



Investing in plants in the classroom leads to increased student attention capacity (Kim et al., 2020)

Princeton Montessori School | Princeton, New Jersey

## Plants in the Classroom

Interaction & Engagement

Indoor Greenery

## Indoor Greenery



Investing in green walls in the classroom leads to increased student sustained attention (Bernardo et al., 2021)

Sydenham Catholic Regional College | Sydenham, Australia

## Green Walls in the Classroom

Indoor Greenery

In a 2020 controlled experiment of two elementary schools in Seoul, South Korea, Kim et al identified that the addition of large potted plants within classrooms (1 plant per student) resulted in an increase in attention capacity through a **52.9% improvement in performance (FAIR-P scores,  $p<0.05$ ) and a 73.2% improvement in quality (FAIR-Q scores,  $p<0.05$ )**. (n = 70 students in two schools, t = 2 measurement periods x 9 days)

Kim, H.-H., Yeo, I.-Y., & Lee, J.-Y. (2020). Higher Attention Capacity After Improving Indoor Air Quality by Indoor Plant Placement in Elementary School Classrooms. The Horticulture Journal, 89(3), 319–327. <https://doi.org/10.2503/hortj.utd-110>

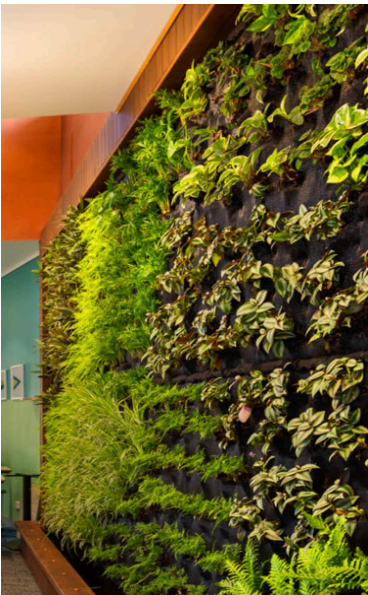


This action aligns with national certifications and standards	
TBG’s 14 Patterns	P1: Visual Connection with Nature
Kellert’s 6	Environmental Features
LEED v4 O+M Schools	IEQ: Daylight & Quality Views
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Plants in the Classroom

In a 2021 field experiment of two classrooms in a primary public school in Lisbon, Portugal, Bernardo et al identified that the introduction of green biophilic elements including artificial green walls and vegetable pots resulted in a **11.21% increase in student sustained and selective attention (p = 0.013)**. (n=95, t = 1 month)

Bernardo, F., Loupa-Ramos, I., Matos Silva, C., & Manso, M. (2021). The Restorative Effect of the Presence of Greenery on the Classroom in Children's Cognitive Performance. Sustainability, 13(6), 3488.



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TBG’s 14 Patterns	P1: Visual Connection with Nature
Kellert’s 6	Environmental Features
LEED v4 O+M Schools	IEQ: Daylight & Quality Views
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Green Walls in the Classroom



Planting outdoor foliage for views from the classroom can improve student reading scores (Kuhlenengel et al., 2019)

Common Ground High School | New Haven, Connecticut

## Landscape Views from the Classroom

Views



Planting outdoor foliage for views from the cafeteria can improve high school graduation rates (Matsuoka, 2010)

The Athenian High School | Danville, California

## Landscape Views from the Cafeteria

Views

In a 2019 observational study of 220 K-12 classrooms in the Midwestern United States, Kuhlenengel et al identified that an increased amount of visual information and the quality of the view from the classroom, especially with multiple view layers, resulted in a **1.9% improvement in reading scores**. (p=0.016, n=220 classrooms)

Kuhlenengel, M., Waters, C. E., & Konstantzos, I. (2019, November). Assessing the impact of outside view on learning: A close look to EN 17037 'view out' practices through the analysis of 220 classrooms. In Journal of Physics: Conference Series (Vol. 1343, No. 1, p. 012159). IOP Publishing.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P1: Visual Connection with Nature P7: Connection with Natural Systems
Kellert's 6	Environmental Features
LEED v4 O+M Schools	IEQ: Daylight & Quality Views
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	EQ 12.1: Views
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Landscape Views from the Classroom

In a 2010 observational study of 101 public high schools in southeastern Michigan, Matsuoka identified that every one-unit increase in views of nature rating (5-point scale ranging from “no view” to “all natural”) in a school cafeteria resulted in a **0.17 increase in graduation rates**. (p<0.01, n=101 schools)

Matsuoka, R. H. (2010). Student performance and high school landscapes: Examining the links. Landscape and urban planning, 97(4), 273-282.



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Kellert's 6	Environmental Features
LEED v4 O+M Schools	IEQ: Daylight & Quality Views
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	EQ 12.1: Views
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Landscape Views from the Cafeteria

# Views



Providing access to window views of the neighborhood can lead to safer communities (Newman, 1996)

MK-S Nursery | Yokohama, Japan

© Kenjiro Yoshimi

## Neighborhood Views from the Classroom

# Views



Providing access to window views of cityscapes can reduce perceived anxiety (Chang & Chen, 2005)

TTC Elite Saigon Kindergarten | Ho Chi Minh City, Vietnam

© Quang Tran

## City Views from the Classroom

In a 1996 publication on community design analysis, Newman identified that access to views of neighborhood creates a sense of ownership and responsibility for the community and results in a **safer neighborhood**.

Newman, O. (1996). Creating defensible space. Diane Publishing.



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TBG's 14 Patterns	P1: Visual Connection with Nature
Kellert's 6	Environmental Features
LEED v4 O+M Schools	IEQ: Daylight & Quality Views
WELL v2	
CHPS	EQ 12.1: Views
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Community Views from the Classroom

In a 2005 field study at the psychophysiological laboratory at National Chung-Hsing University in Taichung, Taiwan, Chang and Chen identified that an office with window views of a city resulted in a **17.6% reduction in perceived anxiety** (State-Trait Anxiety) as compared to an office with no window. (p<0.001, n=38)

Chang, C. Y., & Chen, P. K. (2005). Human response to window views and indoor plants in the workplace. HortScience, 40(5), 1354-1359.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P1: Visual Connection with Nature
Kellert's 6	Environmental Features
LEED v4 O+M Schools	IEQ: Daylight & Quality Views
WELL v2	
CHPS	EQ 12.1: Views
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## City Views from the Classroom



Investing in clear windows for the classroom can improve cognitive function (Boubekri et al., 2020)

Akshar Arbol International School | Chennai, India

© Sreenag BRS

## Clear Windows in the Classroom

Views



Investing in clean, washed windows leads to improvement in cognitive function (Boubekri et al., 2020)

De Zonnepoort Primary School | Ghent, Belgium

© Stijn Bollaert

## Washed Windows in the Classroom

Views

In a 2020 cross-over study of an office building in Durham, North Carolina, Boubekri et al identifies that the implementation of electrochromic glass windows for optimized daylight and views results in a **42% increase in cognitive function (p<0.0001)** as compared to traditional roller blinds. (n = 30, t = 1 week x 2 window conditions)

Boubekri, M., Lee, J., MacNaughton, P., Woo, M., Schuyler, L., Tinianov, B., & Satish, U. (2020). The impact of optimized daylight and views on the sleep duration and cognitive performance of office workers. International journal of environmental research and public health, 17(9), 3219.



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TBG's 14 Patterns	P1: Visual Connection with Nature
Kellert's 6	Environmental Features
LEED v4 O+M Schools	IEQ: Daylight & Quality Views
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	EQ 12.1: Views
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Clear Windows in the Classroom

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Kellert's 6	Environmental Features
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Washed Windows in the Classroom

# Views



Investing in shading devices that allow views through the window improves concentration & working memory (Ko et al., 2020)

## Shading Devices with Views

Views

# Views



Investing in outdoor wildlife habitats near classroom windows leads to health benefits (Browning et al., 2014)

Douglas Magnet Elementary School | Raleigh, North Carolina

## Wildlife Habitats

Interaction & Engagement

Views

In a 2020 randomized crossover study at the University of California, Berkeley, Ko et al identified that access to window views of nature with a 48% window-to-wall ratio resulted in a **6% increase in working memory (p<0.01)** and a **5% increase in concentration (p=0.03)** as compared to a windowless shared workspace. (n=86 participants x 2 window conditions x 1 hour per condition)

Ko, W. H., Schiavon, S., Zhang, H., Graham, L. T., Brager, G., Mauss, I., & Lin, Y. W. (2020). The impact of a view from a window on thermal comfort, emotion, and cognitive performance. Building and Environment, 175, 106779.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P1: Visual Connection with Nature
Kellert's 6	Environmental Features
LEED v4 O+M Schools	
WELL v2	L05: Daylight Design Strategies M02: Nature and Place
CHPS	EQ 11.1: Daylighting: Glare Protection EQ 12.1: Views
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Shading Devices with Views

The 14 Patterns of Biophilic Design by Terrapin Bright Green identifies “Connection with Natural Systems” to be the seventh pattern as it is highly suspected to provide health benefits to those who are exposed to natural systems.

Browning, W., Ryan, C., & Clancy, J. (2014, September 12). 14 patterns of biophilic design. Terrapin Home - Terrapin Bright Green. Retrieved December 1, 2021, from <https://www.terrapinbrightgreen.com/reports/14-patterns/#connection-with-natural-systems>.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P1: Visual Connection with Nature P7: Connection with Natural Systems
Kellert's 6	Environmental Features
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	SS 13.1: School Gardens
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Wildlife Habitats

# Biophilic Finishes



Investing in biophilic carpeting leads to enhanced student test score performance (Determan et al., 2019)

Aldrich Elementary School | Cedar Falls, Iowa

© Kenneth D. Smith, Design Photography

## Flooring with Natural Patterns

Biophilic Finishes

# Biophilic Finishes



Investing in biophilic walls leads to enhanced student test score performance (Determan et al., 2019)

The Garden School | Hackney, UK

Biophilic Finishes

## Walls with Natural Patterns

In a 2019 field experiment of the Green Street Academy in West Baltimore, Determan et al identified that biophilic design integration within a classroom (views of nature and biomorphic patterns on the carpet, ceiling tiles, shades, and wall cover) resulted in a **3 time increase in average iReady test score (p≤0.01)**. (n = 16 students x 15 classrooms, t = 7 months)

Determan, J., Akers, M. A., Albright, T., Browning, B., Martin-Dunlop, C., Archibald, P., & Caruolo, V. (2019). The impact of biophilic learning spaces on student success. American Institute of Architecture, Building Research Knowledgebase.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P8: Biomorphic Forms & Patterns
Kellert's 6	Natural Shapes & Forms
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place
CHPS	
LBC v4.0	I-19: Beauty & Biophilia

## Flooring with Natural Patterns

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Kellert's 6	Natural Shapes & Forms
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place
CHPS	
LBC v4.0	I-19: Beauty & Biophilia

## Walls with Natural Patterns



# Biophilic Finishes

Investing in biophilic ceilings leads to enhanced student test score performance (Determan et al., 2019)

Hahntown Elementary School | North Huntingdon, Pennsylvania

## Ceilings with Natural Patterns

Biophilic  
Finishes

# Biophilic Finishes



Investing in shades with nature prints leads to enhanced student test score performance (Determan et al., 2019)

Green Street Academy | Baltimore, Maryland

## Shades with Natural Patterns

Biophilic  
Finishes

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Kellert's 6	Natural Shapes & Forms
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place
CHPS	
LBC v4.0	I-19: Beauty & Biophilia

## Ceilings with Natural Patterns

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Determan, J., Akers, M. A., Albright, T., Browning, B., Martin-Dunlop, C., Archibald, P., & Caruolo, V. (2019). The impact of biophilic learning spaces on student success. American Institute of Architecture, Building Research Knowledgebase.



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LEED v4 O+M Schools	
WELL v2	M02: Nature and Place
CHPS	EQ 11.1: Daylighting: Glare Protection
LBC v4.0	I-19: Beauty & Biophilia

## Shades with Natural Patterns

# Biophilic Finishes



Investing in wooden furniture can reduce stress recovery time (Fell, 2010)

© Aiste Rakauskaitė

Kindergarten Pelėdžiukas Extension | Pagiriai, Lithuania

## Natural Materials - Wood Furniture

Biophilic Finishes

# Biophilic Finishes



Investing in wooden interiors (floors and walls) improves cognitive test accuracy (Shen et al., 2019)

© Günther Richard Wett

Kindergarten Silz | Silz, Austria

## Natural Materials - Wood Floors + Walls

Biophilic Finishes

In a 2010 controlled experiment at the University of British Columbia in Vancouver, Canada, Fell identified that wooden furniture (chairs, desks, book shelf, coffee table, and blinds) in an office environment resulted in a **44.9% reduction in stress recovery time** (F-NS-SCR) as compared to an office with non-wooden furniture. (p=0.01, n=119)

Fell, D. R. (2010). Wood in the human environment: restorative properties of wood in the built indoor environment (Doctoral dissertation, University of British Columbia).



This action aligns with national certifications and standards	
TBG's 14 Patterns	P9: Material Connection with Nature
Kellert's 6	Environmental Features
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place
CHPS	MW 5.1: Single Attribute - Certified Wood
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Natural Materials - Wood Furniture

In a 2019 controlled experiment in four rooms in Suzhou, China, Shen et al identified that shifting from a non-wooden interior to 50% or 100% wooden interiors resulted in an average **9% increase in accuracy** for five neurobehavioral tests for cognitive performance. (p<0.05, n=20 x 4 tests, t=1 hour)

Shen, J., Zhang, X., & Lian, Z. (2020). Impact of wooden versus nonwooden interior designs on office workers' cognitive performance. Perceptual and motor skills, 127(1), 36-51.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P9: Material Connection with Nature
Kellert's 6	Environmental Features
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place
CHPS	MW 5.1: Single Attribute - Certified Wood
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Natural Materials - Wood Floors + Walls

# Biophilic Finishes



Investing in stone interiors can improve indoor air quality for student and teacher health (Africa et al., 2019)

Moline High School | Moline, Illinois

## Natural Materials - Stone Walls

Biophilic  
Finishes

# Biophilic Finishes



Investing in rammed earth walls can improve human thermal comfort (Brambilla & Jusselme, 2017)

InsideOut School | Abetenim, Ghana

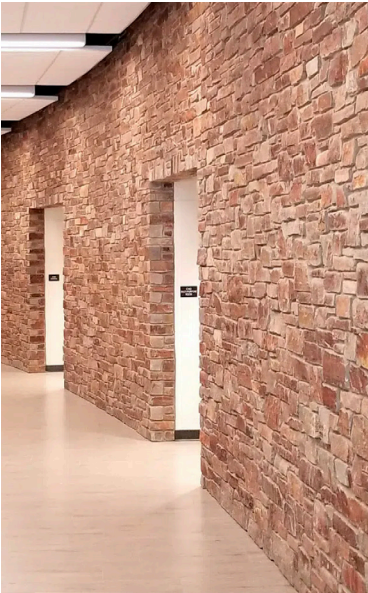
© Andrea Tabocchini

## Natural Materials - Rammed Earth Walls

Biophilic  
Finishes

In a 2019 review of biophilic design and climate change, Africa et al identified that natural materials such as stone are **healthier for building occupants** given that natural materials do not contain “red-listed” chemicals and produce lower concentrations of volatile organic compounds.

Africa, J., Heerwagen, J., Loftness, V., & Ryan Balagtas, C. (2019). Biophilic design and climate change: performance parameters for health. *Frontiers in Built Environment*, 5, 28.



This action aligns with national certifications and standards	
TBG’s 14 Patterns	P9: Material Connection with Nature
Kellert’s 6	Environmental Features
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place
CHPS	EQ 7.1: Additional Low Emitting Materials
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Natural Materials - Stone

In a 2017 controlled lab experiment at the Smart Living Lab in Fribourg, Switzerland, Brambilla and Jusselme identified that adding an internal layer of Compressed Earth Bricks (CEB) to a wall resulted in a **32% increase in thermal comfort range hours** as compared to a standard insulated lightweight frame.

Brambilla, A., & Jusselme, T. (2017). Preventing overheating in offices through thermal inertial properties of compressed earth bricks: A study on a real scale prototype. *Energy and Buildings*, 156, 281-292.



This action aligns with national certifications and standards	
TBG’s 14 Patterns	P9: Material Connection with Nature
Kellert’s 6	Environmental Features
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place
CHPS	EQ 7.1: Additional Low Emitting Materials
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Natural Materials - Rammed Earth



Investing in daylit classrooms leads to improved standardized test scores (Heschong et al., 2002)

Gustav Heinemann Comprehensive School | Essen, Germany

© Philipp Obkircher

## Circadian Light - Daylight

Light



Investing in light shelves for daylit classrooms can improve standardized test scores (Heschong et al., 2002)

Thurston Elementary School | Springfield, Oregon

© Lincoln Barbour

## Light Shelves

Light

In a 2002 observational study of the Capistrano School District in Orange County, California, Heschong et al identified that classrooms with high levels of daylight (1-2 large windows) resulted in an average **21% higher standardized test scores** (math and reading) as compared to classrooms with low levels of daylight. (p<0.01, n=24 schools)

Heschong, L., Wright, R. L., & Okura, S. (2002). Daylighting impacts on human performance in school. Journal of the Illuminating Engineering Society, 31(2), 101-114.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P6: Dynamic & Diffuse Light P7: Connection with Natural Systems
Kellert's 6	Light & Space
LEED v4 O+M Schools	
WELL v2	L01: Light Exposure L05: Daylight Design Strategies
CHPS	EQ 11.1: Daylight Availability
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Circadian Light - Daylight

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TBG's 14 Patterns	P6: Dynamic & Diffuse Light P7: Connection with Natural Systems
Kellert's 6	Light & Space
LEED v4 O+M Schools	
WELL v2	L01: Light Exposure L05: Daylight Design Strategies
CHPS	EQ 11.1: Daylight Availability
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Light Shelves

# Light



Letting sun stream into the classroom creates a healthier space for children (Fahimipour et al., 2018)

© Federico Carroli

Child Care Center | Villeta, Paraguay

## Sunlight

Interaction & Engagement

Light

# Light



Investing in electric circadian lighting leads to increased alertness (Figueiro et al., 2019)

## Circadian Light - Electric

Light

In a 2018 lab experiment of 11 built microcosms at the University of Oregon, Fahimipour et al identified that the presence of visible and ultraviolet light (elements of sunlight) resulted in a **5.9% reduction of viable bacteria** over a 90-day experiment as compared to a dark microcosm. ( $p<0.001$ ,  $n=11$  microcosms)

Fahimipour, A. K., Hartmann, E. M., Siemens, A., Kline, J., Levin, D. A., Wilson, H., ... & Van Den Wymelenberg, K. (2018). Daylight exposure modulates bacterial communities associated with household dust. *Microbiome*, 6(1), 1-13.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P3: Non-Rhythmic Sensory Stimuli P6: Dynamic & Diffuse Light
Kellert's 6	Light & Space
LEED v4 O+M Schools	
WELL v2	L01: Light Exposure L05: Daylight Design Strategies
CHPS	EQ 11.1: Daylight Availability
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Sunlight

In a 2017 field experiment of four federal government buildings, Figueiro et al identified that the addition of circadian-effective lighting with a circadian stimulus value greater than 0.3 results in a **9.2% increase in perceived alertness measured by the Subjective Vitality Score ( $p<0.001$ )**. ( $n=94$ ,  $t=3$  days x 4 measurements)

Figueiro, M. G., Kalsher, M., Steverson, B. C., Heerwagen, J., Kampschroer, K., & Rea, M. S. (2019). Circadian-effective light and its impact on alertness in office workers. *Lighting Research & Technology*, 51(2), 171-183.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P6: Dynamic & Diffuse Light P7: Connection with Natural Systems
Kellert's 6	Light & Space
LEED v4 O+M Schools	
WELL v2	L03: Circadian Lighting Design
CHPS	
LBC v4.0	I-19: Beauty & Biophilia

## Circadian Light - Electric



Using natural ventilation in the classroom can improve standardized test scores (Heschong et al., 2002)

La Référence de Ganthier School | Ganthier, Haiti

© Nadia Todres

## Natural Ventilation in Classrooms

Sound, Taste, and Touch

Sound, Taste & Touch



Introducing a dynamic thermal environment can improve test accuracy and response time (Gwak et al., 2019)

Imagine Montessori School | Paterna, Spain

© Mariela Apollonio

## Thermal Variability & Alliesthesia

Sound, Taste, and Touch

In a 2002 observational study of the Capistrano School District in Orange County, California, Heschong et al identified that classrooms with operable windows resulted in **7% higher standardized test scores** as compared to classrooms with fixed windows. (p<0.01, n=24 schools)

Heschong, L., Wright, R. L., & Okura, S. (2002). Daylighting impacts on human performance in school. Journal of the Illuminating Engineering Society, 31(2), 101-114.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P2: Non-Visual Connection with Nature P4: Thermal & Airflow Variability
Kellert's 6	Natural Patterns & Processes
LEED v4 O+M Schools	
WELL v2	A07: Operable Windows
CHPS	EQ 10.2: Controllability of Systems EE 6.1: Natural Ventilation & Energy Conservation
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Natural Ventilation in Classrooms

In a 2019 lab experiment at the University of Tokyo, Gwak et al identified that introducing a dynamic thermal environment resulted in a **17% increase in accuracy (p<0.01)** and a **4% improvement in response time (p<0.05)** in arithmetic test results as compared to a static environment. (n=210)

Gwak, J., Shino, M., Ueda, K., & Kamata, M. (2019). An investigation of the effects of changes in the indoor ambient temperature on arousal level, thermal comfort, and physiological indices. Applied Sciences, 9(5), 899.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P4: Thermal & Airflow Variability
Kellert's 6	Natural Patterns & Processes
LEED v4 O+M Schools	
WELL v2	
CHPS	
LBC v4.0	I-19: Beauty & Biophilia

## Thermal Variability & Alliesthesia



Investing in water features in the classroom can improve cognitive task accuracy (Zhang et al., 2021)

© Benjamin Benschneider

Bertschi School Living Science Building | Seattle, Washington

## Water Features in the Classroom

Interaction & Engagement

Sound, Taste, and Touch

## Sound, Taste & Touch



Providing opportunities for water play can improve fine motor skills and cognitive development in children (Herrigton & Brussoni, 2015)

Punahou School | Honolulu, Hawaii

## Water Features in Outdoor Play Areas

Interaction & Engagement

Sound, Taste, and Touch

In a 2021 lab experiment simulating an open-plan office environment, Zhang et al identified that introducing a spring water masking sound condition at medium SNR (4.4dB) by loud speaker to an office with noise levels of 31.8 dB resulted in a **10.3% increase in cognitive task accuracy rates (p<0.05)** as compared to an unmasked ‘speech only’ condition. (n=30, t=7 days x 2 measurements)

Zhang, Y., Ou, D., & Kang, S. (2021). The effects of masking sound and signal-to-noise ratio on work performance in Chinese open-plan offices. Applied Acoustics, 172, 107657.



This action aligns with national certifications and standards	
TBG’s 14 Patterns	P1: Visual Connection with Nature P5: Presence of Water
Kellert’s 6	Environmental Features Natural Patterns & Processes
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Water Features in the Classroom

In a 2015 review of nature-based play spaces, Herrington & Brussoni identified that water play allows children to **further develop their fine motor skills and cognitive development.**

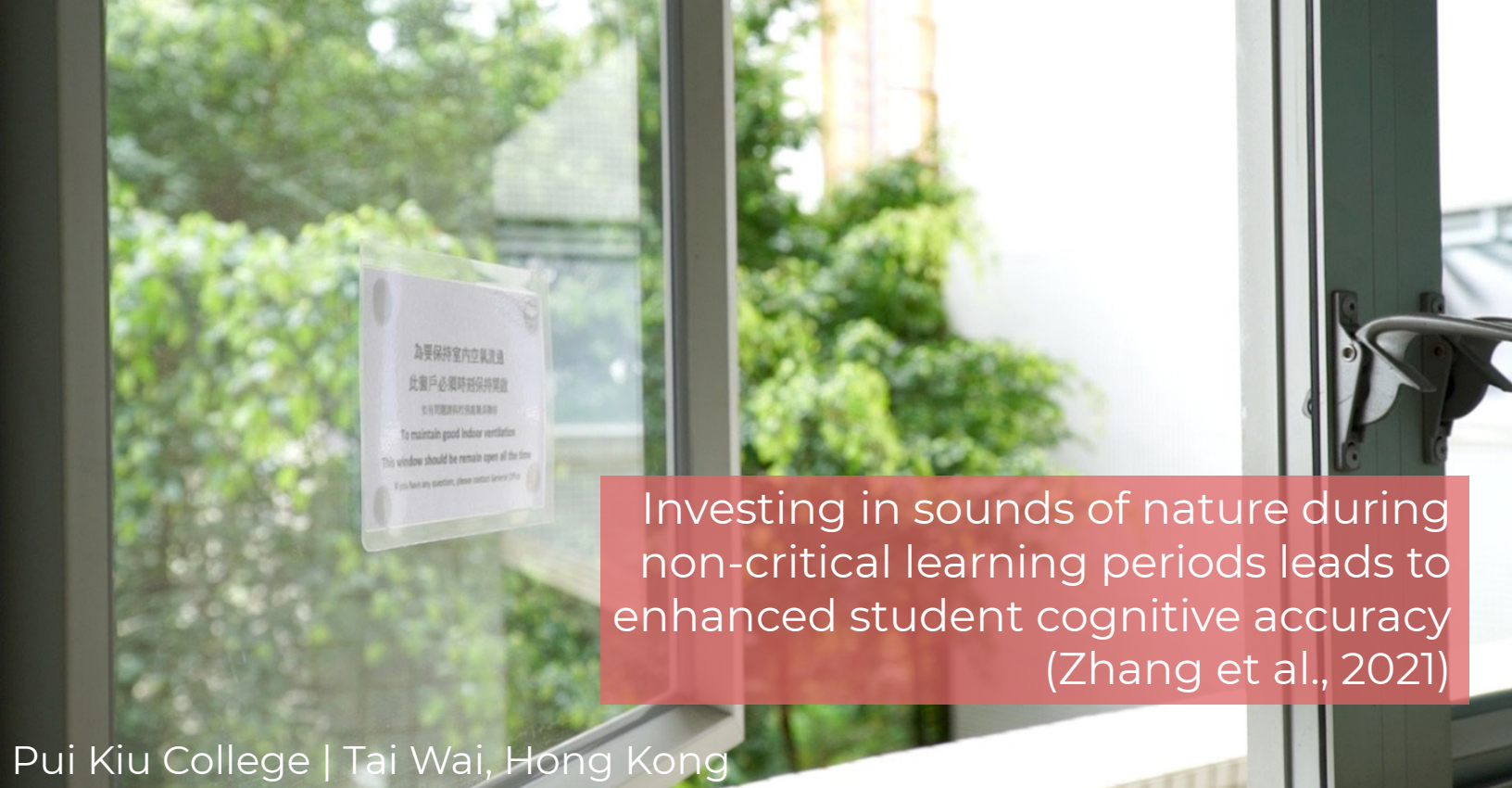
Herrington, S., & Brussoni, M. (2015). Beyond physical activity: The importance of play and nature-based play spaces for children's health and development. Current obesity reports, 4(4), 477-483.



This action aligns with national certifications and standards	
TBG’s 14 Patterns	P1: Visual Connection with Nature P5: Presence of Water
Kellert’s 6	Environmental Features Natural Patterns & Processes
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Water Features in Outdoor Play Areas

# Sound, Taste & Touch



Investing in sounds of nature during non-critical learning periods leads to enhanced student cognitive accuracy (Zhang et al., 2021)

Pui Kiu College | Tai Wai, Hong Kong

## Sounds of Nature - Outside the Classroom

Sound, Taste, and Touch

# Sound, Taste & Touch



Investing in sounds of nature during non-critical learning periods leads to enhanced student cognitive accuracy (Zhang et al., 2021)

St. Martins School | Jefferson City, Missouri

## Sounds of Nature - Inside the Classroom

Interaction & Engagement

Sound, Taste, and Touch

In a 2021 lab experiment simulating an open-plan office environment, Zhang et al identified that introducing a spring water masking sound condition at medium SNR (4.4dB) by loud speaker to an office with noise levels of 31.8 dB resulted in a **10.3% increase in cognitive task accuracy rates (p<0.05)** as compared to an unmasked ‘speech only’ condition. (n=30, t=7 days x 2 measurements)

Zhang, Y., Ou, D., & Kang, S. (2021). The effects of masking sound and signal-to-noise ratio on work performance in Chinese open-plan offices. Applied Acoustics, 172, 107657.



This action aligns with national certifications and standards	
TBG’s 14 Patterns	P2: Non-Visual Connection with Nature P3: Non-Rhythmic Sensory Stimuli
Kellert’s 6	Natural Patterns & Processes
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Sounds of Nature - Outside the Classroom

In a 2021 lab experiment simulating an open-plan office environment, Zhang et al identified that introducing a spring water masking sound condition at medium SNR (4.4dB) by loud speaker to an office with noise levels of 31.8 dB resulted in a **10.3% increase in cognitive task accuracy rates (p<0.05)** as compared to an unmasked ‘speech only’ condition. (n=30, t=7 days x 2 measurements)

Zhang, Y., Ou, D., & Kang, S. (2021). The effects of masking sound and signal-to-noise ratio on work performance in Chinese open-plan offices. Applied Acoustics, 172, 107657.



This action aligns with national certifications and standards	
TBG’s 14 Patterns	P2: Non-Visual Connection with Nature P3: Non-Rhythmic Sensory Stimuli
Kellert’s 6	Natural Patterns & Processes
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Sounds of Nature - Inside the Classroom



Investing in fragrant flowers and herbs leads to a reduction in student stress levels (Seo, 2009)

## Fragrant Flowers & Herbs

Interaction & Engagement

Indoor Greenery

Sound, Taste, and Touch

## Sound, Taste & Touch



Investing in natural acoustic control leads to enhanced student teamwork performance (Damián-Chávez et al., 2021)

## Natural Acoustic Control

Indoor Greenery

Sound, Taste, and Touch

In a 2009 crossover study of students in an all-female high school in South Korea, Seo identified that the use of aromatherapy with bergamot essential oils resulted in a **440% reduction in self-reported stress levels (p=0.006)** as compared to a control group with no essential oils. (n = 400, t = 2 measurement periods x 6 weeks)

Seo, J. Y. (2009). The effects of aromatherapy on stress and stress responses in adolescents. Journal of Korean Academy of Nursing, 39(3), 357-365.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P2: Non-Visual Connection with Nature; P3: Non-Rhythmic Sensory Stimuli
Kellert's 6	Natural Patterns & Processes
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Fragrant Flowers & Herbs

In a 2021 field experiment in the library at Tecnologico de Monterrey in Monterrey, Mexico, Damián-Chávez et al identified that a quiet room resulted in an average **3.43% improvement in university student teamwork performance** as compared to a noisy room (75-80 dB). (p=0.035, n=16)

Damián-Chávez, M. M., Ledesma-Coronado, P. E., Drexel-Romo, M., Ibarra-Zárate, D. I., & Alonso-Valerdi, L. M. (2021). Environmental noise at library learning commons affects student performance and electrophysiological functioning. Physiology & Behavior, 241, 113563.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P1: Visual Connection with Nature P2: Non-Visual Connection with Nature
Kellert's 6	Environmental Features
LEED v4 O+M Schools	
WELL v2	S05: Sound Reducing Surfaces M02: Nature and Place
CHPS	EQ 14.0: Acoustical Performance
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Natural Acoustic Control



Investing in animals in the classroom leads to improved student system thinking skills (Junge et al., 2014)

Montessori Day School of Chapel Hill | Chapel Hill, North Carolina

## Animals for Multisensory Enrichment

Sound, Taste, and Touch Interaction & Engagement

## Interaction & Engagement



Introducing edible plants in the classroom can improve student science exam passing rates (Fitz, 2016)

Bronx Green Machine | New York, New York

## Edible Plants

Sound, Taste, and Touch

Indoor Greenery Interaction & Engagement

In a 2014 field experiment of three classrooms in Zurich, Switzerland, Junge et al identified that the introduction of aquaponics systems in the classroom resulted in a **211% improvement in student systems thinking skills**. (n = 68, t = 3 months)

Junge, R., Wilhelm, S., & Hofstetter, U. (2014). Aquaponic in classrooms as a tool to promote system thinking. In 3rd Conference with International Participation- Conference VIVUS, Conference on Agriculture, Environmentalism, Horticulture, Floristics, Food Production and Processing, Strahinj, Naklo, Slovenia, 14-15 November 2014 (pp. 234-244). Biotehniški center Naklo.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P1: Visual Connection to Nature P2: Non-Visual Connection with Nature
Kellert's 6	Environmental Features
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Animals for Multisensory Enrichment

In the 2015-2016 school year, the Green Bronx Machine reported that the introduction of edible plants in the classroom resulted in a **45% increase in school-wide passing rates of NYS Science Exams**.

Green Bronx Machine - About. Green Bronx Machine. (2014, January 25). Retrieved November 8, 2021, from <https://greenbronxmachine.org/about/>.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P1: Visual Connection to Nature P7: Connection with Natural Systems
Kellert's 6	Environmental Features Natural Patterns & Processes
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Edible Plants



Including educational content related to nature leads to health benefits (Browning et al., 2014)

## Educational Content

Interaction & Engagement

## Interaction & Engagement



Investing in 3D surfaces can allow for increased opportunities for child cognitive development (Drown, 2014)

Environmental Nature Center and Preschool | Newport Beach, California

## 3D Surfaces

Spatial Interaction & Engagement

The 14 Patterns of Biophilic Design by Terrapin Bright Green identifies “Connection with Natural Systems” to be the seventh pattern as it is highly suspected to provide health benefits to those who are exposed to natural systems.

Browning, W., Ryan, C., & Clancy, J. (2014, September 12). 14 patterns of biophilic design. Terrapin Home - Terrapin Bright Green. Retrieved December 1, 2021, from <https://www.terrapinbrightgreen.com/reports/14-patterns/#connection-with-natural-systems>.



This action aligns with national certifications and standards	
TBG’s 14 Patterns	P7: Connection with Natural Systems
Kellert’s 6	Natural Patterns & Processes Evolve Human-Nature Relationships
LEED v4 O+M Schools	
WELL v2	
CHPS	
LBC v4.0	I-19: Beauty & Biophilia

## Educational Content

In a 2014 observational study at the Dolores Doré Eccles Center for Early Care & Education in Logan, Utah, Drown identified that natural playgrounds resulted in **increased opportunities for cognitive development measured by dramatic play affordances** as compared to manufactured playgrounds. (p=0.007, n=24)

Drown, K. K. C. (2014). Dramatic play affordances of natural and manufactured outdoor settings for preschool-aged children. Utah State University.



This action aligns with national certifications and standards	
TBG’s 14 Patterns	P2: Non-Visual Connection with Nature
Kellert’s 6	Natural Shapes & Forms
LEED v4 O+M Schools	
WELL v2	
CHPS	
LBC v4.0	I-19: Beauty & Biophilia

## 3D Surfaces

# Spatial



Partial refuge (eg reading nooks) can improve cognitive performance and reduce anxiety (Roskams & Haynes, 2020)

© Dave Burk

WeGrow | New York, New York

## Partial Refuge

Spatial

# Spatial



Including wide views of the surrounding area (ie prospect) can improve attention (Gatersleben & Andrews, 2014)

© DOF SkyGround

HEI Schools Bangkok | Bangkok, Thailand

## Prospect

Spatial

In a 2020 randomized field experiment in an office in Central London, Roskams and Haynes identified that the use of biophilic restoration pods for breaks resulted in a **26% improvement in arithmetic task performance (p=0.005) and a 26% reduction in anxiety (p=0.01)** as compared to meeting rooms. (n=32)

Roskams, M., & Haynes, B. (2020). A randomised field experiment to test the restorative properties of purpose-built biophilic “regeneration pods”. Journal of Corporate Real Estate.



This action aligns with national certifications and standards	
TBG’s 14 Patterns	P12: Refuge
Kellert’s 6	Evolve Human-Nature Relationships
LEED v4 O+M Schools	
WELL v2	
CHPS	
LBC v4.0	I-19: Beauty & Biophilia

## Partial Refuge

In a 2013 experimental study at an university in the South-East of England, Gatersleben and Andrews identified that walking through a high prospect-low refuge environment resulted in a **42% improvement in attention** (NCPCT). (p<0.01, n=17)

Gatersleben, B., & Andrews, M. (2013). When walking in nature is not restorative—The role of prospect and refuge. Health & place, 20, 91-101.



This action aligns with national certifications and standards	
TBG’s 14 Patterns	P11: Prospect
Kellert’s 6	Evolve Human-Nature Relationships
LEED v4 O+M Schools	
WELL v2	
CHPS	
LBC v4.0	I-19: Beauty & Biophilia

## Prospect

# Spatial



Elements of mystery (eg partially obscured views) can improve attention restoration potential (Marois et al., 2021)

© Tianpei Zeng

Shenzhen King's Kindergarten | Shenzhen, China

# Mystery

# Spatial



Including outdoor elements indoors leads to improved mood (Kim et al., 2021)

© Toshinari Soga (studio BAUHAUS)

KB Primary and Secondary School | Sasebo, Japan

# Creating Outdoor Spaces Indoors

Sound, Taste, and Touch

Indoor Greenery

Spatial

In a 2021 controlled experiment at the University of Colorado Denver, Marois et al identified that images with high levels of mystery resulted in **115% greater attention restoration potential** (measured by pupillary response) after being statistically controlled for luminance as opposed to images with low levels of mystery. (p=0.026, n=50)

Marois, A., Charbonneau, B., Szolosi, A. M., & Watson, J. M. (2021). The Differential Impact of Mystery in Nature on Attention: An Oculometric Study. *Frontiers in psychology*, 12, 759616-759616.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P13: Mystery
Kellert's 6	Light & Space Evolve Human-Nature Relationships
LEED v4 O+M Schools	
WELL v2	
CHPS	
LBC v4.0	I-19: Beauty & Biophilia

## Mystery

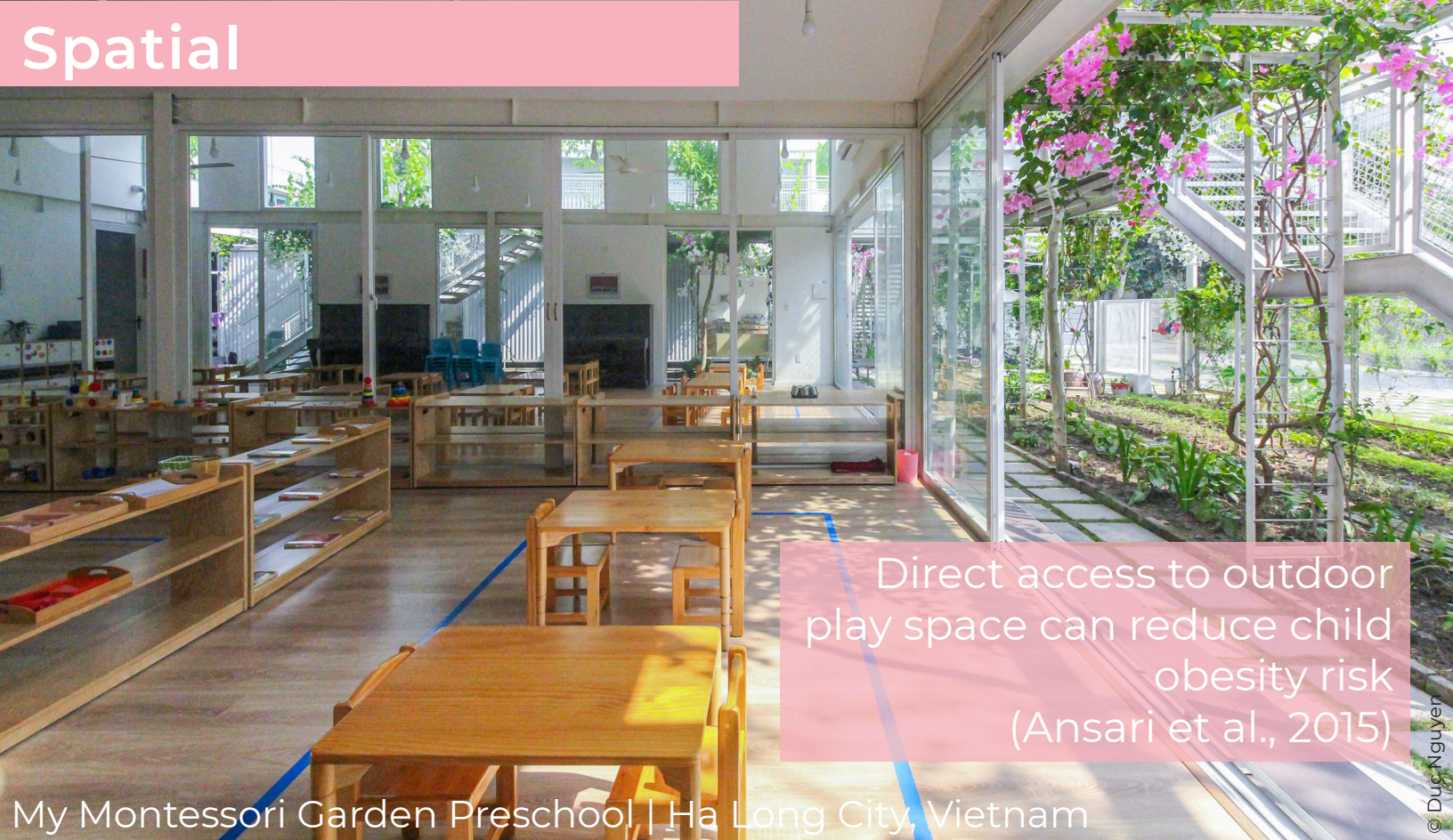
In a 2021 lab experiment at Hankyong National University in Anseong, South Korea, Kim et al identified that a room with an indoor vertical garden resulted in a **94% reduction in perceived negative emotional tension** (POMS) as compared to a control room with no outdoor elements. (p<0.01, n=18)

Kim, S., Kang, M., & Lee, J. (2021). Verification of Physiological and Psychological Effects of Vertical Indoor Garden. *Journal of Environmental Science International*, 30(1), 1-10.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P1: Visual Connection with Nature
Kellert's 6	Light & Space Evolve Human-Nature Relationships
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Creating Outdoor Spaces Indoors



Direct access to outdoor play space can reduce child obesity risk (Ansari et al., 2015)

My Montessori Garden Preschool | Ha Long City, Vietnam

© Duc Nguyen

## Opening to Outdoor Play Space

Spatial

Spatial



Utilizing outdoor classroom space leads to improved classroom engagement (Kuo et al., 2018)

Unterdorf Elementary School | Bregenz, Austria

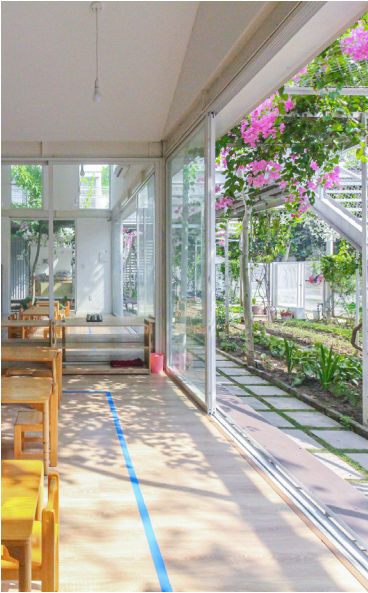
© Bruno Klotz

## Opening to Outdoor Classroom Space

Spatial

In a 2015 retrospective study of the Family and Child Experiences Survey, Ansari et al identified that access to an average of 37 minutes of outdoor play time resulted in a **42% reduction in child obesity risk**. (p=0.05, n= 2,810)

Ansari, A., Pettit, K., & Gershoff, E. (2015). Combating obesity in head start: outdoor play and change in children's BMI. Journal of developmental and behavioral pediatrics: JDBP, 36(8), 605.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P1: Visual Connection with Nature P7: Connection with Natural Systems
Kellert's 6	Light & Space Evolve Human-Nature Relationships
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Opening to Outdoor Play Space

In a 2018 field study in an environmental magnet school in the Midwestern United States, Kuo et al identified that implementing a lesson in nature results in a **74% likelihood of better teacher-rated classroom engagement for a lesson afterwards** as compared to after a matched lesson in the classroom on the same topic. (p<0.01, n=20 measurements)

Kuo, M., Browning, M. H., & Penner, M. L. (2018). Do lessons in nature boost subsequent classroom engagement? Refueling students in flight. Frontiers in psychology, 8, 2253.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P1: Visual Connection with Nature P7: Connection with Natural Systems
Kellert's 6	Light & Space Evolve Human-Nature Relationships
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Opening to Outdoor Classroom Space



Learning through outdoor landscapes can improve overall student health and well-being (Osama Mohammed Fikry & Elfiki, 2020)

A Steiner Kindergarten | Finland

## Outdoor Landscape for Teaching



Outdoor eating spaces can help reduce student sedentary time (Romar et al., 2019)

Maplewood Elementary School | Austin, Texas

## Outdoor Eating Spaces

In a 2020 qualitative study in public schools in Egypt, Osama Mohammed Fikry & Elfiki identified that learning through landscapes (LTL) has five main advantages including **improved attainment, interaction with nature and biodiversity, physical and mental health, psychological well-being, and social relationships.**

Osama Mohammed Fikry, N., & Elfiki, S. (2020). Teachers' Interpretation of "Learning through Landscapes" in Egyptian School Grounds. Engineering Research Journal, 168, 325-342.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P1: Visual Connection with Nature P7: Connection with Natural Systems
Kellert's 6	Light & Space Evolve Human-Nature Relationships
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Outdoor Landscape for Teaching

In a 2018 field study in primary schools in Finland, Romar et al identified that eating lunch outdoors in the forest **reduces the amount of sedentary time a student experiences** as compared to eating lunch indoors in a school dining room. (n=21 students)

Romar, J. E., Enqvist, I., Kulmala, J., Kallio, J., & Tammelin, T. (2019). Physical activity and sedentary behaviour during outdoor learning and traditional indoor school days among Finnish primary school students. Journal of Adventure Education and Outdoor Learning, 19(1), 28-42.



This action aligns with national certifications and standards	
TBG's 14 Patterns	P1: Visual Connection with Nature P7: Connection with Natural Systems
Kellert's 6	Light & Space Evolve Human-Nature Relationships
LEED v4 O+M Schools	
WELL v2	M02: Nature and Place M09: Enhanced Access to Nature
CHPS	
LBC v4.0	I-11: Access to Nature I-19: Beauty & Biophilia

## Outdoor Eating Spaces