia might be incorporated into school environments.

Biophilic design applies the principles of biophilia to architecture by bringing nature into our built environments, both literally and symbolically.

There are many ways to accomplish biophilic design. Biophilic design patterns are a method for grouping strategies of biophilic design that relate to the same biophilic principal. The following are 12 design patterns that can be implemented in the design of the built environment. The patterns are from Terrapin's "14 Patterns of Biophilic Design" and revised with a focus on elementary school design and applications (Terrapin).

The design patterns included are:

1. Visual connection with nature
2. Non-visual connection with nature
3. Non-rhythmic sensory stimuli
4. Thermal and airflow variability
5. Presence of water
6. Connection with natural systems
7. Dynamic and diffuse light
8. Biomorphic forms and patterns
9. Material connection with nature
10. Complexity and order
11. Prospect
12. Refuge

Each of these patterns are powerful and can build off one another. These 12 patterns are listed with equal emphasis on each - in an ideal world, every pattern would be used. It likely will not be possible for every design pattern to be incorporated in a single school due to budget, program, or site constraints. Rather than incorporating many patterns, it is more significant that the patterns incorporated are intentional and specific to the community or site.

In addition to Terrapin's design patterns, additional questions when choosing patterns to incorporate in an existing school might include:

> Which patterns would be the most impactful based on what is missing from the school?
>
> Is it possible to build off existing structures/systems to create or enhance their positive benefits?
>
> What are the students currently missing mentally, physically, academically, or socially?

In the design of new schools, factors that may be considered are:

> Does the site provide opportunities for biodiverse landscape or views?
>
> What is the local ecology?
>
> Are there design strategies that incorporate multiple patterns and benefits?

While each of the patterns have merit and can address the previous considerations, the following sections of this report will focus on a material connection with nature for several reasons:

Student learning and resiliency can be directly impacted by a material connection with nature. This idea will be explored in the last section of this report.

A material connection with nature can be accomplished through a variety of design moves, both big and small, making it achievable for all types of schools. This claim will be explored in the following section.

Material connection with nature through Mass Timber

Overview

Many students have limited access to the natural environment. They may live in apartments and not have access to a green backyard. Or they may live in a dense area that has few opportunities for play outdoors.

School is one place for all students, regardless of their background or home conditions, to have access to the natural environment.

Considering how much time students spend inside their classroom, it is crucial that design strategies bring the elements of the outdoors or natural environment inside. One way to accomplish this is through natural materials and colors inside of the classroom.

Pattern Definition:

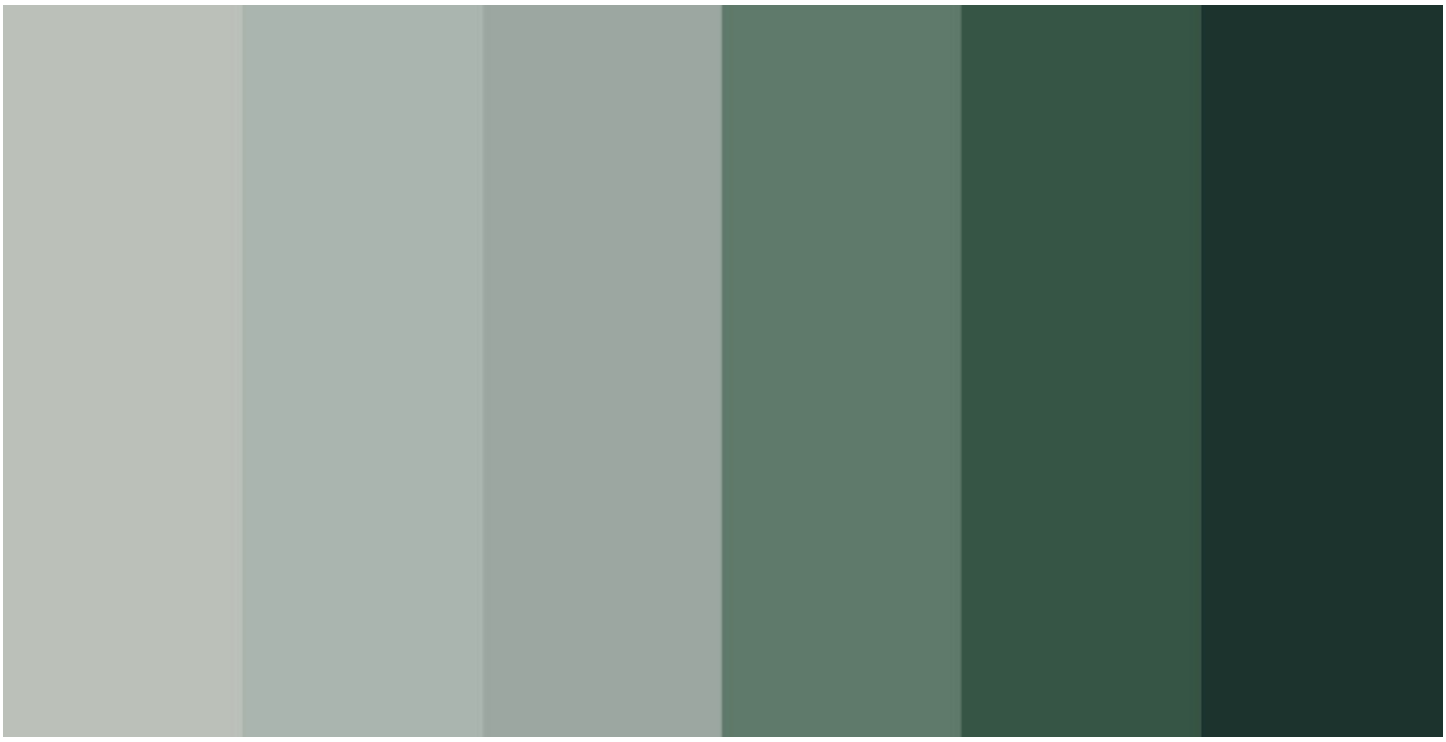
Materials that reflect elements of nature or the local ecology, thus creating a sense of place (Terrapin).

Example design strategies:

Stone pathways
Shades of green
Wood surfaces*
Natural decor elements

*Wood surfaces will be explored in the next subsection "Mass Timber".

Design Strategies



Shades of green used in wallpaper, paint, or furniture.

Stone pathways leading to class garden.

Unprocessed wood elements of decor.

Wood surfaces, including walls, floors, or ceilings.

Mass Timber

Shinrin-yoku is the Japanese concept of "forest air bathing" or spending time in nature (Morita). Many studies have been conducted that uncover the benefits of shinrin-yoku. Generally, forest environments are beneficial in reducing stress, especially for those who experience chronic stress (Morita). While time in nature as a whole has stress reliving benefits, it is important to note that this existing research specifically explores the biophilic benefits of a material connection with nature accomplished through wood rich environments.

One way to accomplish a material connection to nature within the classroom is by using mass timber. Mass timber is structural wood that consists of layers of wood that are glued or adhered together. Columns, panels, floors, and ceilings can all be made of mass timber. There are many benefits to using mass timber as a building material. The benefits of mass timber as they relate to developmental assets are explored in this chapter.

Developmental Asset: Achievement Motivation
Child is encouraged to remain curious

The Arbor Day Foundation is an organization that facilitates connections with K-12 students and trees. The organization asserts that these experiences help students become stewards of the environment and develop a curiosity about mitigating climate change (Tree Campus K–12 at Arborday.org).

This report proposes that the presence of wood exemplifies a commitment to sustainable building practices and allows students to remain curious about their role in caring for the planet.

Developmental Asset: Self-Regulation
Child develops skills in emotional regulation

Sympathetic Nervous System (SNS) activation is reduced in spaces were wood is visually present. Students in classrooms featuring wood have lower heart rates than students in classrooms featuring plastic and metal (Kelz 26).

Interior spaces with 90% or more of wood creates a highly restorative environment. A space with a moderate ration of wood (45%) decreases blood pressure and increases pulse rate (Tsunetsugu, Miyazaki & Sato 14).

This report proposes that students in wood rich classrooms are better able to regulate their emotions and feel calm.

Developmental Asset: Bonding to School
Child feels a sense of belonging at school.

People inherently recognize the value of wood as it is a familiar material that is used in daily life, whether is be the flooring in a house or logs of wood in a fireplace (Martinez).

This report proposes that the familiarity of wood is beneficial in a classroom setting as students will subconsciously relate the wood in their classroom to the wood in their home.

Developmental Asset: Self-Regulation
Child develops skills in emotional regulation

In recent years, studies about the benefits of wood in the built environment have become more widespread. David Fell's study "Wood in the Human Environment: Restorative Properties of Wood in the Built Indoor Environment" was instrumental in exploring and conveying many of the psychological benefits of wood. Fell researched the impact of wood in reducing the stress of employees in an office setting. He found that subjects in the office space with wood displayed lower stress activation than those in the non-wood office. He also found that wood has the greatest impact on stress reduction in low to moderate stress situations. Overall, Fell asserts that visually wood as a material has stress reducing qualities that reflect concepts of biophilia or time in nature as a whole (Fell).

Marjut Wallenius, doctor of psychology at University of Tempere has also explored the emotional benefits of wood spaces. In addition to the visual aspects of wood spaces, the tactile quality also contributes to its benefits. Wallenius asserts that the feel of wood translates to feelings of comfort and safety, stating that "It is especially interesting that the feel of wood is softer than other materials, not only experientially but also physiologically" (Wood Construction). This claim is supported scientifically - touching stainless steel, plastic, or aluminum at room temperature causes a rise in blood pressure, while touching wood did not elicit the same reaction (Sakuragawa 112).

This report proposes that using wood in the classroom will reduce student stress and feel more comfortable in their classroom.

CASE STUDIES + SURVEY FINDINGS

Chapter Overview

These surveys were intended to gather information and test concepts from the literature review, particularly how wood impacts student learning and resiliency. The developmental assets identified in the sections on biophilia and mass timber were utilized as a basis to form survey questions and evaluate responses.

One survey was distributed to teachers across four schools that utilize mass timber. 14 teachers responded to the survey. A second survey was distributed to third grade students across two schools. 80 students responded. These students were exposed to varying levels of wood in their environment.

The results from both surveys, particularly the teacher survey, are intended to be anecdotal evidence.

Survey Goals

The primary goal of both surveys was to understand how mass timber might support student learning and resiliency. The goal of this survey was to understand:

1. Teacher preferences:
    - How much do teachers care about the appearance of their classroom?
    - Does the environment that teachers are in make a difference in how they feel and teach?

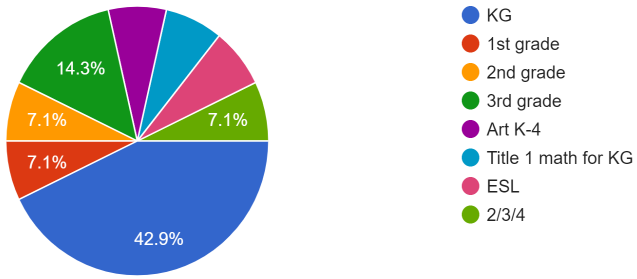
2. Teacher Observations:
    - What do teachers observe about their students' learning and resiliency?

The literature review and exploration of developmental assets were used as guides in creating survey questions that would relate to learning and resiliency. The surveys also uncovered general information about how teachers and students perceive their spaces and what their preferences might be. This information is useful as it provides a foundation when thinking about how mass timber can be used effectively.

Methodology

Principals of schools that feature wood elements were contacted via email to recruit teacher participation. Out of the 60 schools that were contacted across the United States and British Columbia, 4 schools were willing to participate.

Teachers from grades K-3 were asked to participate. The breakdown of responses is as follows:



These teachers were given an online survey via Google Forms consisting of both multiple choice and short answer questions. Students were recruited through these teachers. Only students from 2 out of the 4 schools were able to participate. These students were in 3rd grade. The study was approved through the university's IRB process.

Teachers distributed an online survey to their students via Google Forms. The survey had multiple choice and short answer questions.

23% of students who responded had exposure to both a classroom and school that was rich in wood.

66% of students who responded has exposure to a wood rich classroom.

11% of students who responded were from neither a wood rich school nor classroom.

All of the students surveyed have been exposed to a classroom environment with wood elements at some point in their schooling.

Both teachers and students were given 2 weeks to respond.

Survey Limitations

Distribution/Recruitment: Most schools did not respond to the request for survey participation. A few schools declined to participate.

Number of participants: The number of participants limits the survey to producing anecdotal evidence.

Range of Wood Exposure: More students in standard classroom settings were needed to be comparable statistically to the number of student that responded from wood rich classrooms.

Survey Results

The following sections convey data and key findings from the surveys.

The findings, particularly those from the teacher surveys, are anecdotal. A larger sample group is needed for future research.

The results shared in this report point to trends and conclusions that can be made based on the results of a small sample groups.

Teacher Surveys

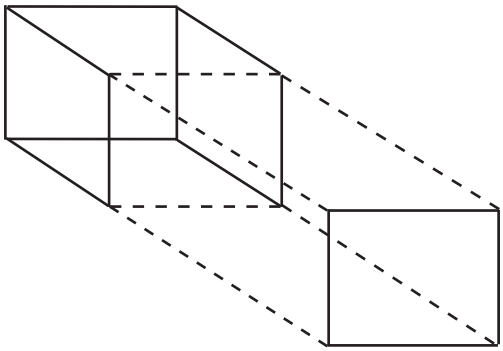
Information was gathered from fourteen teachers who are in wood rich schools and/or classrooms to understand how their experience differs from previous teaching experiences in a standard classroom. Teachers from two types of schools were surveyed: the first is teachers from a wood rich classroom where the classroom has major wood elements, such as a wood ceiling, walls, or floors. This includes Maple Elementary, Jefferson Elementary, Grey Wolf Elementary, and C.W. Morey Elementary. The second type of school is wood rich school, where the wood is distributed throughout the school, for example both the hallways and classrooms may have wood. C.W. Morey fits under this type.

Student Surveys

Eighty 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. The first type of classroom is wood rich classroom, similar to the teacher group. The next type is standard classroom, what you might think of when you imagine a traditional classroom: gypsum walls and concrete, tile, or carpet floors. The last type is wood rich school, where the students experience wood in both their common spaces and classrooms.

Standard Classroom

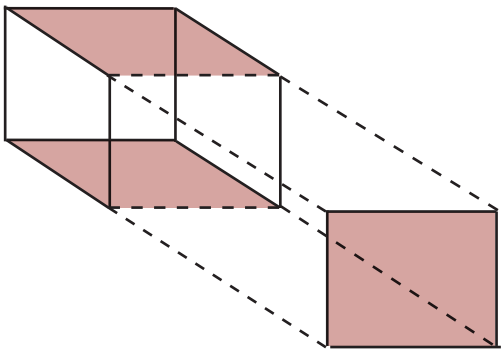
Maple Elementary School



Gypsum walls and concrete,tile, or carpet floors

Wood Rich Classroom

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

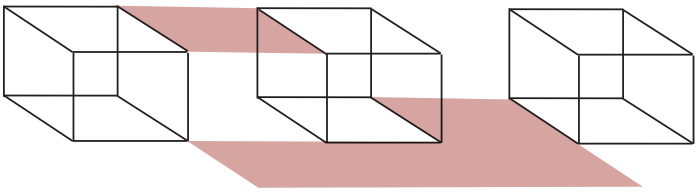


Type Description: Significant wood elements in classroom: ceiling, floor, wall(s)

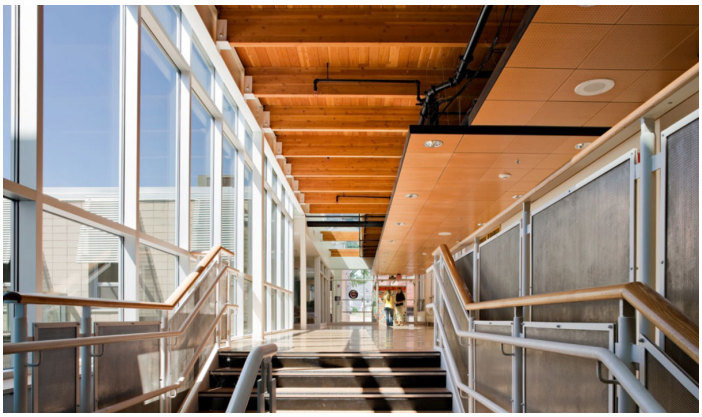
Wood Rich Classroom: Maple Elementary School - Seattle, WA. CLT construction exposed in classroom.

Wood rich school

C.W. Morey Elementary School- Lowell, MA



Type Description: Wood distributed throughout school



Wood Rich Classroom (not pictured) and School: C.W. Morey - Lowell, MA. Wood beams and ceilings distributed throughout the school.

Teacher Surveys

Starting with teachers, its important to acknowledge the relationship between teachers and students. Happy and healthy teachers support happy and healthy students.

So what do teachers want?

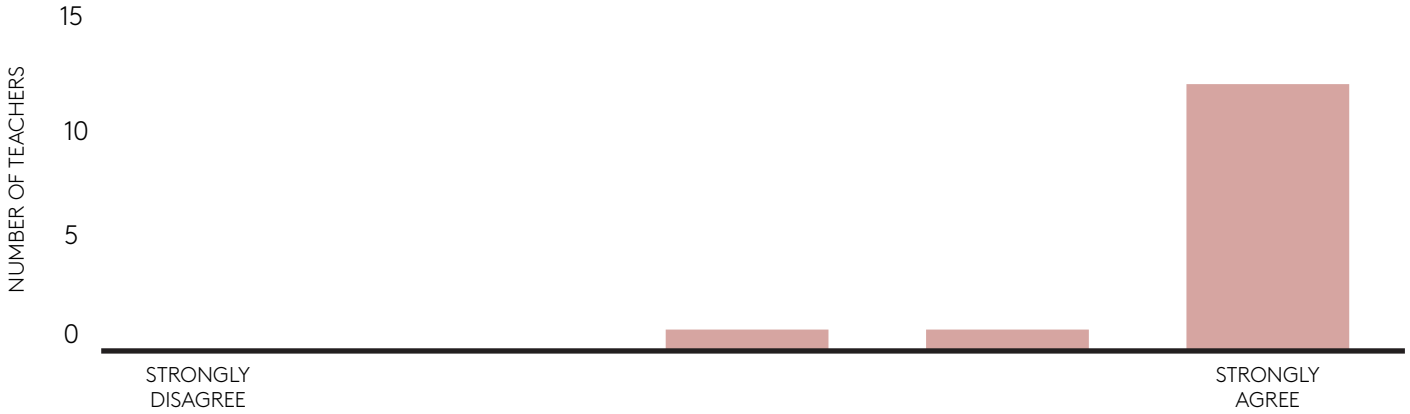
"Connections to nature in an urban atmosphere is even more imperative when thinking about design. I think it is as important to the soul as universal design is to the needs to the body."

-3rd Grade teacher in Seattle, WA

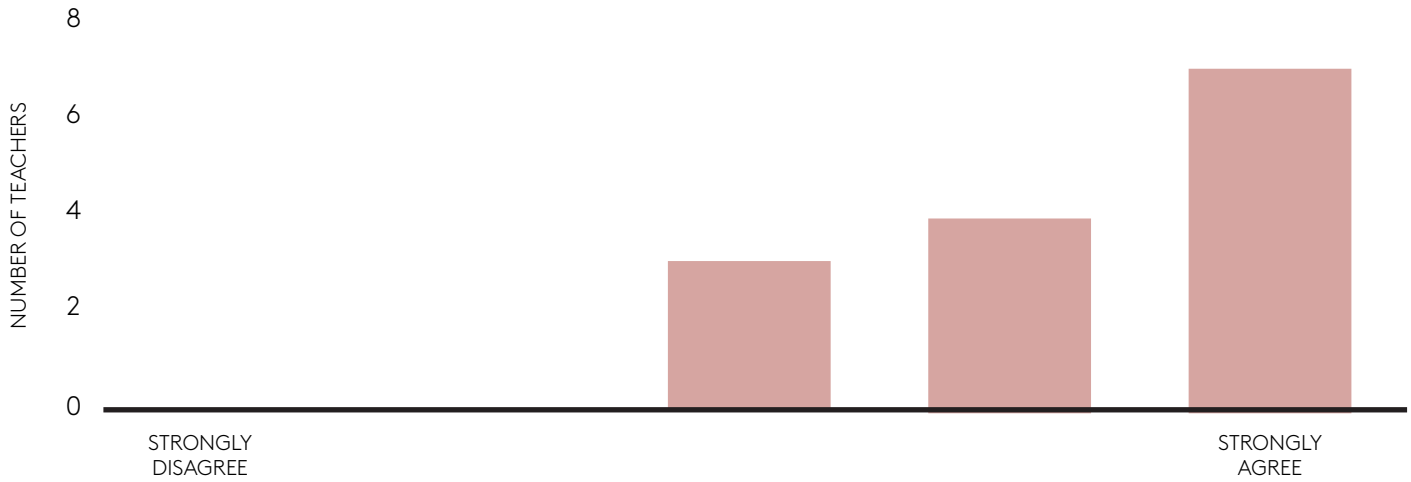
Before exploring how teachers feel about biophilia in the classroom, it's important to understand how teachers feel about their spaces and how it impacts the way they teach.

Survey questions were distributed to teachers from four elementary schools in order to gather their opinions and thoughts on classroom design.

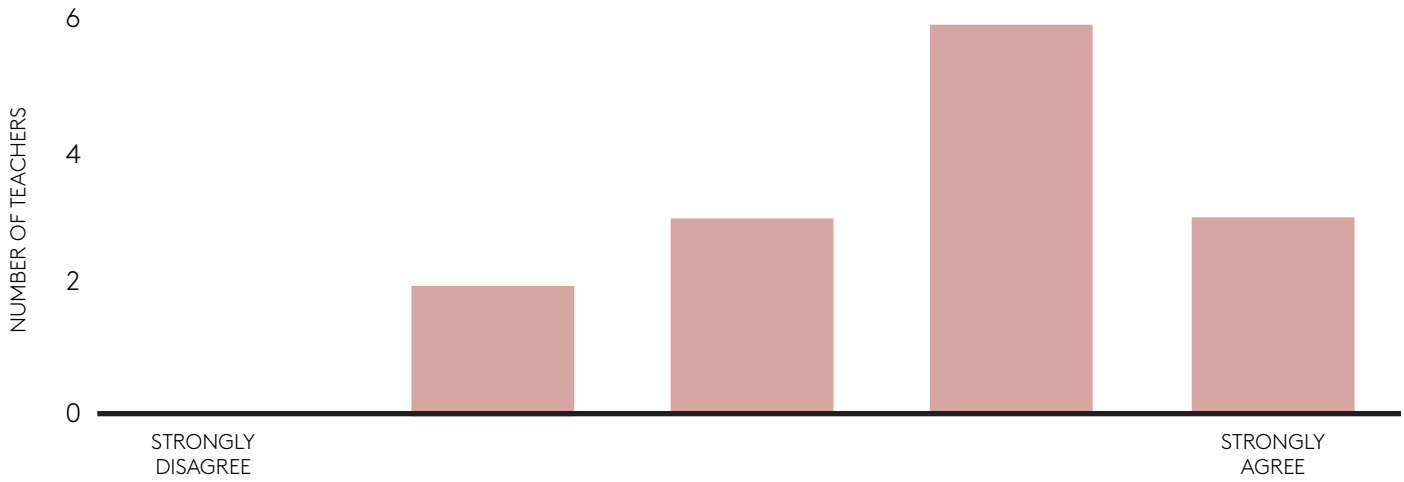
I care about the way my classroom looks.



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



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



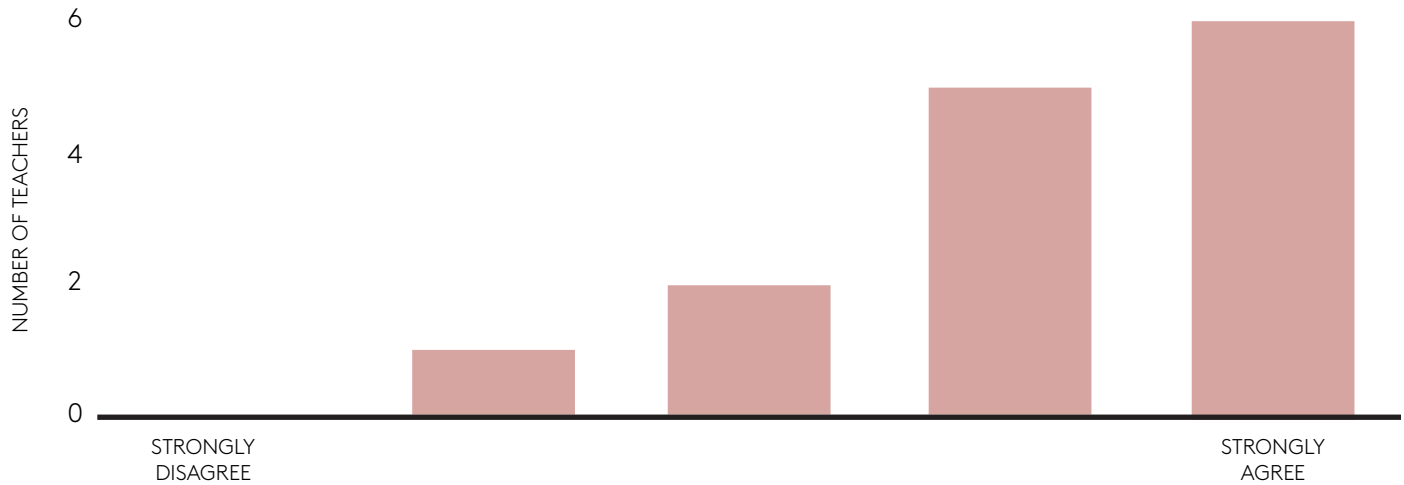
The answers to these survey questions reveal that:

85.7% of teachers report feeling strongly about how their classroom looks.

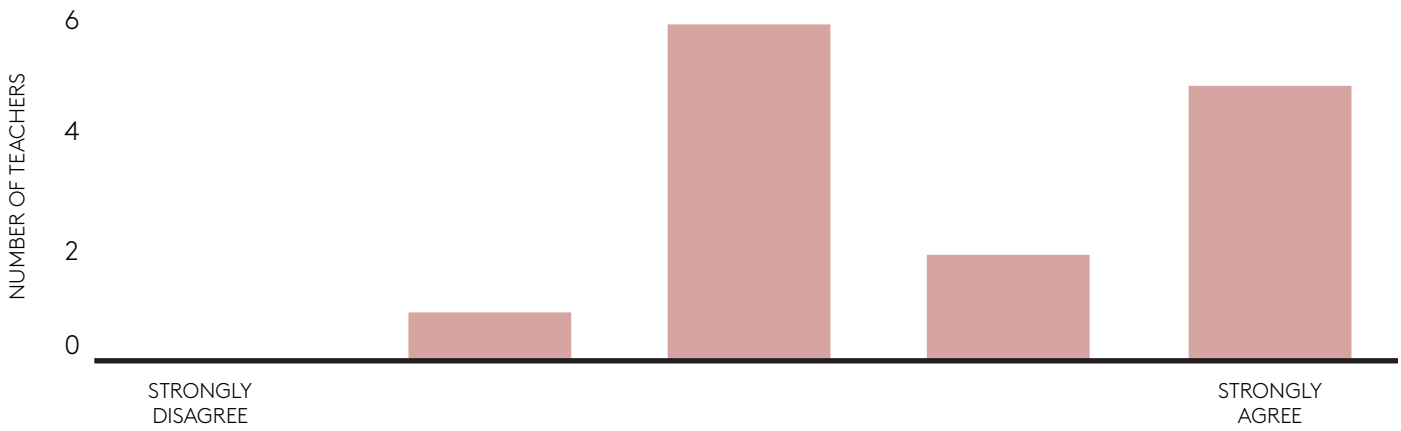
50% care strongly about the architectural finishes and materials.

42.9% feel that the construction materials in their classroom make a difference in how they feel when teaching, and 21.1% strongly feel that it impacts them.

I enjoy having wood in my classroom.

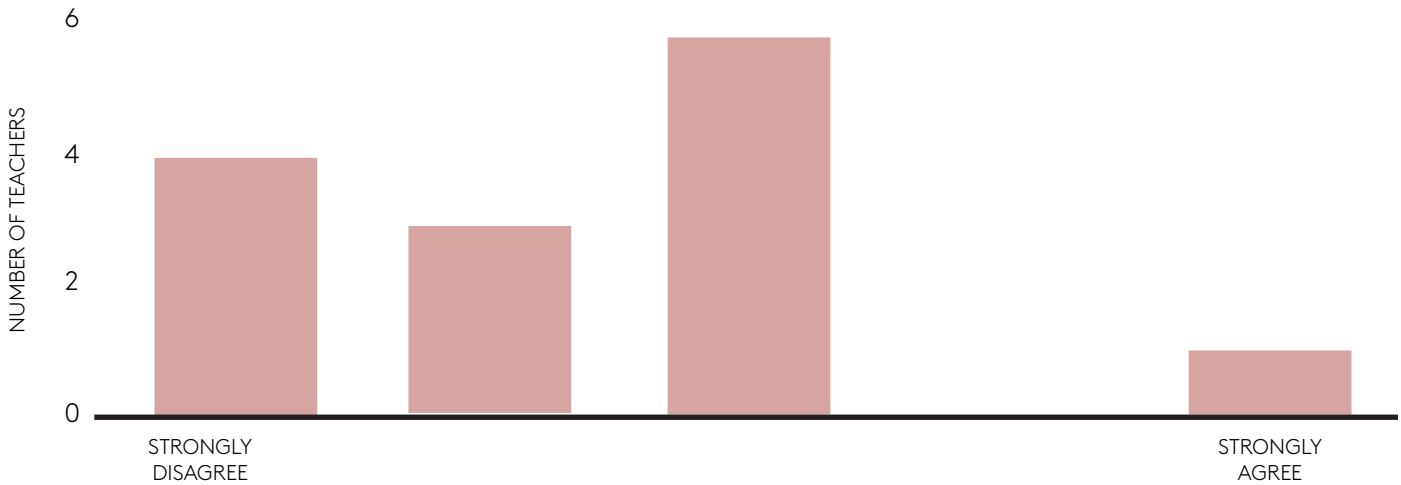


I prefer teaching in a classroom with exposed wood features.

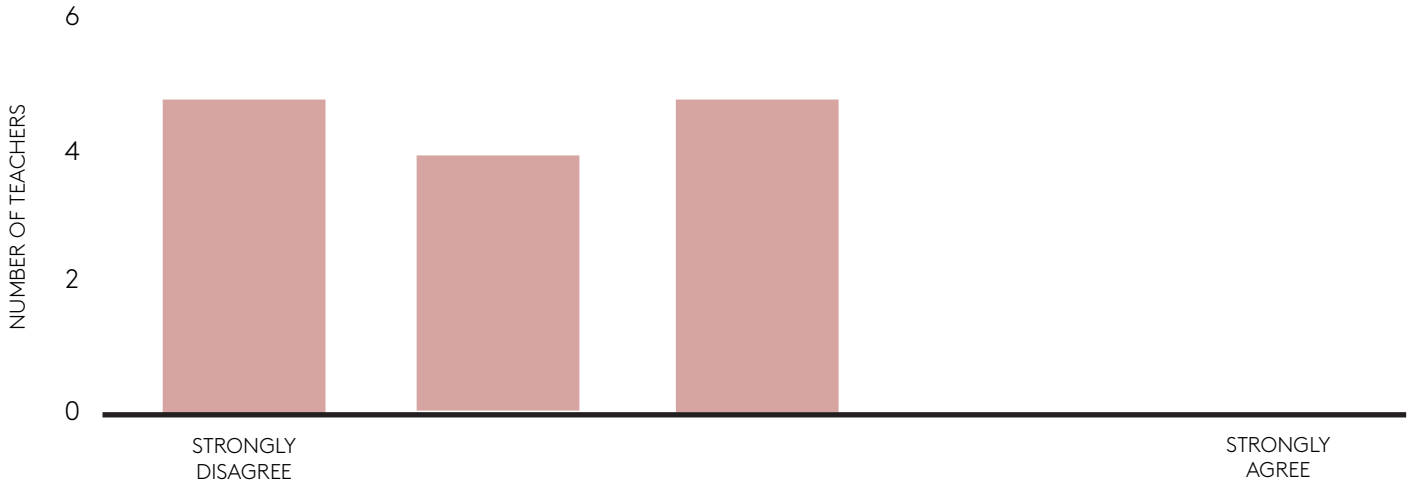


This set of questions conveys that teachers care about how their classroom looks and do notice the architectural features. Wood is not necessarily a preference for teachers, but it is positively received when present.

Students notice the wood in their surroundings.

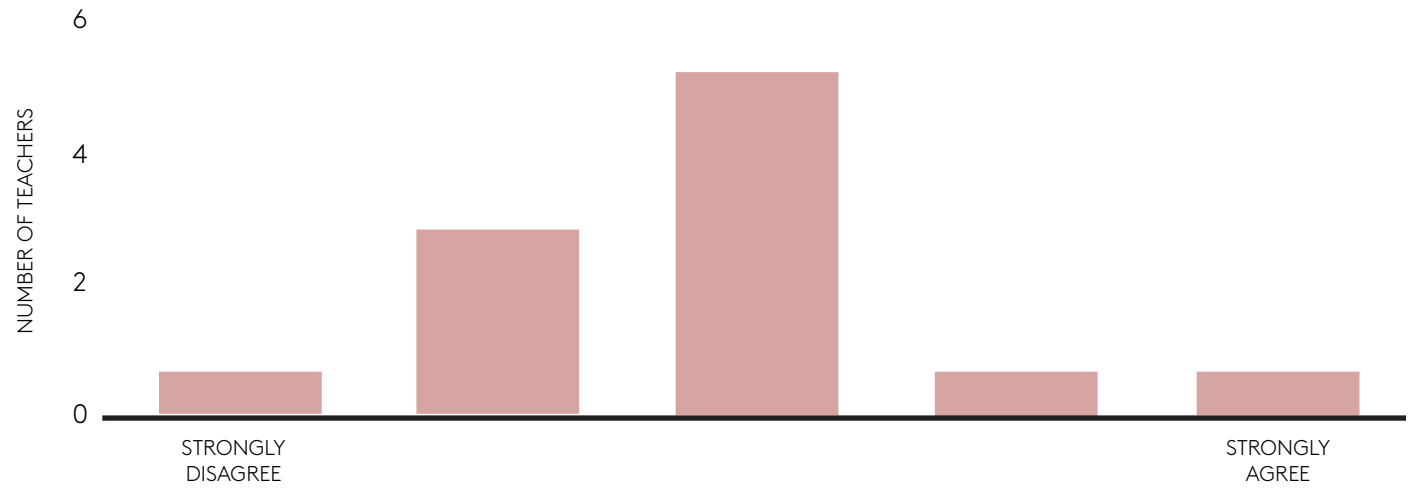


Students interact with the wood in their surroundings.

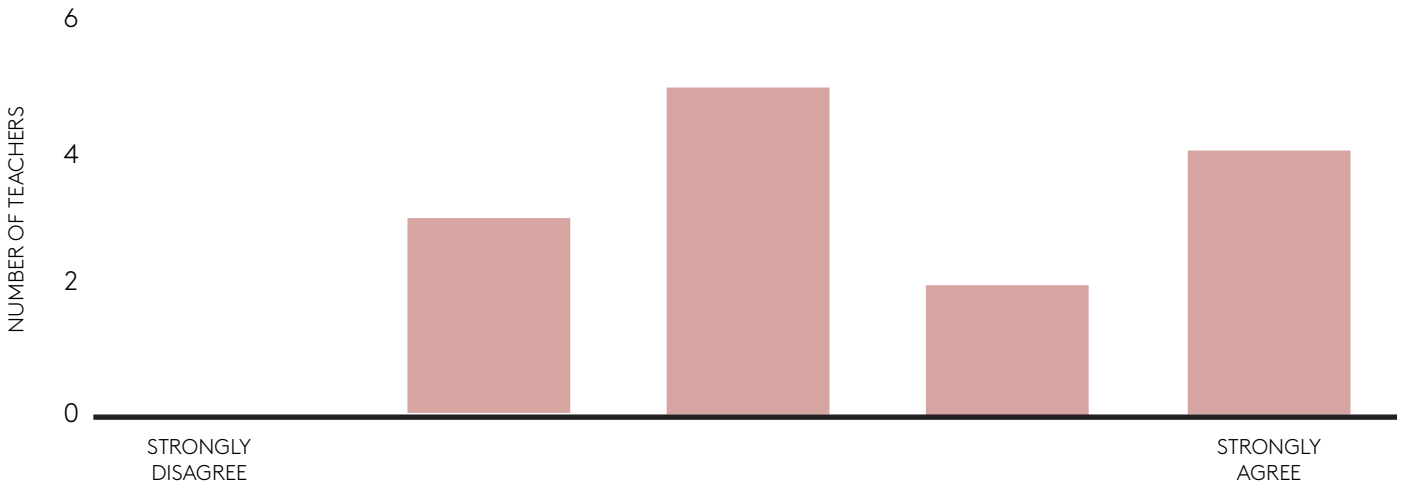


Next, we looked at what teachers' observe about students in wood classrooms. 42.9% feel that their students may or may not notice the wood. A majority of teachers shared that their students do not interact with the wood.

Classrooms with wood provide ecological learning opportunities.

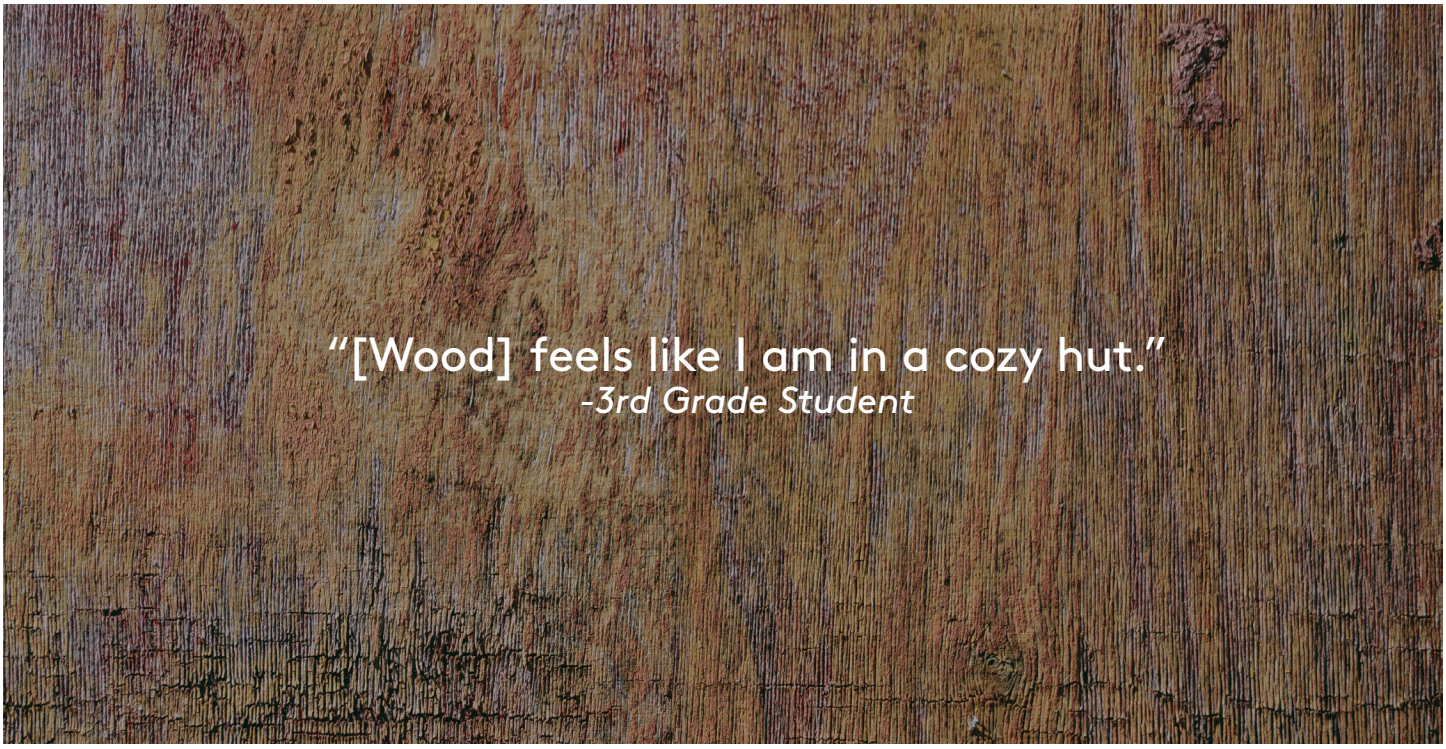


Students can implicitly learn lessons from their surroundings.



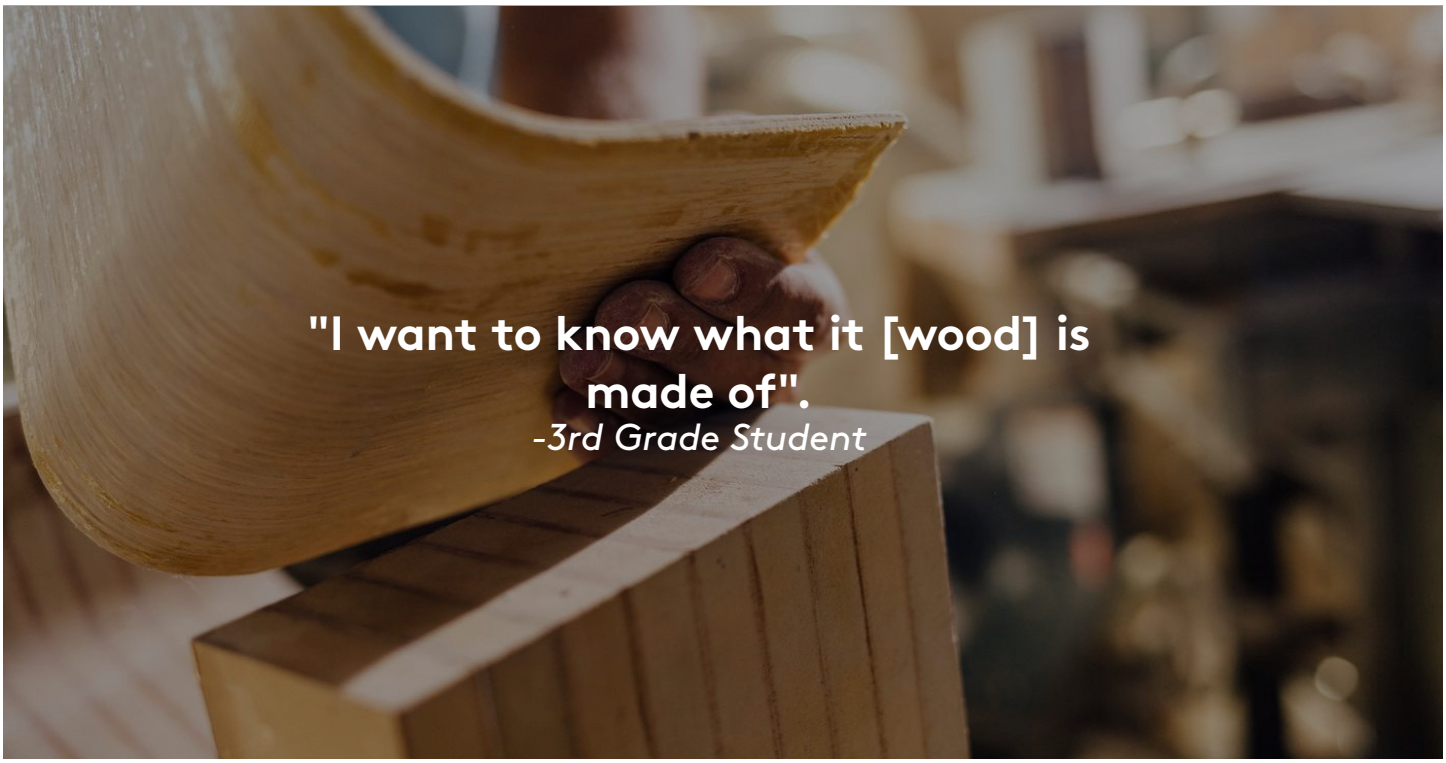
42.9% think that students can learn implicitly through their surroundings. From this question and the previous one, we can conclude that there may be ways for the surroundings to teach students, but how wood can do that is not yet clear to teachers.

Student Surveys



Developmental Asset: Bonding to School
Child feels a sense of belonging at school.

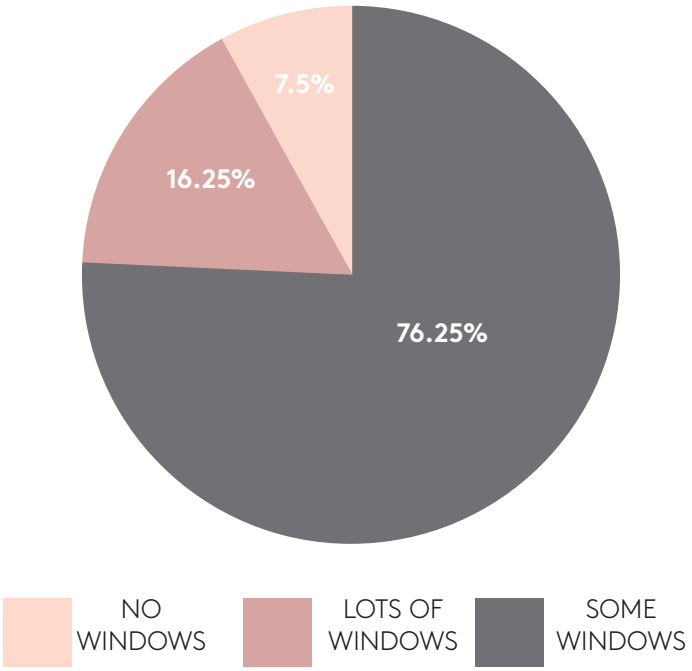
This student related the wood in their classroom to the wood in their home. This leads to the conclusion that wood in the classroom evokes a sense of familiarity that creates feelings of belonging.



Developmental Asset: **Achievement Motivation**
Child is encouraged to remain curious.

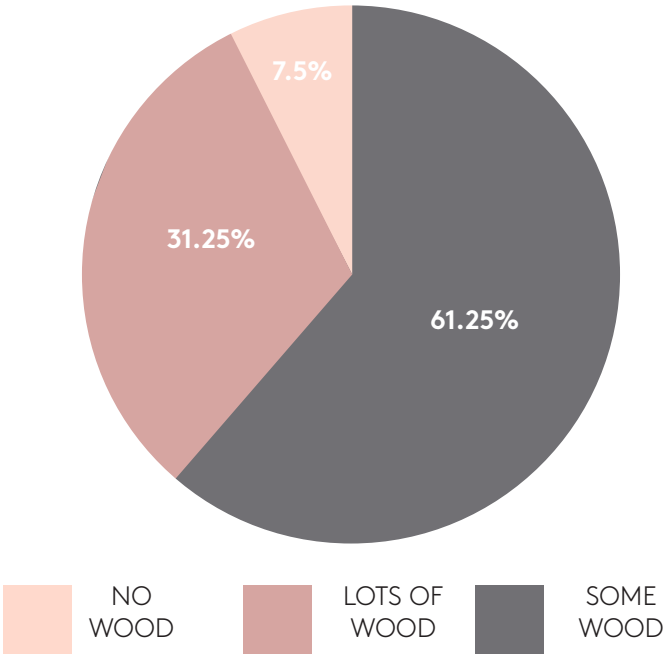
This student is showing a curiosity in the way the wood panels at their school are formed. Future research may explore if students wonder about the formation of unnatural materials equally, such as concrete.

I like to learn in a classroom with...



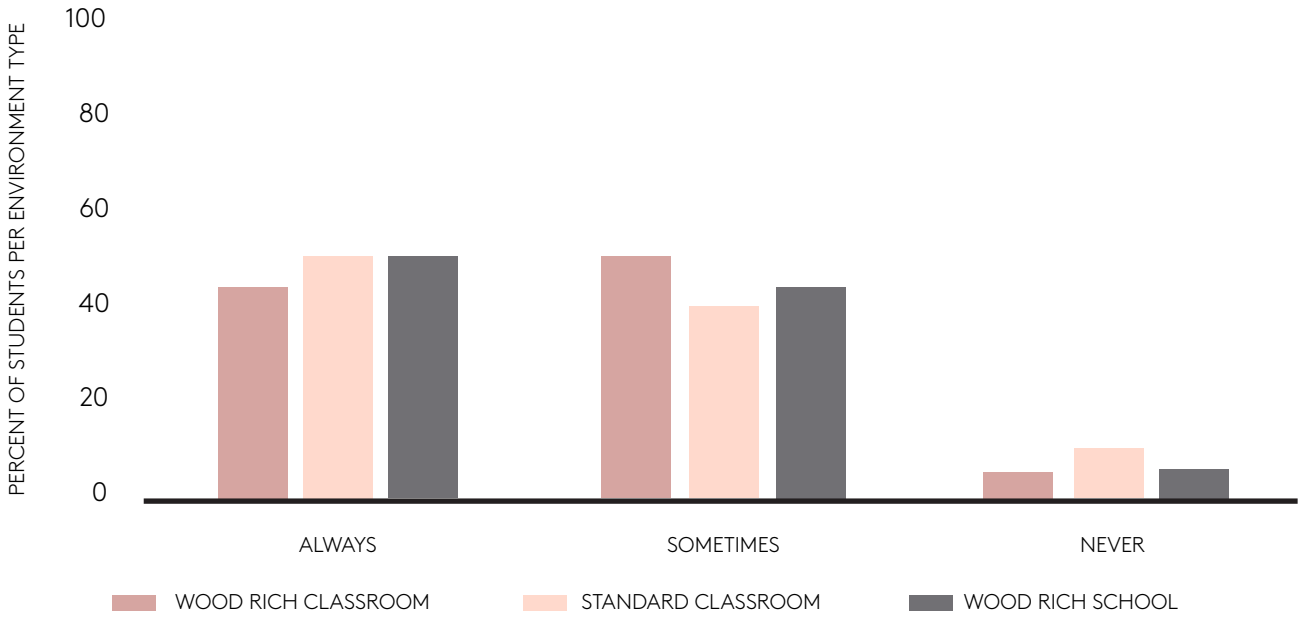
The previous two survey questions were intended to gather information about the overall classroom setting that students are fond of.

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



These questions reveal that the majority of students prefer to be in a room with some wood and some windows.

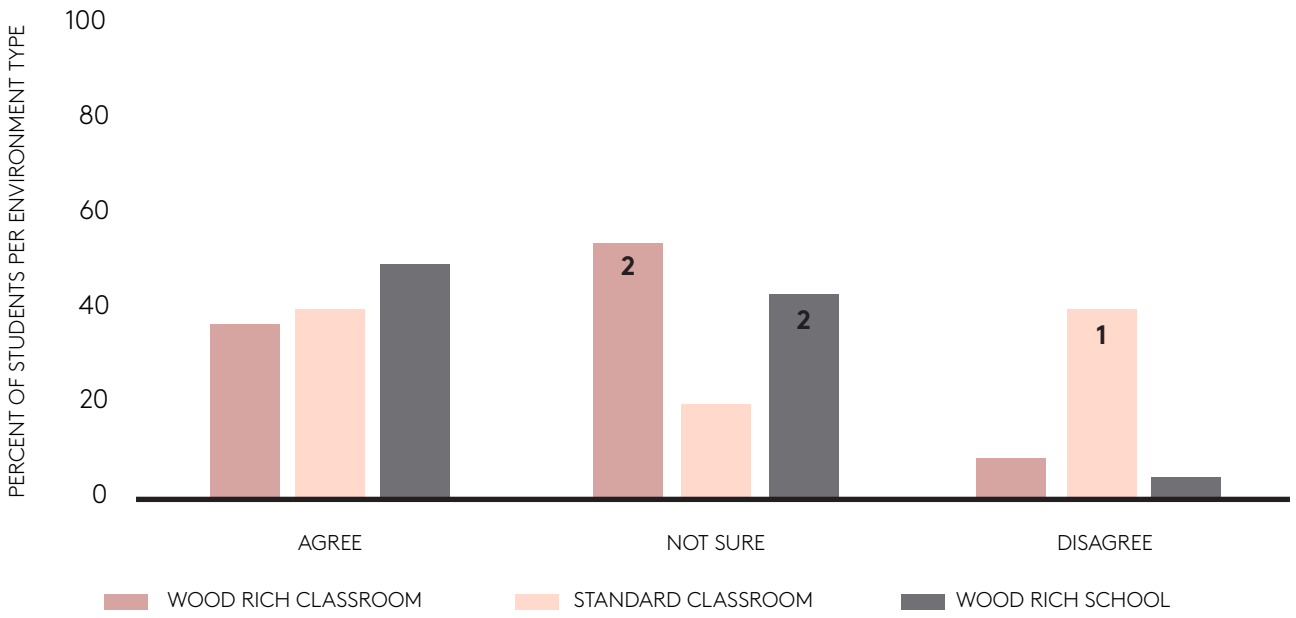
I notice when there is wood around me...



Key Findings

Whether or not a student notices wood does not seem to depend on the exposure the student has to wood. A similar mix of answers is evident in all three groups. The results of this question revels that the majority of all students either always or sometimes notice the wood around them, which is the opposite of what teachers perceived of their students. It is possible that teachers did not perceive their students noticing wood because the students are not physically interacting with it.

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



Developmental Asset: Self-Regulation
Child develops skills in emotional regulation

This question tested how calm students in each type of surveyed environment feel. The goal was to understand if exposure to wood increases, decreases, or does not impact how calm students perceive themselves to be.

Key Findings

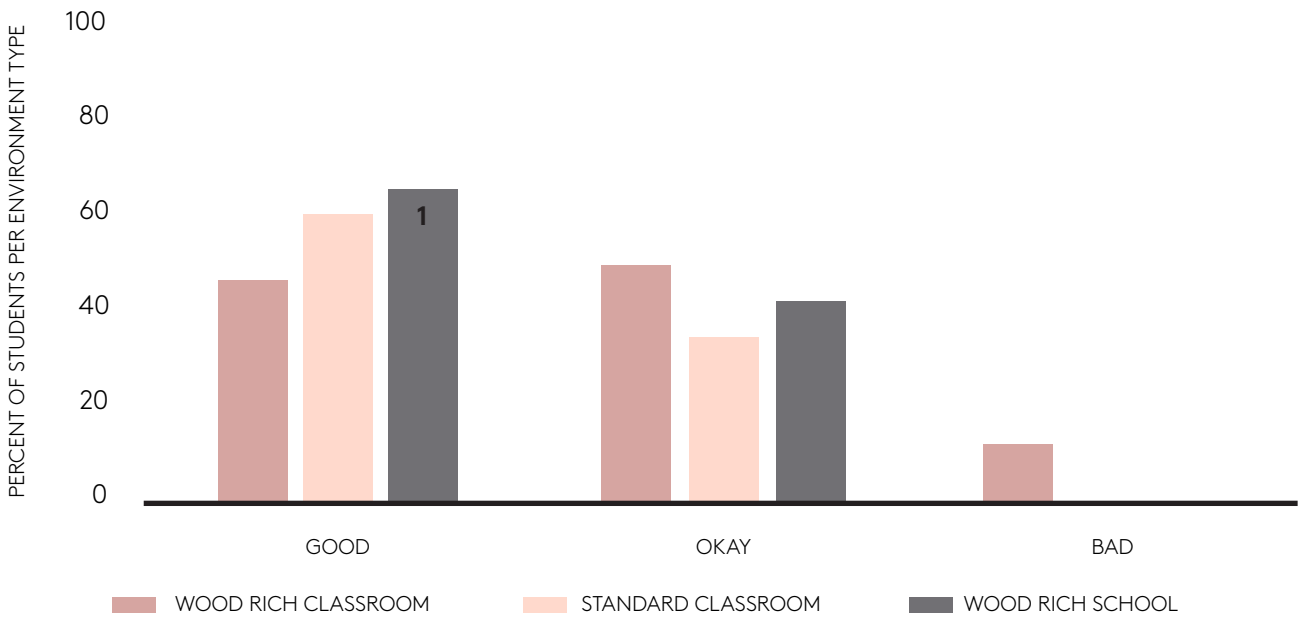
More students from the wood rich school group agreed that they feel calm when around wood than students from the other groups.
Out of the students who disagreed to feeling calm when around wood, there was a significantly larger proportion from the students in the standard classroom. This may be due to the fact that they are not consistently around wood.

Discussion

1. A high percentage of students from the standard classroom disagreed with feeling calm around wood in comparison to the percentages of students from the other environments. While this result may lead to the conclusion that students in wood rich environments do not feel calm in wood settings, there is another conclusion that may be drawn. Students in standard classrooms have not been exposed to wood environments enough to be able to agree that they feel more calm in these settings.

2. The students in the wood rich environments who responded "unsure" may be responding this way due to the fact that this survey was administered at the end of the academic school year. At this point, students have spent almost nine months in their respective spaces and may not be able to accurately compare how they feel in wood spaces versus how they felt previously in spaces that were not wood rich. A future study might be more effective by surveying students how they feel immediately after transitioning from one type of space to another.

I feel...



Developmental Asset: Self-Regulation
Child develops skills in emotional regulation

This question tested the impact of wood environments on self-regulation by exploring how students in each type of surveyed environment feel. The goal was to understand if exposure to wood has an impact on student feelings.

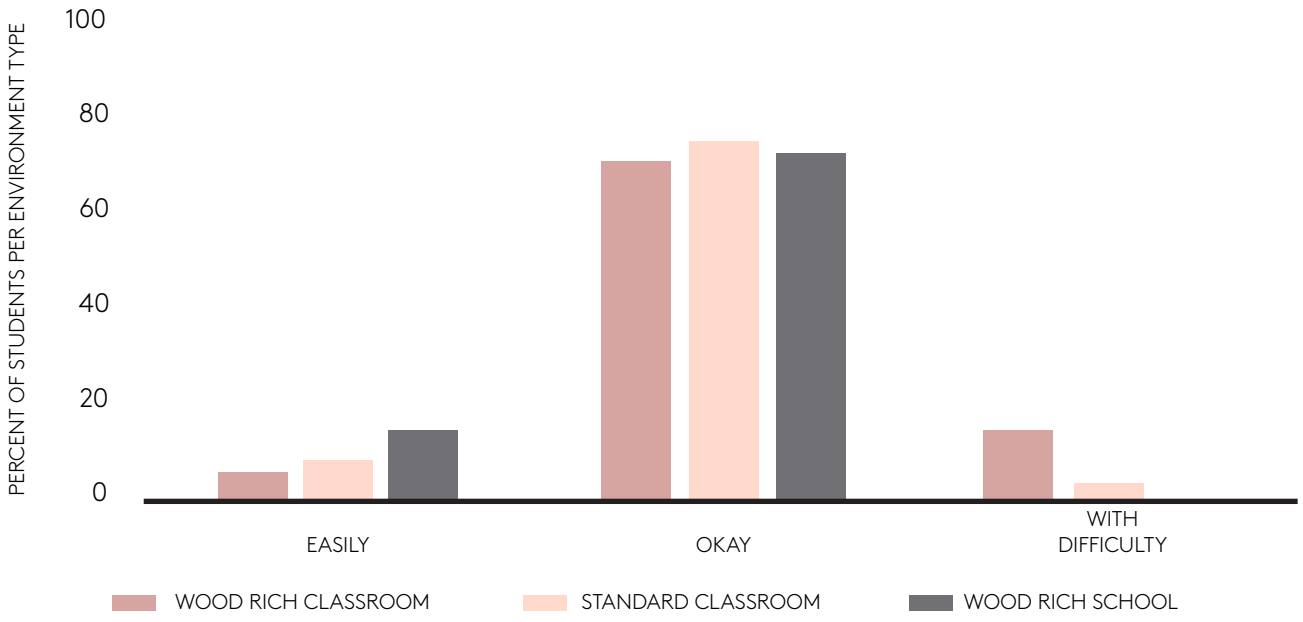
Key Findings

A higher proportion of students from the wood rich school reported feeling "good" in comparison to students from the other groups. Only students from the wood rich classroom reported feeling "bad". This likely does not reflect that students from the other environments do not feel "bad", but rather may be a reflection of the small sample size, without enough data to draw solid conclusions.

Discussion

1. The way a student feels in their classroom can be impacted by several factors. Students in the wood rich school had the highest percentage of feeling "good," however, this reporting is impossible to isloate from other environmental and social factors at the schools. Ideally, data from students in the same school district would be compared in order to reduce external variations that may impact how a student feels, such as state guidelines or curriculum.

I focus...



Developmental Asset: Achievement Motivation
Child shows interest in academic success.

This question tested the impact of wood environments on achievement motivation by exploring if students in wood spaces are better able to focus than students in spaces with less or no wood.

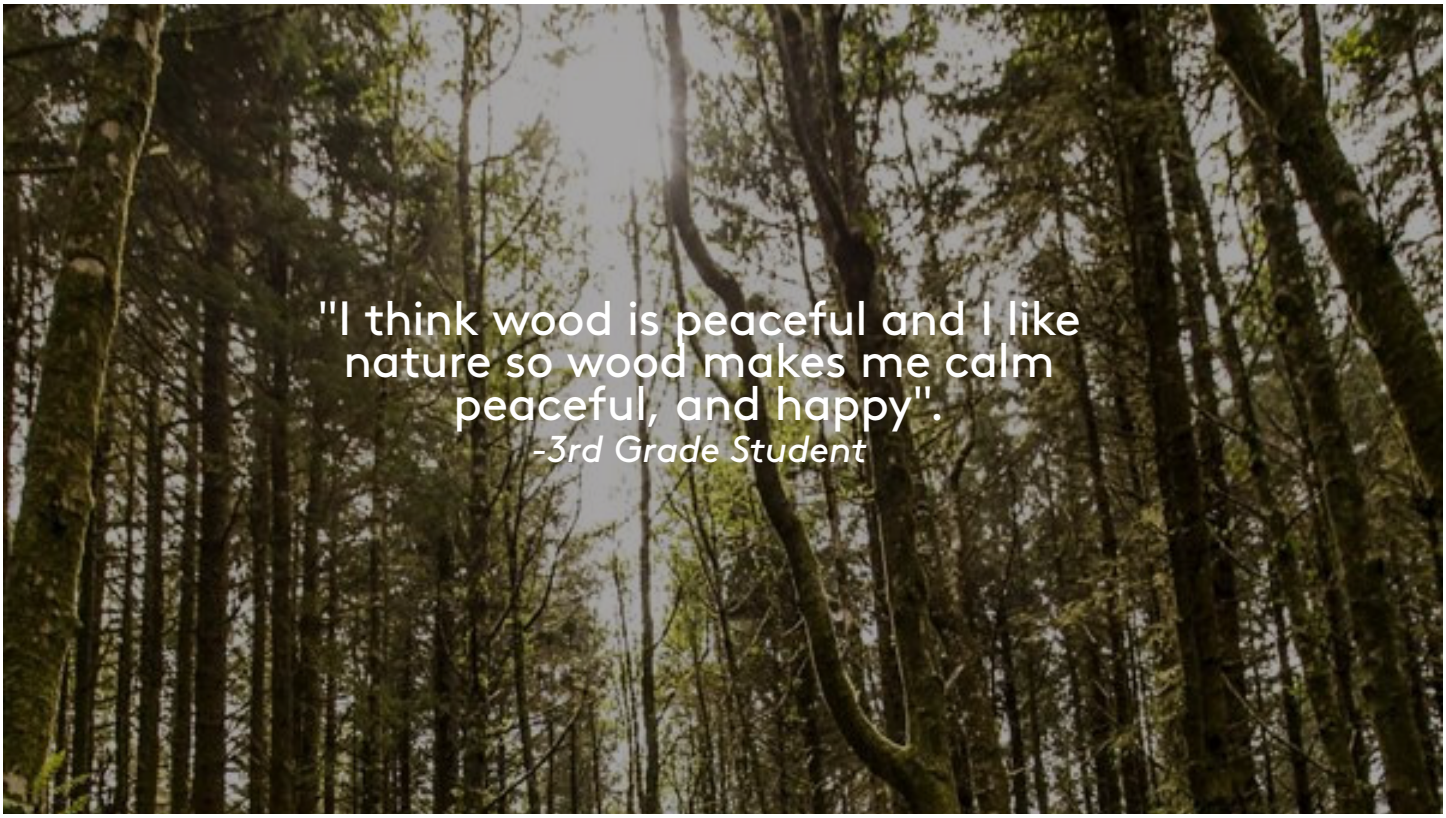
Key Findings

A higher proportion of students from the wood rich school reported focusing "easily" in comparison to students from the other groups. No students from the wood rich school reported focusing "with difficulty". The proportion of students who reported focusing "okay" was fairly equal across the three groups.

Discussion

The majority of students responded "okay" to this question. This conveys that either students are focusing "okay" or that 3rd grade students may not be able to accurately assess how they focus and "okay" is a safe middle answer. Future research should look to examine how students focus based on physical responses rather than self-reported answers. The self-reported answers are useful in understanding how students perceive their level of focus and may be accurate. Further testing is required to prove this.

Discussion



Developmental Asset: Self-Regulation
Child develops skills in emotional regulation

In one quote, this student conveyed many of the claims this report explored, particularly that nature (biophilia) and wood (a material connection to nature) impacts their emotions and feelings positively.

Learning

One question the report addressed is student learning and how mass timber spaces impact their learning.

The literature review showed a correlation between biophilia and student ability to focus, positively impacting their academic success.

The surveys also showed this correlation. 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. Teachers report that their students do focus better which is a major factor in how well students learn.

In examining the student responses, the total percent of students from the wood rich school who reported focusing easily was higher in the wood rich school than in the other two environments.

The surveys reveal that there is a connection between mass timber and encouraging curiosity. Many of the students wrote that they wonder how the wood is made, want to know how it works structurally, and think about its ability to withstand fire. Curiosity is very important for students in this age group's learning development, specifically the internal asset of commitment to learning as the wood environments encourage students to remain curious.

Students' ability to focus better around wood supports general learning and curricular goals. There may be an opportunity to use the surroundings as a teaching tool, but this connection is either unclear or not established enough. If it is more clear, mass timber could

reflect Next Generation Science Standards as students could explore the materiality and use their wood environment as a way to question human design and how we impact the environment. Though teachers were unsure of how this may happen, students may already be doing this subconsciously as existing research has shown that our surroundings impact us implicitly. Additional research would need to be conducted to understand what is absorbed by students in wood rich environments.

Resiliency

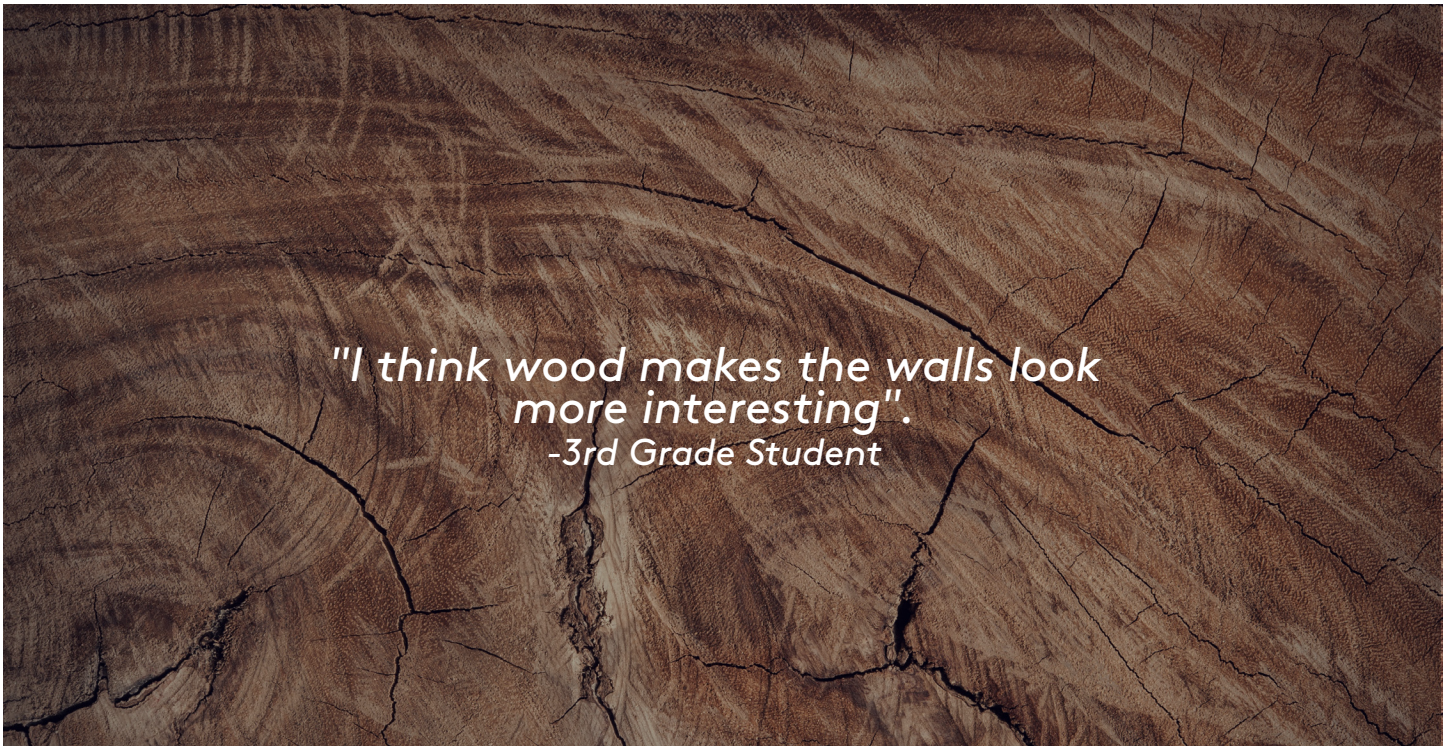
This report looked to determine whether or not mass timber spaces could improve student resiliency. To answer this question, the literature review and surveys explored ideas around student mood and comfort.

Wood spaces improve student mood and give them a sense of comfort. This was proven through the literature review as well as the student surveys. The literature review highlighted the many ways in which time in nature regulate mood and increase feelings of peacefulness. The surveys were intended to determine whether these feelings of peace in nature translated to feelings of peace when around natural materials, specifically mass timber. 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.

There are many areas for future research, which could clarify some of the questions raised in this study and provide further quantitative research.

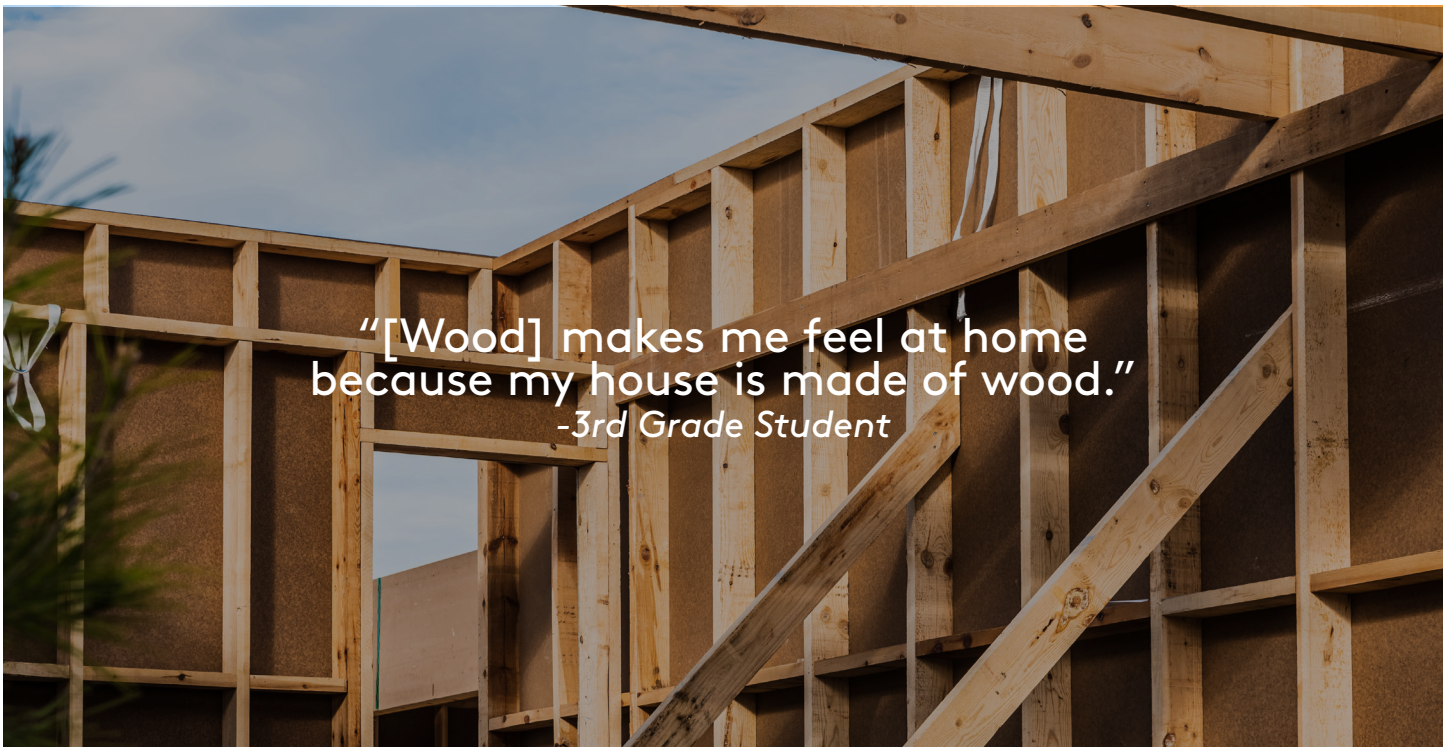
Developmental Asset: **Achievement Motivation**
Child is encouraged to remain curious.

This student is conveying an understanding of the benefits of wood, either environmental or personal. A curiosity in the materiality of the classroom and its greater implications is evident here.



***Developmental Asset:* Achievement Motivation**
Child is encouraged to remain curious.

This student is noting a visual interest in wood as a wall material. This interest may peak their curiosity both in the wood and their surroundings as a whole, encouraging them to remain curious.



Developmental Asset: Bonding to School
Child feels a sense of belonging at school.

This student related the wood in their classroom to the wood in their home. This leads to the conclusion that wood in the classroom evokes a sense of familiarity that creates feelings of belonging.

Future Research

The research in this report highlights many ways in which elementary students are impacted by the design of their school. It is clear that the mental and psychological health of students is very dependent on their surroundings and as such the design of their schools should be thoughtful and utilize biophilic patterns.

There are many opportunities for this research to develop and grow in order to better serve students and assess the design of schools more holistically. In addition to the topics covered in this thesis, several other design elements may be explored in relation to how they impact the mental and psychological health of children. One of these elements is play as it is crucial to the healthy development of children. Play is "so important to optimal child development that it has been recognized by the United Nations High Commission for Human Rights as a right of every child." (Ginsburg). Play allows children to develop emotional and cognitive strength, as well as imaginations. It is also shown to help children conquer their fears and become more resilient (Ginsburg). Lastly, children experience great joy when playing which positively impacts their mental health. Many schools already incorporate play into their design, though it would be interesting to explore how play can become a more central component of school design and extend beyond the playground and into the classrooms. Another design element that should be explored in future research is color. Colors have a great impact on mood and perception of the world. The use of color in school design should be intentional and thoughtful as to not have unintended harmful impacts on students.

The literature also conveys a major gap as there is limited information or studies from the perspective of students. While it is crucial to understand the mental impact through social science, it is also important to consider the voices of the people who these spaces are being designed for. Future research should seek out the direct opinion and perspective of children. This information can then be compared to the findings from the existing studies to understand if there are any design elements that have not been considered or have been misrepresented.

In addition, future research can examine how much of a role the structure of the

education system has on students' mental and psychological health. Data from schools abroad can be compared to the data presented in this research that focuses on schools in the United States. Schools with similar architecture or design strategies can be compared to understand how much of the impact on students' wellbeing stems from design and how much stems from the structure of the education system, such as the subjects taught, expectations on students, and hours spent in class studying.

Future research should also be extended to consider older and younger children in middle school, high school, and preschool. These children are all at different developmental phases in their lives. As such, the design of their schools might impact them to varying degrees. Also, different design elements may impact some age groups more than others.

In addition to exploring additional age groups, a study should be conducted to understand how socio-economic status impacts school design. Schools may be restricted in how much they can implement biophilic design strategies due to their budget or limited funding. This thesis considered all schools equally and proposed strategies for all schools, regardless of their size, socio-economic status, or other factors that differentiate schools. Further development of design guidelines to create a set of recommendations that are informed by justice, diversity, and social equity.

Lastly, the impacts of schools on the physical health of students can be explored in subsequent research. This will help uncover if the design decisions made for mental health are sufficient for physical health, or if there are additional considerations that designers must make for schools to be healthy places for children.

Aside from future research, it is also important to explore how the claims and results of this research might be implemented. Many designers and architects already consider the mental health of students when designing a building and as such do not need an incentive to do so. This is not the case in all school designs as there is not a widespread knowledge of the specific and proven ways that architecture impacts children. Also, there are often budget or site restrictions that prevent designers from implementing all of the positive design decisions that can go into elementary schools. This leads to the question of how a culture can be created in which the mental health of students is a primary design consideration and not one that can be easily pushed away. One way to do this may be through city code and incentives. For example, cities might allow additional building height or square footage to schools that significantly incorporate nature into the design. Another way to create this culture might be to include students in the design process. If students are given the opportunity to advise designers on the qualities of a school that make them feel the best, there would be a clearer understanding of what a school that supports the mental wellbeing of children looks and feels like.

Design that considers the mental and psychological wellbeing of children is imperative to creating a healthy, productive, and safe environment for students. There are many ways in which an elementary school can incorporate design elements that support children. A world in which architecture is approached as a social factor with mental and psychological wellbeing at the forefront of design is a more considerate, thoughtful, and supportive place.


"I think that wood is important".
-3rd Grade Student

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