



A Natural Vision: the Data-Driven Impact of Biophilic Design for Student Success

For the South Carolina School Boards Association Conference

February 22, 2020

Anthony J. Cox, PE (Facilitator)

Jim Determan, FAIA (Presenter)

One Team. One Mission. One Rock Hill.

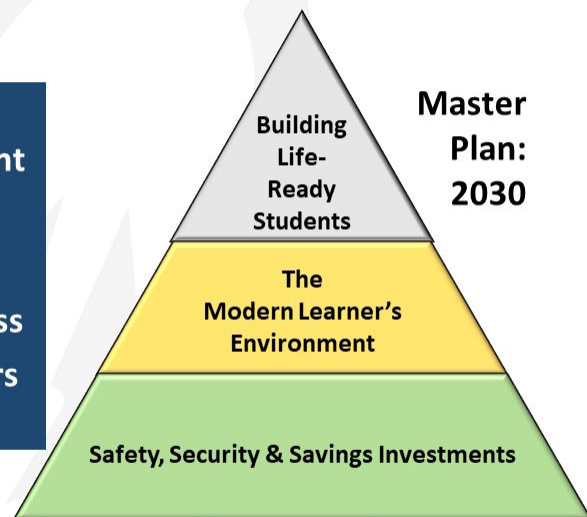
1



Why?


Superintendent's Five Focus Areas:

1. Safe and Secure Learning Environment
2. Recruitment and Retention
3. Student Achievement
4. Organizational Culture & Effectiveness
5. Communication With All Stakeholders



One Team. One Mission. One Rock Hill.

2



en·vi·ron·ment

/in 'vīrənmənt/
noun

1.1. the surroundings or conditions in which a person, animal, or plant lives or operates.

2.2. the natural world, as a whole or in a particular geographical area, especially as affected by human activity.









One Team. One Mission. One Rock Hill.

3



Safe and Secure Learning Environments



In complement to safety and security, we will continue our state-leading effort of adopting sustainability in the construction and operation of our school campuses. Academic research is now conclusive that an energy efficient, sustainably constructed environment is a necessity for improved learning. More than 20% improvement in test scores has been documented as due to increased natural light, or "daylighting"

Rock Hill School District 3 Facilities Master Plan 39

ONE : MASTER PLAN 2030

in our schools. Reduction of stress and absenteeism for both students and teachers has been reported through healthier indoor air quality from improved HVAC systems and building materials.

A safe and secure learning environment IS a sustainable learning environment.

One Team. One Mission. One Rock Hill.

4

RHS Sustainability:

- Investment Driven,
- Health & Safety Centered,
- Student Achievement Focused

Policy EB Environmental Sustainability

Issued 2/19

General Principles

The board recognizes the importance of environmental sustainability in today's changing world and its critical role in ensuring a successful future for our children.

In complement to safety and security, we will continue our state-leading effort of adopting sustainability in the construction and operation of our school campuses. Academic research is now conclusive that an energy efficient, sustainably constructed environment is a necessity for improved learning. More than 20% improvement in test scores has been documented as due to increased natural light, or "daylighting"

Rock Hill School District 3 Facilities Master Plan

39

ONE : MASTER PLAN 2030

in our schools. Reduction of stress and absenteeism for both students and teachers has been reported through healthier indoor air quality from improved HVAC systems and building materials.

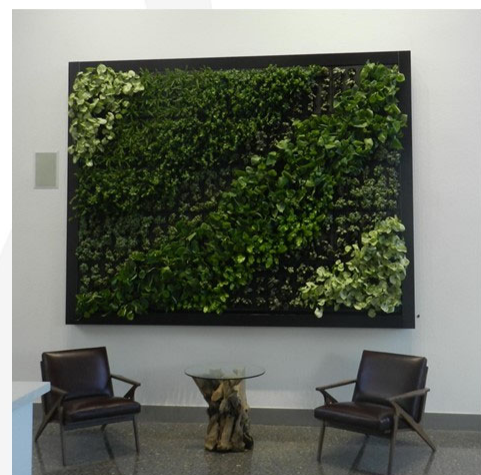
One Team. One Mission. One Rock Hill.

5

Researching the Research!

Can biophilic design concepts help us create a learning environment where students feel safe and healthy and learn better?

Help us decide if we should move forward with this as a district design standard ... Why? How?



One Team. One Mission. One Rock Hill.

6

DESIGNTEX
Steelcase



Interface®



AIA
College of Fellows



AIA Board Knowledge Committee

hord | coplan | macht

7



Jim Determan, FAIA
Principal
Craig Gaulden Davis Architects



Thomas Albright, Ph.D.
Professor
Salk Institute



Bill Browning, Hon. AIA
Managing Partner
Terrapin Bright Green



Mary Anne Akers, Ph.D.
Dean
School of Architecture and Planning
Morgan State University



Paul Archibald, Ph.D.
Assistant Professor
School of Social Work
Morgan State University



Catherine Martin-Dunlop, Ph.D.
Director
Center for Excellence in Teaching and Learning
Morgan State University



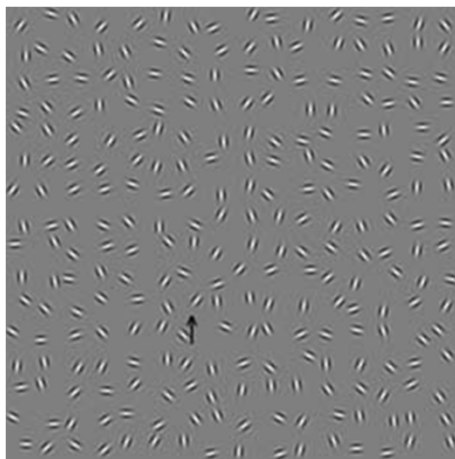
Valerie Caruolo
Architect
Hord Coplan Macht

8

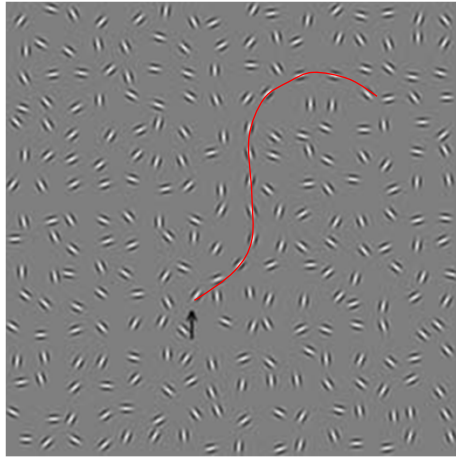
CAN NEUROSCIENCE TELL US ANYTHING USEFUL ABOUT ARCHITECTURE AND DESIGN?



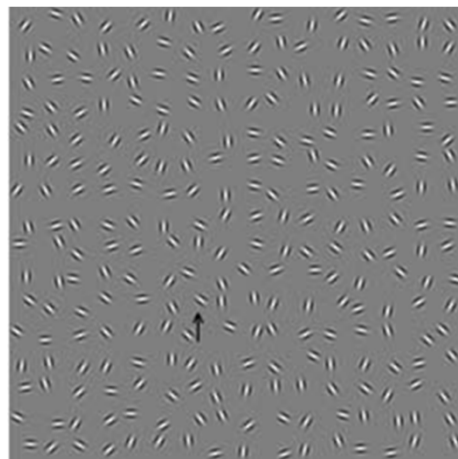
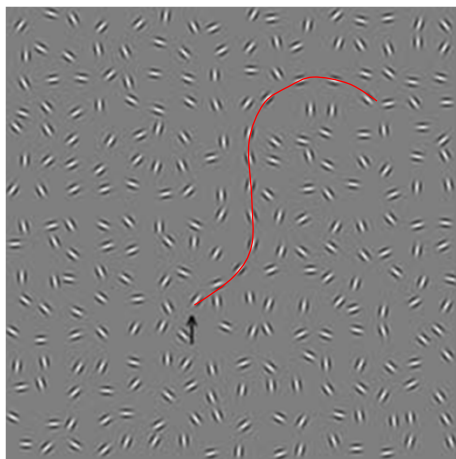
9



10



11



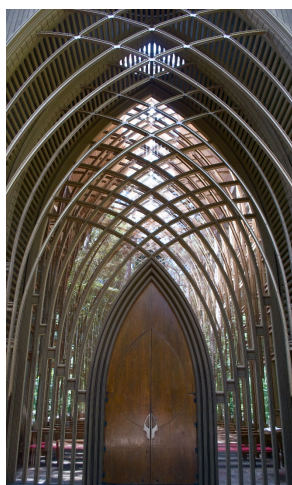
12

THE NATURAL WORLD TAPS INTO ORGANIZATIONAL PROPERTIES OF THE VISUAL BRAIN

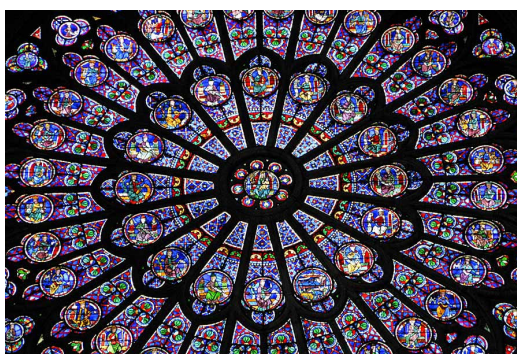


13

THE **BUILT ENVIRONMENT** TAPS INTO ORGANIZATIONAL PROPERTIES OF THE VISUAL BRAIN



Fay Jones, *Cooper
Memorial Chapel*, Bella
Vista, Arkansas, 1987



North Rose Window, Cathedral of Notre Dame,
Paris, 14th century



14

THE **BUILT ENVIRONMENT** TAPS INTO ORGANIZATIONAL PROPERTIES OF THE VISUAL BRAIN



Millau Viaduct Bridge, France, 2004



Scripps Crossing Bridge, La Jolla, 1993



Chords Bridge, Jerusalem, 2008



15

THE SENSE OF ORDER

- Simple, regular, repeating forms
- Activate specialized neuronal systems that have evolved because they facilitate detection of natural stimuli that confer selective advantage for survival and reproduction



- Structural understanding is immediate
- Visual ease ("easy adjustment")
- Conventional beauty



16

BIOPHILIA

WHAT IS BIOPHILIA?

“Biophilia...

is the innately emotional affiliation of human beings to other living organisms....

Life around us exceeds in complexity and beauty anything else humanity is ever likely to encounter.”

Edward O. Wilson
The Biophilia Hypothesis

BIOPHILIC DESIGN

Improving Health and Well-Being in the Built Environment

17

GREEN HELPS PEOPLE HEAL

ULRICH STUDY, 1984

A view to nature equals...

- Shorter hospital stays
- Fewer negative comments
- Fewer strong analgesics

THE SCIENCE OF BIOPHILIA

Translational research for design application

18



19

FRACTALS & VISUAL RESPONSE

SALINGAROS, 2012; TAYLOR, 2006;
HÄGERHALL ET AL., 2008; JOYE, 2005

Key takeaways...

- Fractal patterns encourage perceptual rather than cognitive thinking.
- Humans have a preference for patterns with a moderate fractal dimension like that found and processed in nature.
- Moderate fractal dimensions are perceived as are most restorative and relaxing.
- High fractal dimensions can engender stress in some people, or creativity in others.

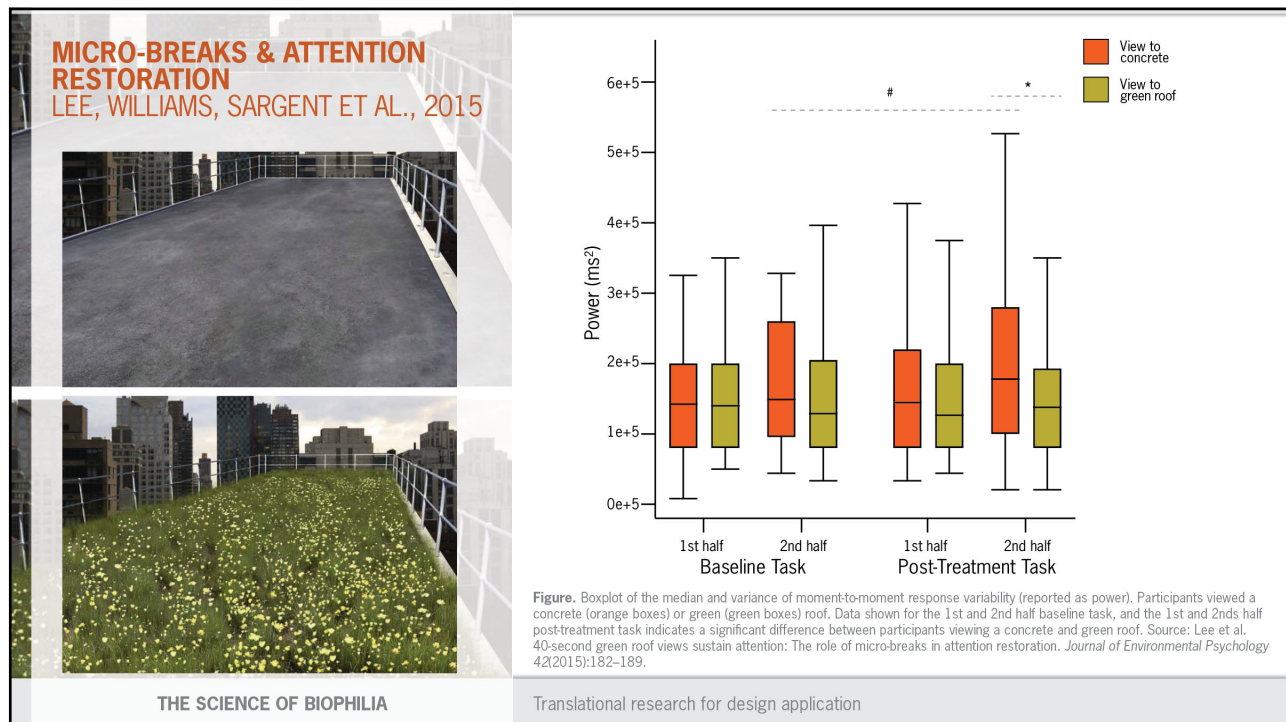
(a) (b) (c) (d)

BIOPHILIC DESIGN

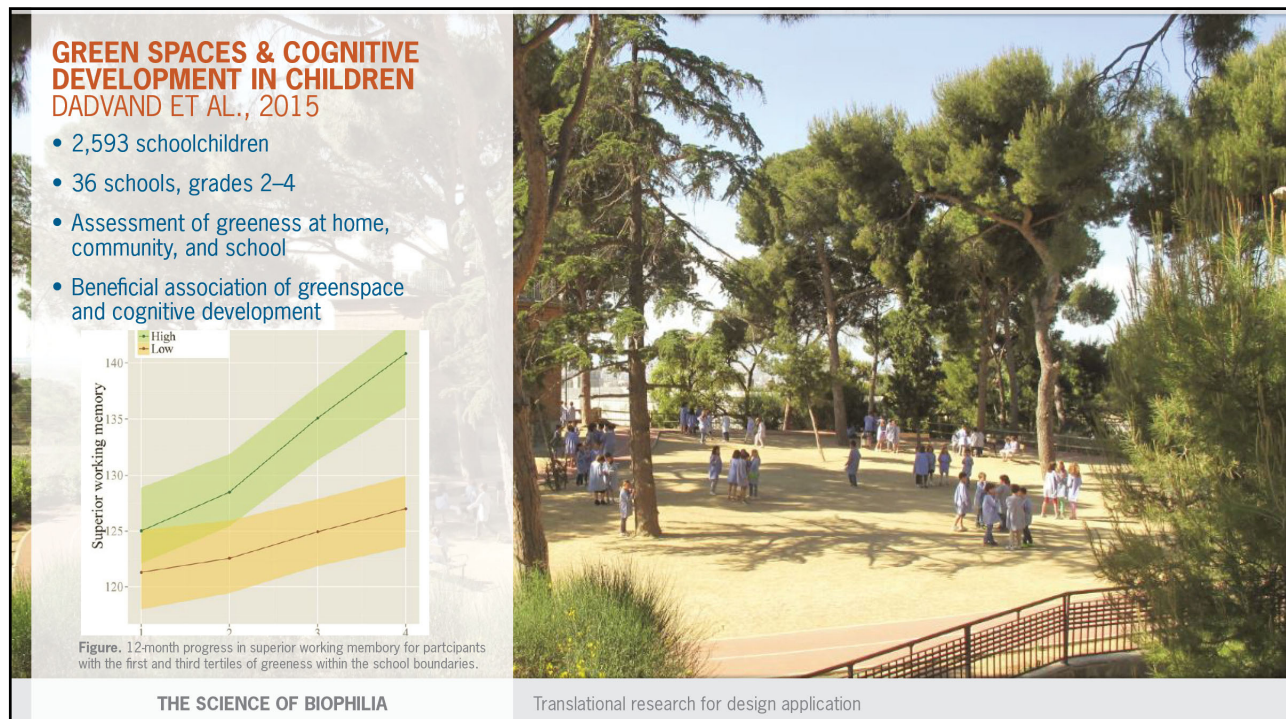
Complexity & Order

Courtesy of Hägerhall et al., 2008

20



21



22

14 PATTERNS OF BIOPHILIC DESIGN

Nature In The Space

1. Visual Connection with Nature
2. Non-Visual Connection with Nature
3. Non-Rhythmic Sensory Stimuli
4. Thermal & Airflow Variability
5. Presence of Water
6. Dynamic & Diffuse Light
7. Connection With Natural Systems

Natural Analogues

8. Biomorphic Forms & Patterns
9. Material Connection with Nature
10. Complexity & Order

Nature Of The Space

11. Prospect
12. Refuge
13. Mystery
14. Risk

NY TIMES BIRCH GARDEN by Thomas J. Shep

BIOPHILIC DESIGN
Improving Health and Well-Being in the Built Environment

23

THE SCIENCE

BIOLOGICAL RESPONSES & BIOPHILIC DESIGN PATTERNS

	14 PATTERNS	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
NATURE IN THE SPACE	Visual Connection w/ Nature	Lowered blood pressure and heart rate	Improved mental engagement/ attentiveness	Positively impacted attitude and overall happiness
	Non-Visual Connection w/ Nature	Reduced systolic blood pressure and stress hormones	Positively impacted cognitive performance	Perceived improvements in mental health and tranquility
	Non-Rhythmic Sensory Stimuli	Positively impacted heart rate, systolic blood pressure and sympathetic nervous system activity	Observed and quantified behavioral measures of attention and exploration	
	Thermal & Airflow Variability	Positively impacted comfort, well-being and productivity	Positively impacted concentration	Improved perception of temporal and spatial pleasure (alliesthesia)
	Presence of Water	Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure	Improved concentration and memory restoration; Enhanced perception and psychological responsiveness	Observed preferences and positive emotional responses
	Dynamic & Diffuse Light	Positively impacted circadian system functioning; Increased visual comfort		
	Connection w/ Natural Systems			Enhanced positive health responses; Shifted perception of environment
N. ANALOGUES	Biomorphic Forms & Patterns			Observed view preference
	Material Connection w/ Nature		Decreased diastolic blood pressure; Improved creative performance	Improved comfort
	Complexity & Order	Positively impacted perceptual and physiological stress responses		Observed view preference
NATURE OF THE SPACE	Prospect	Reduced stress	Reduced boredom, irritation, fatigue	Improved comfort and perceived safety
	Refuge		Improved concentration, attention and perception of safety	
	Mystery			Induced strong pleasure response
	Risk/Peril			Resulted in strong dopamine or pleasure responses

Biological Response Table, 14 PATTERNS OF BIOPHILIC DESIGN (p.12) © 2014 Terrapin Bright Green LLC

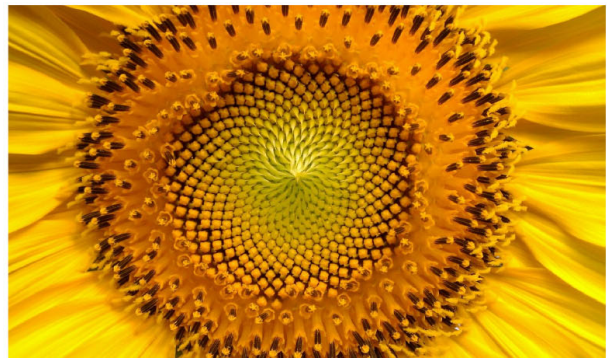
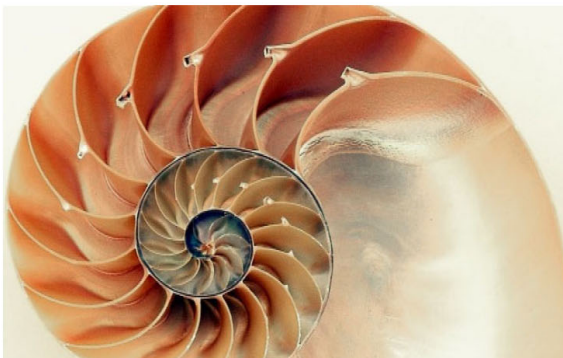
24

What Do You



Think?

25



26

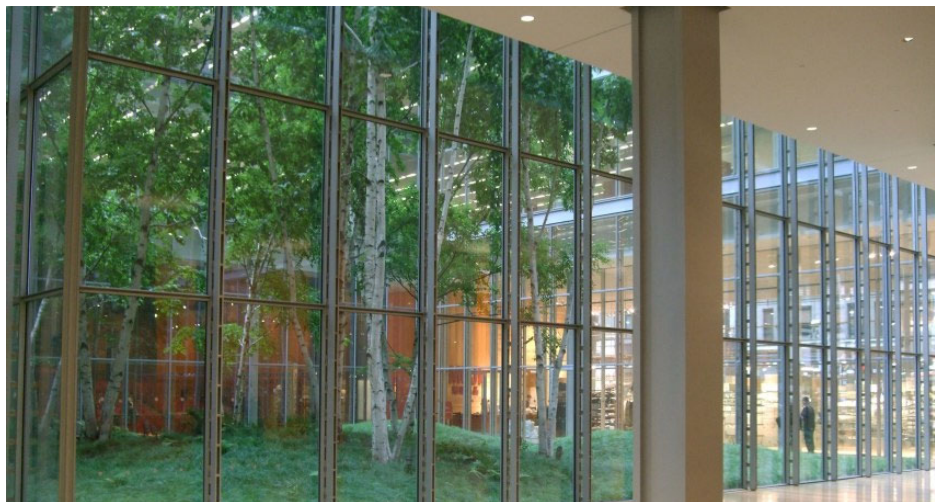
The proposed study aims to test and understand the contribution of a biophilic learning space to reduce student stress and enhance learning outcomes.

Experiment Objective

27



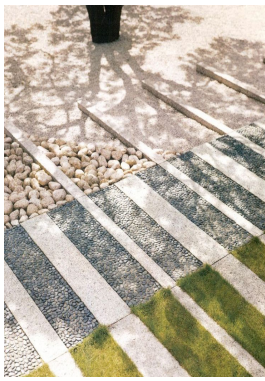
Visual Connection with Nature

14 PATTERNS	+	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
Visual Connection with Nature	•	Lowered blood pressure and heart rate (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005)	Improved mental engagement/ attentiveness (Biederman & Vessel, 2006)	Positively impacted attitude and overall happiness (Barton & Pretty, 2010)

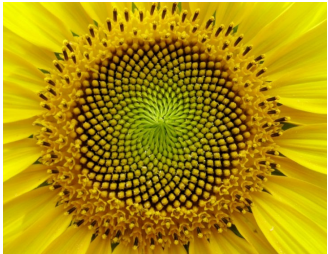




28

Dynamic & Diffuse Light

14 PATTERNS	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
Dynamic & Diffuse Light	<div>Positively impacted circadian system functioning</div> <div>(Figueiro, Bruns, Pilnick et al., 2011; Beckett & Roden, 2009)</div> <div>Increased visual comfort</div> <div>(Elyezadi, 2012; Kim & Kim, 2007)</div>		
			

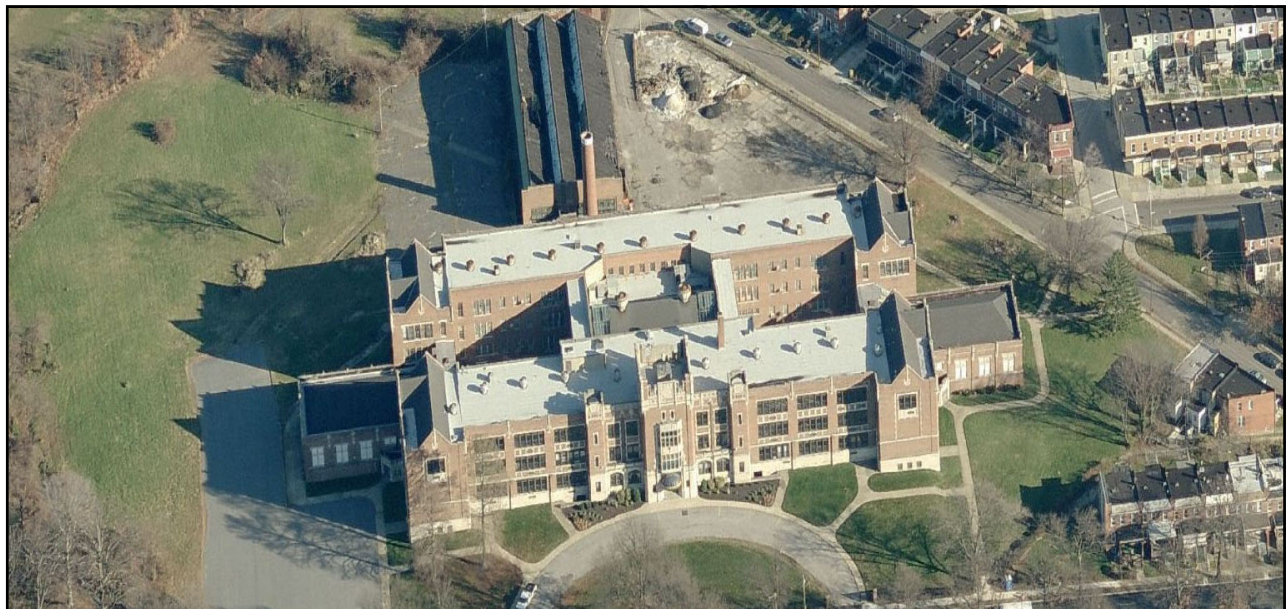
Biomorphic Forms & Patterns

14 PATTERNS	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
Biomorphic Forms & Patterns			<div>Observed view preference</div> <div>(Vessel, 2012; Joye, 2007)</div>
			

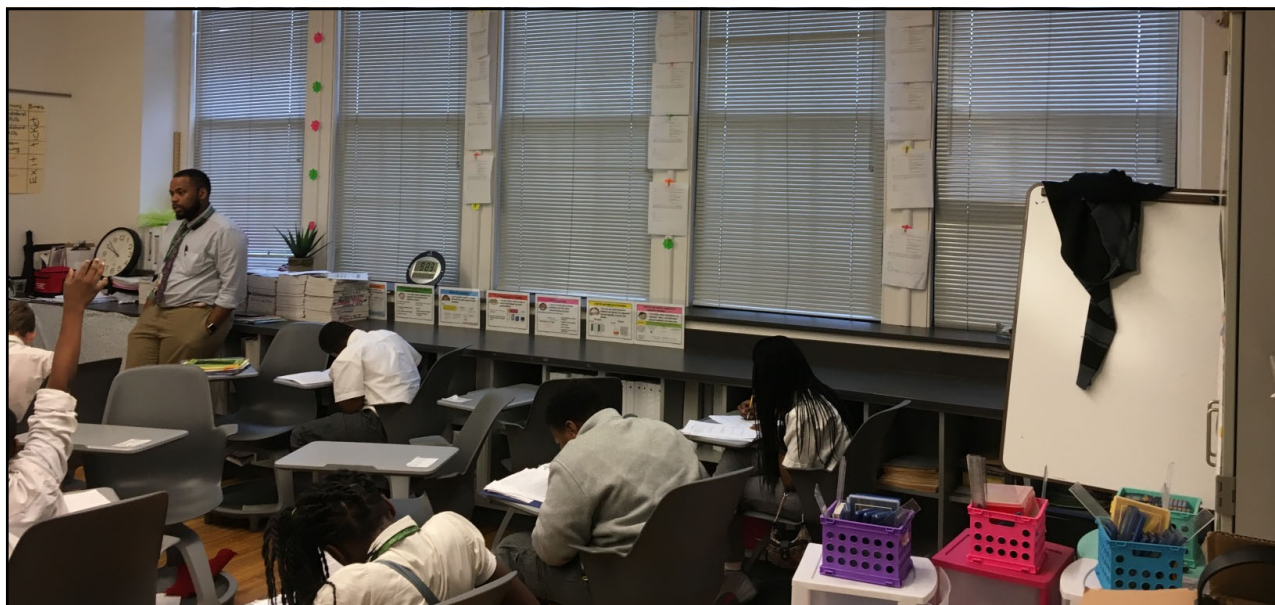
Fill the Research Gap

14 PATTERNS	• STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
Visual Connection with Nature	<ul style="list-style-type: none"> Lowered blood pressure and heart rate (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005) 	Improved mental engagement/ attentiveness (Biederman & Vessel, 2006)	Positively impacted attitude and overall happiness (Barton & Pretty, 2010)
Dynamic & Diffuse Light	<ul style="list-style-type: none"> Positively impacted circadian system functioning (Figueiro, Brons, Pilnick et al., 2011; Beckett & Roden, 2009) Increased visual comfort (Elyezadi, 2012; Kim & Kim, 2007) 	gap	gap
Biomorphic Forms & Patterns	gap	gap	Observed view preference (Vessel, 2012; Joye, 2007)
Non-Rhythmic Sensory Stimuli	<ul style="list-style-type: none"> Positively impacted on heart rate, systolic blood pressure and sympathetic nervous system activity (Li, 2009; Park et al, 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991) 	Observed and quantified behavioral measures of attention and exploration (Windhager et al., 2011)	Not a target objective but related to visual connection to nature

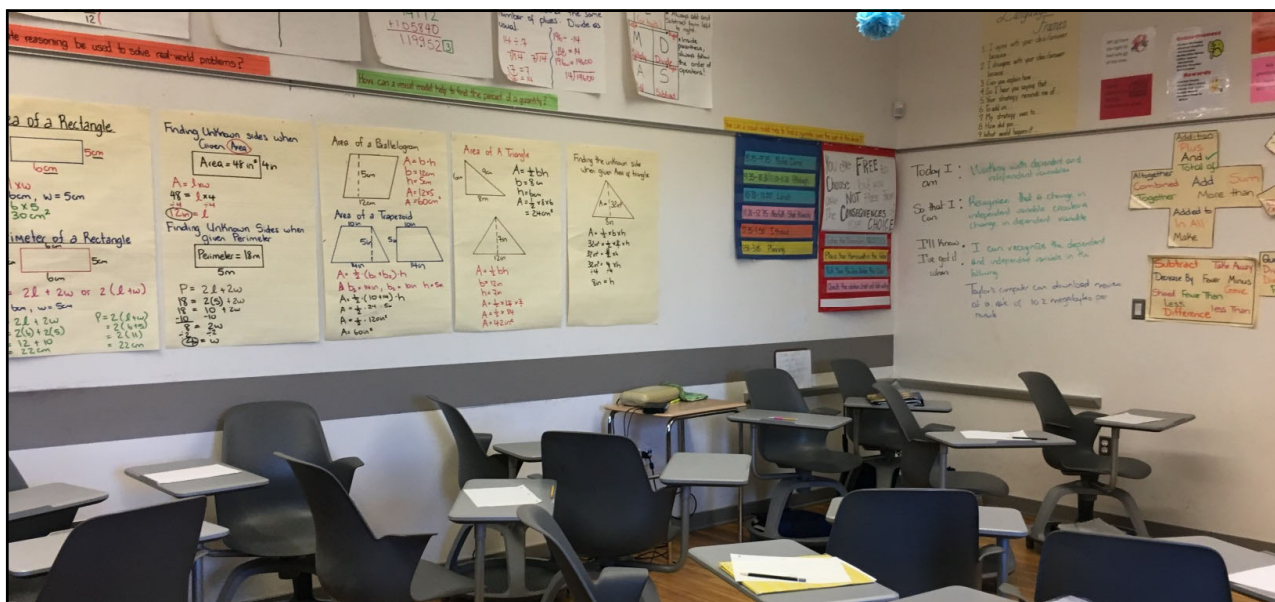
31



32



33



34



35



36



37



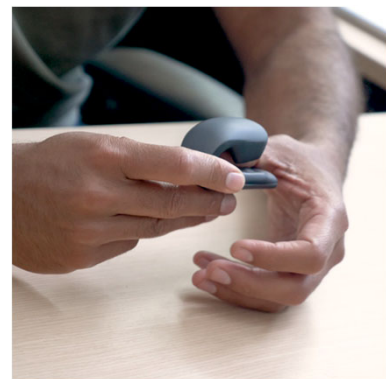
38



39

Assessment

1. *Stress (Heart Rate Variability)*
2. *Student Survey*
3. *Student/ Instructor interviews*
4. *Learning Outcomes*



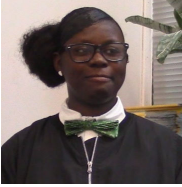
CRAIG
GAULDEN
DAVIS

TERRAPIN
BRIGHT GREEN

MORGAN
STATE UNIVERSITY
UNIVERSITY OF THE FUTURE
STRATEGY FOR EXCELLENCE

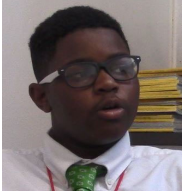
salk
Where Curiosity Begins

40



"It's like a nice bright light, so it gives me a more purpose to learn, knowing that I'm in a good environment. I'm sitting by the light so it's better for me to understand and I'm more comfortable in the classroom."

Shavon



"Along with the floors, the lighting and stuff, it just makes it easier for me to focus more and get back into what I'm doing."

Kendall



"Well, the windows are solar panel. Now would be like cool if you do that for every classroom. It's cool. They relax you. Because with the light of the sun makes you concentrate better, Instead of having regular lights".

"...the ceiling has like little-- it's look like waves...that makes me feel good..."

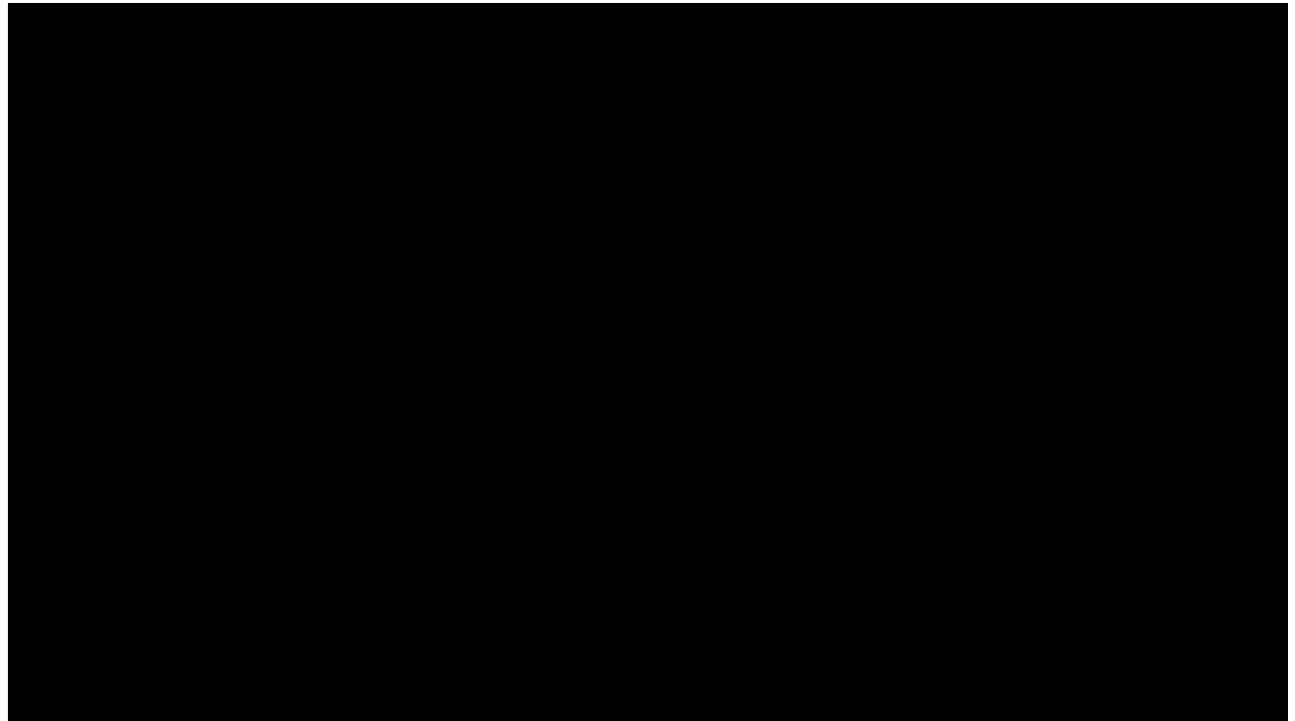
Kervin

CRAIG
GAULDEN
DAVIS

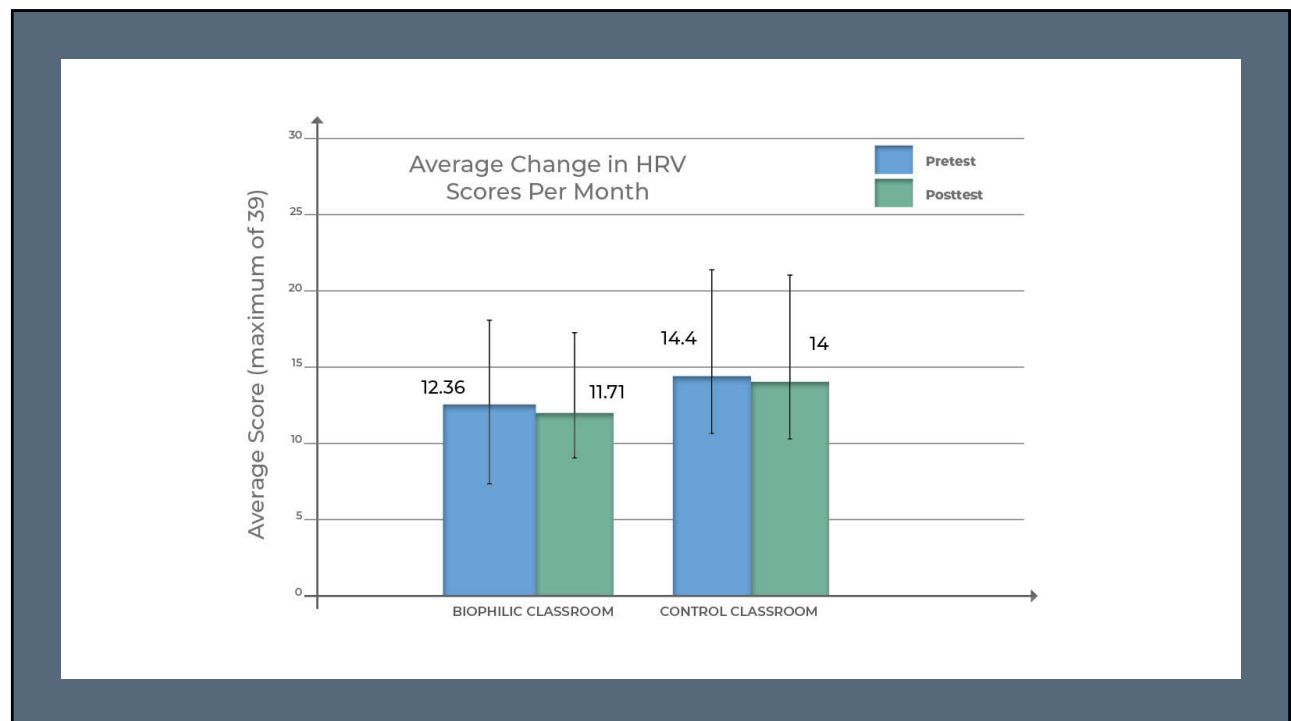
TERRAPIN
BRIGHT GREEN

MORGAN
STATE UNIVERSITY
MORGAN, WYOMING

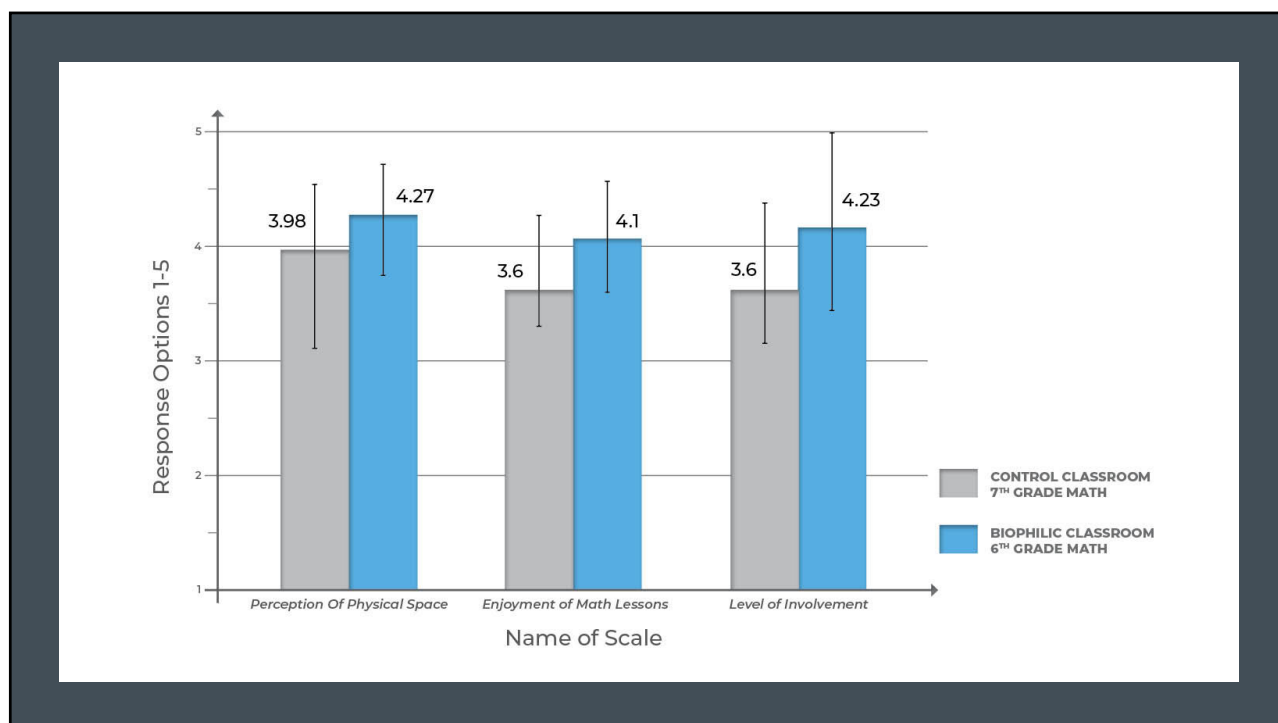
salk
Where Curiosity Begins



43



44



45

Findings

Student Stress *Heart Rate Variability*

CRAIG
GAULDEN
DAVIS

TERRAPIN
BRIGHT GREEN

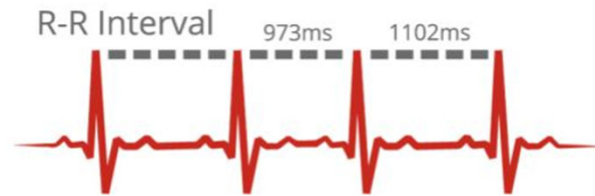
MORGAN
STATE UNIVERSITY
EXCELLENCE FOR ALL

salk
Where Curiosity Begins

46

What is HRV?

- Heart Rate Variability refers to the tiny fluctuations (variability) between heart beats

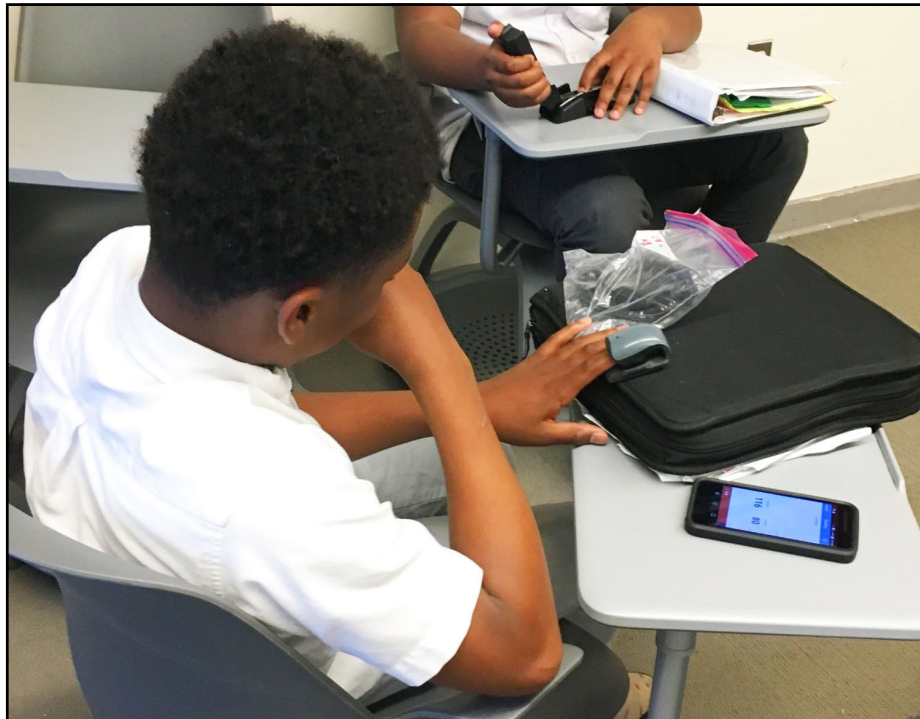


- It is very different from beats-per-minute (heart rate), steps, VO2max, calories or many other biomarkers.

Copyright EliteHRV © 2019



47



HRV TESTING

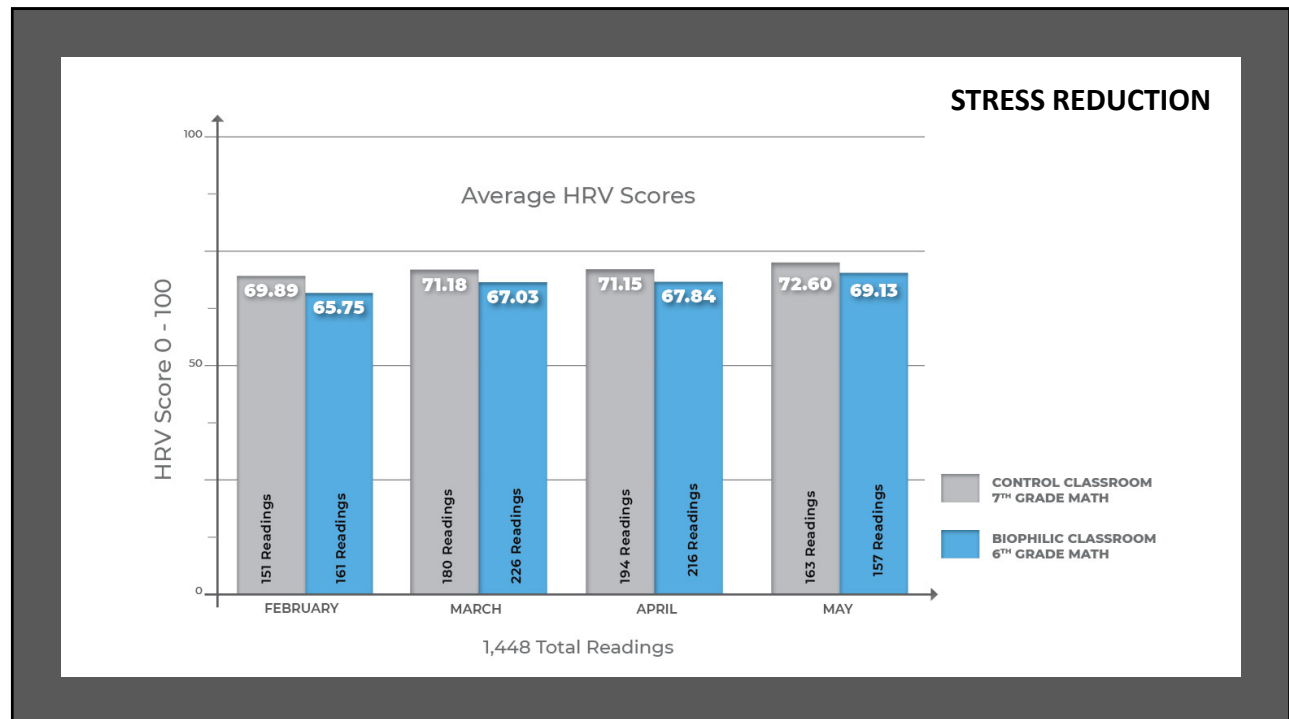
48



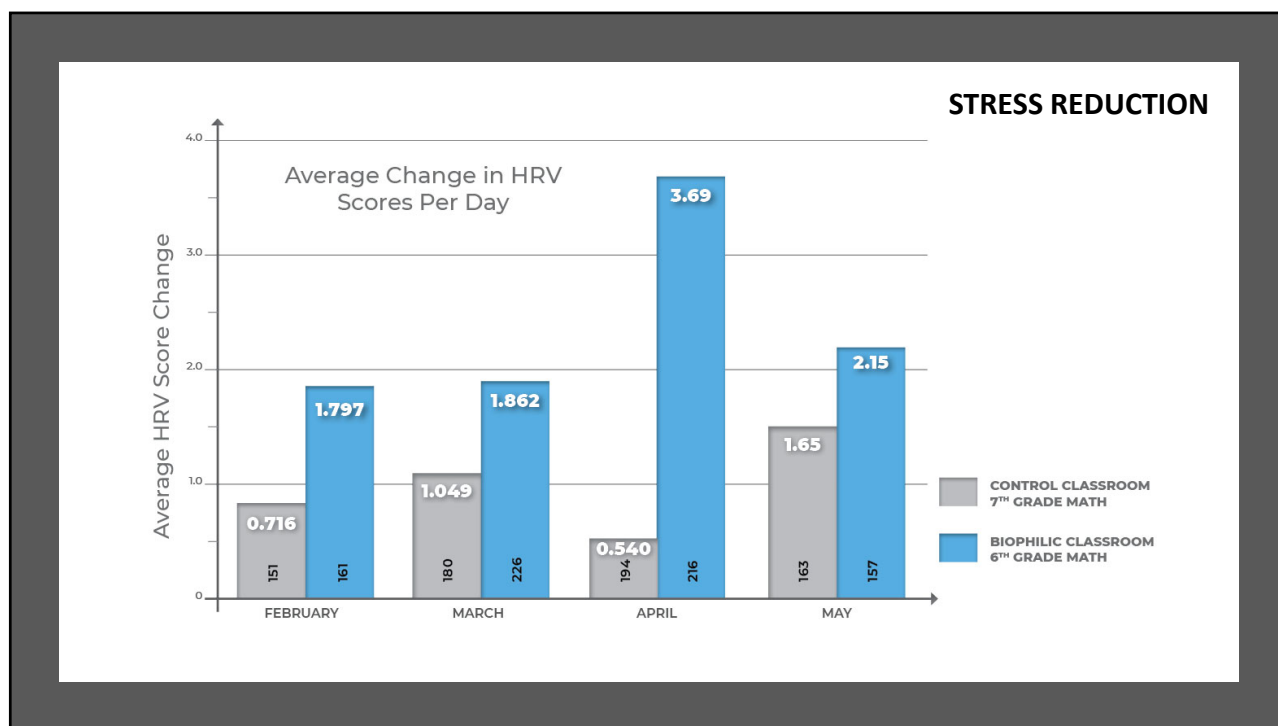
RAW DATA FROM ONE STUDENT IN THE BIOPHILIC CLASSROOM

Member	Type	Date Time Start	Date Time End	Duration	HRV	HRV Average	Delta	Delta Subtotal
B12	open	3/4/2019 12:40	1st	27.117	73			
B12	open	3/4/2019 13:46	2nd	48.4102	68		-5	
B12	open	3/6/2019 10:54	1st	37.62	74			
B12	open	3/6/2019 11:25	2nd	43.7024	78		4	
B12	open	3/8/2019 12:39		55.0524	75			
B12	open	3/11/2019 12:39	1st	34.575	68			
B12	open	3/11/2019 13:48	2nd	34.4737	63		-5	
B12	open	3/13/2019 12:40	1st	38.8852	77			
B12	open	3/13/2019 13:46	2nd	39.8623	79		2	
B12	open	3/25/2019 12:40	1st	57.4512	63			
B12	open	3/25/2019 13:47	2nd	50.7476	74		11	
B12	open	3/27/2019 12:40	1st	31.72	57			
B12	open	3/27/2019 13:45	2nd	35.9231	71		14	
B12	open	3/29/2019 12:41		50.7985	65			
Subtotal						70.3571429		21

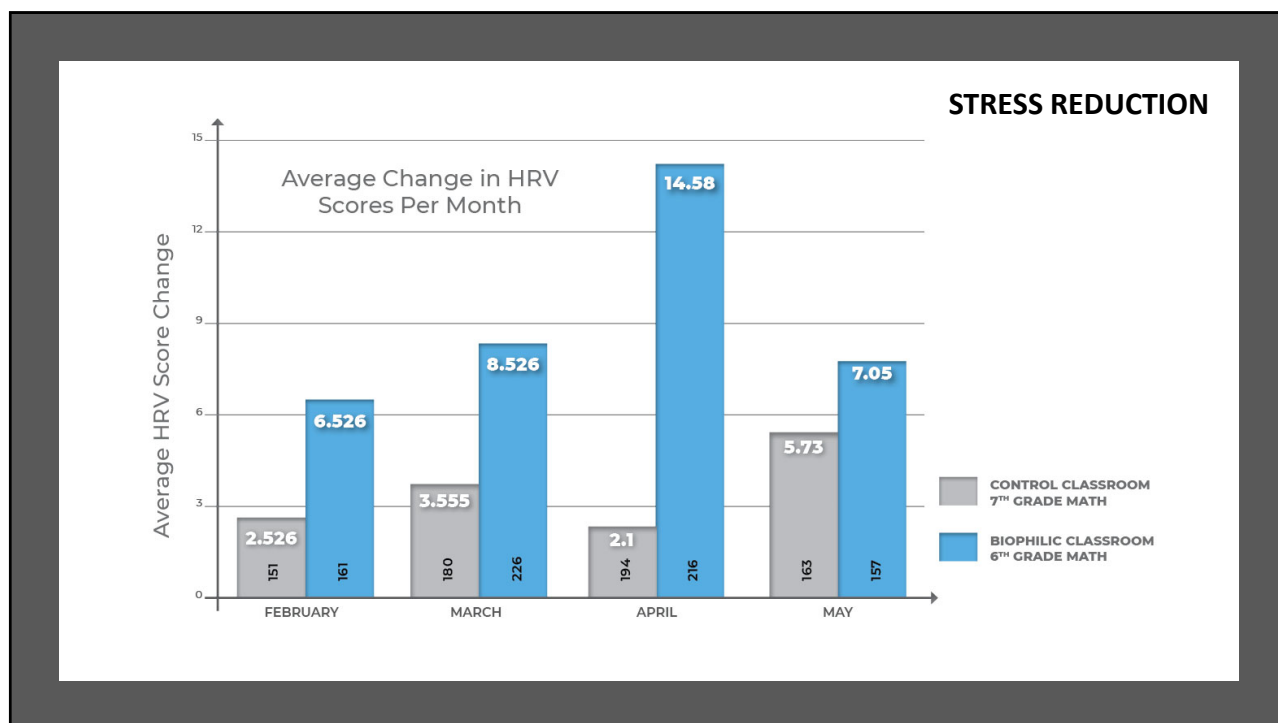
49



50



51



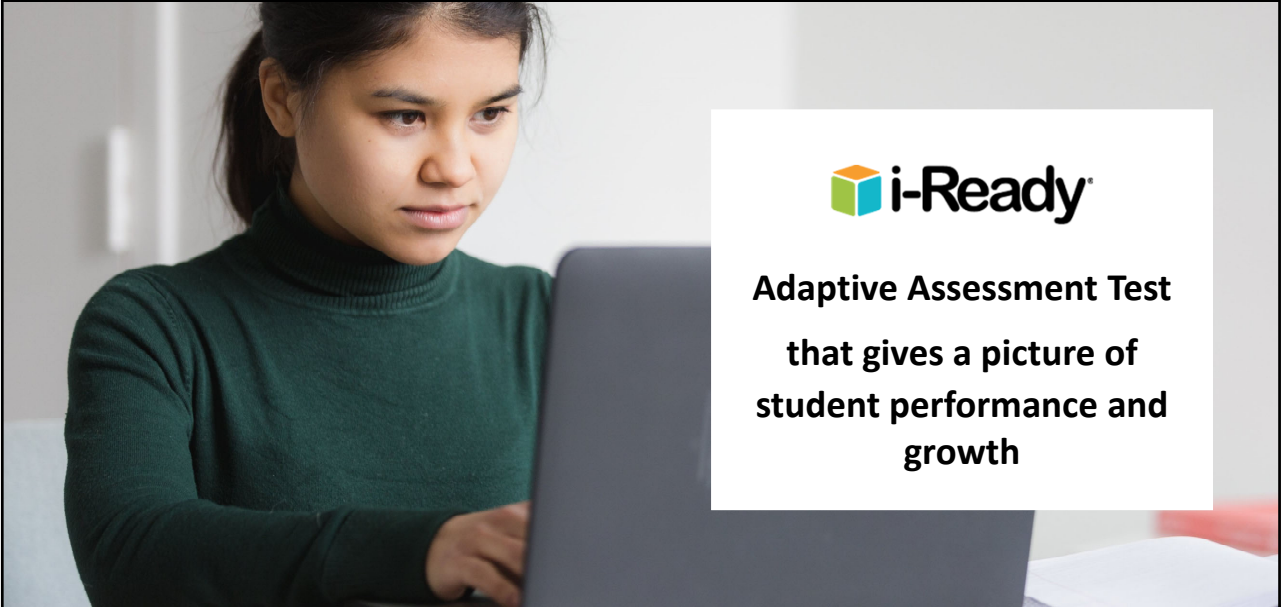
52


Findings

Learning Outcomes



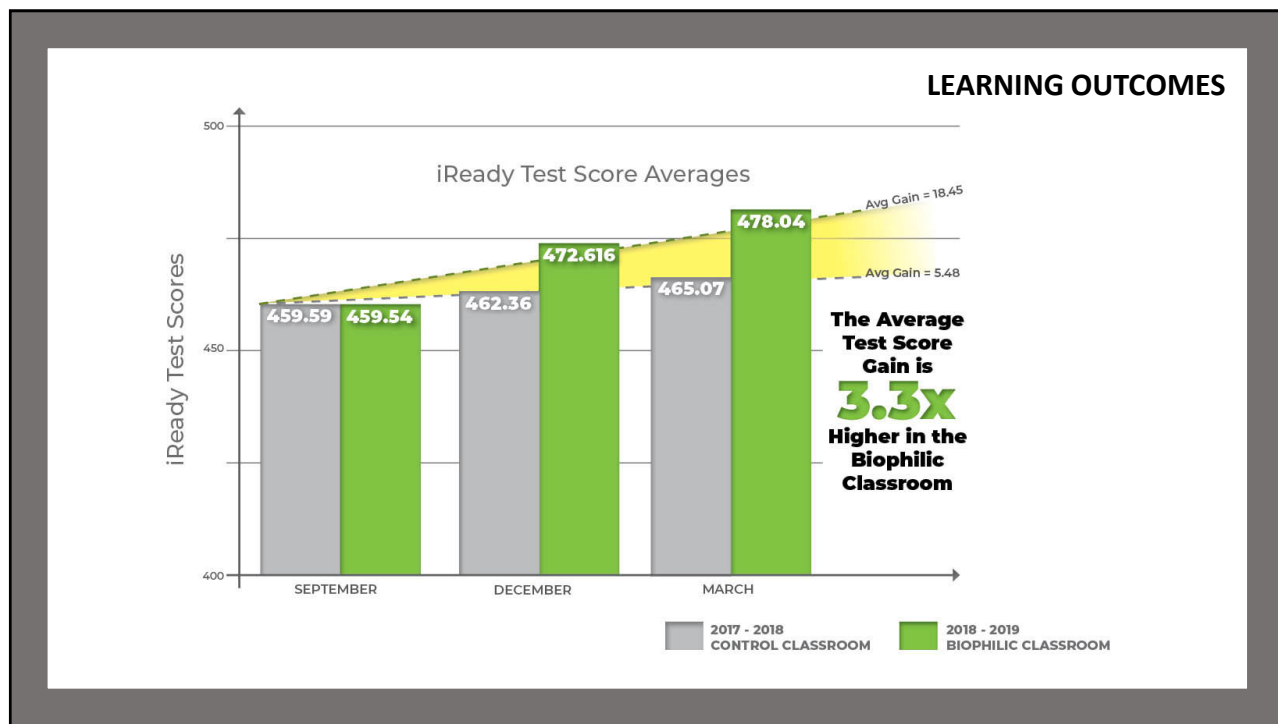
53



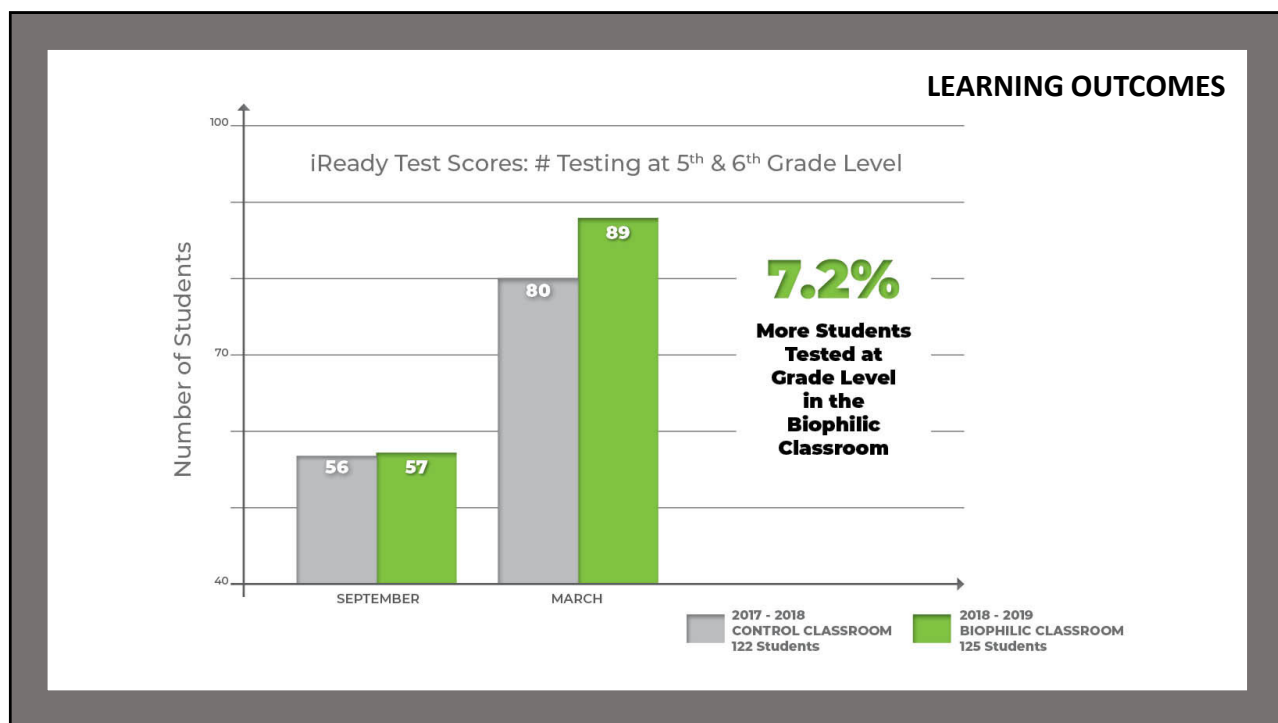
 **i-Ready**

Adaptive Assessment Test
that gives a picture of
student performance and
growth

54



55



56

Findings Summary

Stress reduction during the class experience was significantly higher in the biophilic classroom when compared to a control classroom.

Improvement in Math test scores over a 7 month period was more than 3 times higher in the biophilic classroom when compared to a control classroom.

Students claim to feel “more relaxed”, “calm”, “better able to concentrate”, “easier to focus”, “have more of a purpose to learn” in the biophilic classroom when compared to their other classrooms.

CRAIG
GAULDEN
DAVIS

TERRAPIN
BRIGHT GREEN

MORGAN
STATE UNIVERSITY
LEARNING THE FUTURE

salk
where culture begins

57



What is the impact of the spaces we design?

Bill Browning	bill@terrabinbg.com
Jim Determan	jdeterman@cgdarch.com
Catherine Martin Dunlop	catherine.martin@morgan.edu
Mary Anne Akers	maryanne.akers@morgan.edu

58