

[architecture]

High Performance Sustainable Schools

March 6, 2007

Creating Places to Learn

[engineering]

FANNING  HOWEY

Fanning/Howey Associates, Inc.

- Specializing in Planning and Design of Educational Facilities for 46 years
- Six offices, 275 employees
- Completed Research on Impact of Design on Learning
- Future-Proofing Technology Design
- Author of 3 Books on Educational Facility Design
- Resource to National Publications
- www.fhai.com



Our Green Journey

- Top-down Support
 - Our Board of Directors had to embrace the concepts and the expenditures in staff education.

- Leadership Support
 - We then gained the support of the Principals.

- Development of Expertise
 - We then identified “champions” in each office.
 - We began LEED registration for our staff.



The Issues

- Two issues facing every school district in the country:
 - Test Scores/No Child Left Behind (NCLB)
 - Operating Costs
- We believe there is a valid approach to address these issues simultaneously



Increased Student Learning and Teacher Performance

Creating Places to Learn



Educational Research

Intelligent School Design



Qualities That Affect Student/Teacher Performance

Educational Research

TOPIC	# OF STUDIES
INDOOR AIR QUALITY	13
THERMAL COMFORT	6
LIGHTING	7
ACOUSTICS	13
BUILDING QUALITY	19
SCHOOL SIZE	42



Do School Facilities Affect Academic Outcomes?

National Clearinghouse for Educational Facilities

Summary Data Collated by Michael E. Hall, AIA, REFP, LEED® AP
From National Clearinghouse for Educational Facilities
Booklet "Do School Facilities Affect Academic Outcomes?",
by Mark Schneider, November 2002

The Challenge

- “Between the ages of 5 and 18, a **student may spend 14,000 hours inside a school building.**”
(Environmental Defense Fund, 1999).
- “**Children are more severely affected by air pollution than adults** because of their narrow airways, more rapid rate of respiration, and the fact that they inhale more pollutants per pound of body weight”.
(American Academy of Pediatrics)

Indoor Air Quality

RESEARCH OUTCOME	SUPPORTING RESEARCH
1. Poor IAQ Increases Student Absenteeism	Smedje and Norback (1999) Rosen and Richardson (1999) EPA (2000) American Lung Association (2002)
2. Improving Air Quality Reduces Absenteeism	Rosen and Richardson (1999)
3. Increased Relative Humidity Reduces Absenteeism	Leach (1997)
4. Mental Tasks Are Effected By Changes In Temperature	Wyon (1991)
5. Mental Tasks Are Performed Best In 40-70% Humid./68-74F Temp.	Harner (1974) Wyon, Andersen, and Lundqvist (1979)
6. Most Staff Health-Related Problems Are Due To Poor Indoor Air Quality	Schneider (2002), Chicago and DC Schools
7. Improved Ventilation Systems Reduce Reports of Asthma	Smedje and Norback (1999)
8. Students In Schools With Low Ventilation Rates Have More Nasal Mucosa Swelling (Which May Lead To Increased Absenteeism)	Walinder et al. (1997), Study In Swedish Schools
9. VOCs Are 2 To 8 Times Higher In Schools With Low Ventilation Rates (Which May Lead To Increased Absenteeism)	Walinder et al. (1997), Study In Swedish Schools

DESIGN DIRECTION INDICATED BY RESEARCH FINDINGS:

1. Indoor air quality has a direct effect on attendance and performance.
2. The temperature range most conducive to learning is 68-74 degrees F.
3. The humidity range most conducive to learning is 40-70% RH.

Do School Facilities Affect Academic Outcomes?

National Clearinghouse for Educational Facilities

Summary Data Collated by Michael E. Hall, AIA
From National Clearinghouse for Educational Facilities
Booklet "Do School Facilities Affect Academic Outcomes?",
by Mark Schneider, November 2002

Thermal Comfort

RESEARCH OUTCOME	SUPPORTING RESEARCH
1. Mental Tasks Are Performed Best In 40-70% Humid./68-74F. Temp.	Harner (1974)
2. Achievement, Performance, and Attention Spans Decrease As Temperature and Humidity Increase	King and Morans (1979)
3. There Is A Link Between Heating/Air Conditioning And Learning Conditions	McGuffey (1982)
4. Teacher's Ability To Control Temperature Is Central To Teacher/Student Performance	Lowe (1990)
5. Thermal Comfort Affects Teaching Quality And Student Achievement	Lackney (1999)
6. Physical Working Conditions Affect Teacher Morale And Effectiveness	Corcoran et al. (1988)

DESIGN DIRECTION INDICATED BY RESEARCH FINDINGS:

1. The physical environment affects the performance of both teachers and students.
2. Temperature has a direct affect on attendance, performance, and learning.
3. Humidity has a direct affect on attendance, performance, and learning.
4. Teachers should have the ability to control the classroom's physical environment.



Lighting

RESEARCH OUTCOME

1. Classroom Lighting Affects Student Performance

2. There Are Optimal Lighting Levels

3. Appropriate Lighting Improves Test Scores And Reduces Poor Behavior

4. Daylight Fosters Higher Student Achievement

SUPPORTING RESEARCH

Phillips (1997)

Mayron et al. (1974)
Dunn et al. (1985)

Jago and Tanner's Review (1999)

Lemasters (1997)
Heschong Mahone (1999)
Plympton, Conway, and Epstein (2000)

DESIGN DIRECTION INDICATED BY RESEARCH FINDINGS:

1. Special attention must be given to optimal classroom lighting levels.
2. Daylighting (natural light) improves student achievement.



“Among twelve models considered in that study we identified a central tendency of a **21% improvement in student learning rates** from those in classrooms with the least amount of daylight compared to those with the most.

Daylighting in Schools Re-analysis Report, for the California Energy Commission, 2001

Capistrano School District

by The Heschong Mahone Group

- “In the California district studied, students in classrooms with the most daylight **progressed 20% faster on math tests and 26% faster on reading tests** over the course of one year compared to students in classrooms with the least daylighting.”
 - Quoting from “Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance,”
 - by the Heschong Mahone Group for Pacific Gas & Electric, August, 1999.
 - **TESTIMONY BEFORE THE SENATE ENVIRONMENT AND PUBLIC WORKS COMMITTEE**
Hearing on High-Performance Schools, October 1, 2002
Presented by: Alex Wilson, President, BuildingGreen, Inc.

The Benefits

- Students in classrooms with large windows and skylights that let in natural light **outperformed other students in their school district by 5 to 14 percent** on end-of-grade tests.

(Nicklas and Bailey, 1995)



The Benefits

- The **daylit schools used 22 to 64 percent less energy** than non-daylit schools. They also noted that the payback on all the new daylit schools was below three years.

(Nicklas and Bailey, 1995)



Acoustics

RESEARCH OUTCOME

1. Noise Has A Negative Affect On Student Achievement

2. There Are Health-Related Issues With Excessive Noise

3. Noise Issues Are More Acute For Children With Hearing Impediments

4. Teachers Believe Noise Impairs Student Performance

5. Noise Causes Lowered Efficiency For Teachers

6. Many Classroom Acoustics Impede Listening And Learning

SUPPORTING RESEARCH

Earthman and Lemasters (1998)
Crandell et al. (1995)
Nabelek and Nabelek (1994)
ASHA (1995)
Crandell (1991)
Crandell and Bess (1986)
Evans and Maxwell (1999)
US Arch/Trans. Barriers Compliance Board (2002)

Fisher (2000)

Nelson and Soli (2000)

Lackney (1999)

Lucas (1981)

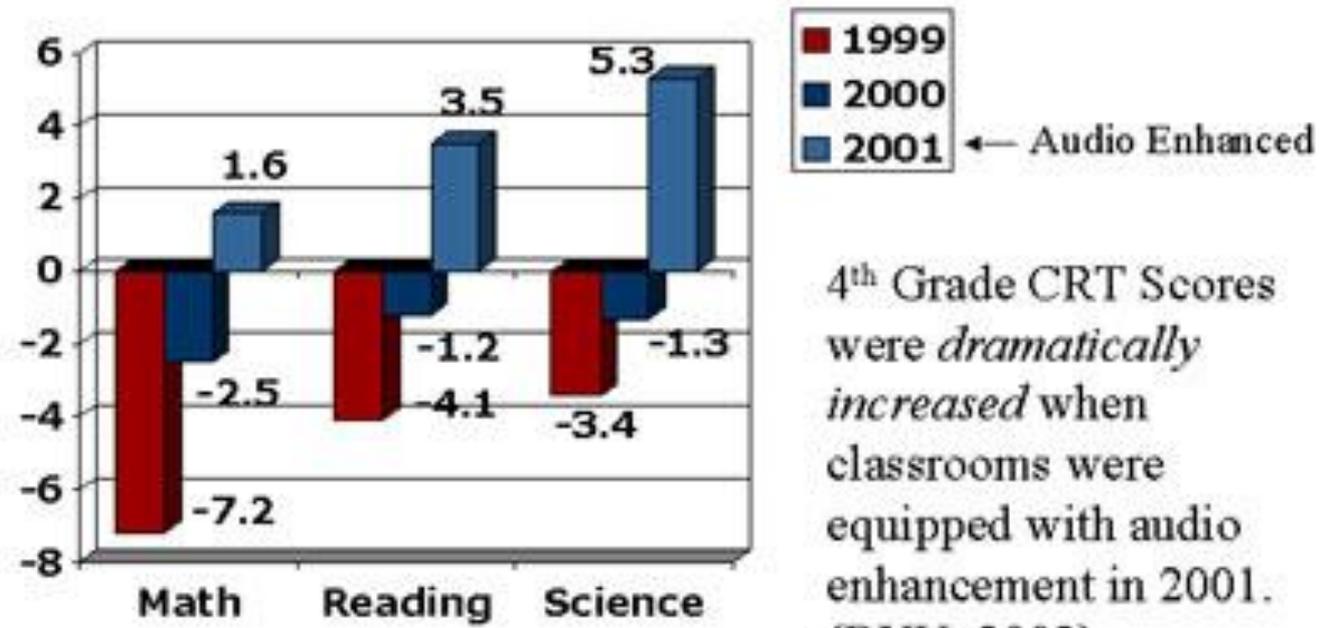
Feth and Whitelaw (1999), 32 Ohio Elementary Classrooms

Design Direction Indicated by Research Findings:

1. Special attention must be given to optimal classroom noise levels.



State Criterion Reference Test Gains Pioneer Elementary-Salt Lake County, Utah



4th Grade CRT Scores were *dramatically increased* when classrooms were equipped with audio enhancement in 2001. (BYU, 2002)

*Point differences from previous year's test scores.

The Benefits

- “Studies indicate that the benefits of green schools are numerous.
 - Green schools can **save 40 percent or more on energy costs.**
 - Students in schools that rely primarily on daylighting **perform up to 26 percent better** on standardized tests than their counterparts in poorly lit schools.
 - An estimated 17 million school days were lost in 1997 due to asthma. Taking steps to address air pollutants leading to asthma would mean **higher school attendance.**”
 - Statement of Chairman James M. Jeffords
Senate Environment & Public Works Committee
Hearing on Green Schools: Environmental Standards for Schools

Building Quality

RESEARCH OUTCOME

SUPPORTING RESEARCH

1. Better Building Quality Positively Affects Student Achievement

McGuffey (1982)
Earthman and Lemasters (1996, 1998)
Plumley (1978)
Chan (1979)
Bowers and Burkett (1987)
Phillips (1997)
Jago and Turner (1999)
Edwards (1992)
Cash (1993)
Hines (1996)
Andersen (1999)
Maxwell (1999)
Claus and Girbach (1985)

2. Good Facilities Have A Major Impact On Learning

Lewis (2000)

3. Student Achievement Lags Inadequate School Buildings

Stricherz(2000)

4. Disciplinary Incidents Decrease As Building Quality Increases

McGuffey (1982)
Earthman et al. (1995)

5. There Is A Strong Link Between Capital Outlay And Leadership/Teaching

Pricewaterhouse-Coopers (2001)

DESIGN DIRECTION INDICATED BY RESEARCH FINDINGS:

1. Good physical facilities result in good student achievement.
2. Renovation can be a good investment in education.



- “Here in Washington, DC, the renovation of the run-down Charles Young Elementary School, completed in 1997, resulted in dramatic improvements in math and reading test scores.”
 - TESTIMONY BEFORE THE SENATE ENVIRONMENT AND PUBLIC WORKS COMMITTEE
 - Hearing on High-Performance Schools, October 1, 2002
 - Presented by: Alex Wilson, President, BuildingGreen, Inc.

The Benefits

- “Prior to the restoration, almost half of the students scored in the lowest quartile on standardized tests (49% in math and 41% in reading);
- After the renovation, **those percentages dropped to 24% and 25%, respectively.**
- TESTIMONY BEFORE THE SENATE
ENVIRONMENT AND PUBLIC WORKS COMMITTEE
 - Hearing on High-Performance Schools, October 1, 2002
 - Presented by: Alex Wilson, President, BuildingGreen, Inc.

School Size

RESEARCH OUTCOME

SUPPORTING RESEARCH

1. Small Schools Enhance Achievement	Howley, Strange, and Bicknel (1999)	
2. Small School Benefits Are Achieved In Elementary Schools Less Than 400 And High Schools Less Than 1000-Students	Cotton (1996)	
3. Noise Issues Are More Acute For Children With Hearing Impediments	Cotton (2001)	
4. Returns Diminish As School Size Increases	Barker and Gump (1964)	
5. Small Schools Improve Education, Reduce Isolation, and Reduce Achievement Discrepancies	Wasley et al. (2000)	
6. Small Schools Encourage Parental Involvement	Schneider et al. (2000)	
7. Small Schools Have Many Positive Benefits	Nathan and Febey (2001) Raywid (1999)	
8. Small Schools Create Positive Learning Values	Howley (1994) Irmsher (1997) Cotton (1996 and 2001)	
9. School Size Is The Best Predictor Of Higher Test Scores	Fowler and Walberg (1991) Lee and Smith (1997) Keller (2000) Cotton (1996) Friedkin and Necochea (1988)	
10. Small Schools Can Reduce Violence	Gregory (1992) Stockard and Mayberry (1992) Kershaw and Blank (1993)	



School Size - continued

RESEARCH OUTCOME

SUPPORTING RESEARCH

11. Small Schools Can Improve A Wide Range Of Student Attitudes And Behaviors	Barker and Gump (1964) Fowler and Walberg (1991) Stockard and Mayberry (1992) Foster and Martinez (1995)
12. Small Schools Have Lower Drop-Out Rates	Toenjes (1989) Pittman and Haughwout (1987) Stockard and Mayberry (1992)
13. Small Schools Have Higher Attendance Rates	Fowler (1995) Howley (1994)
14. Small Schools Have Higher Graduation Rates	Farber (1998)
15. Small Schools Can Improve Teacher Attitudes	Hord (1997) Gottfredson (1985) Stockard and Mayberry (1992) Lee and Loeb (2000)
16. Small Schools May Be Cost-Effective And Economies Of Scale Do Not Appear With School Size	Steifel et al. (2000) Gregory (1992) Walberg (1992) Robertson (1995)
17. Supposed Curricular Improvements Associated With School Size Rapidly Diminish	Pittman and Haughwout (1987)
18. Public Opinion Data Confirm A Preference For Small Schools	Public Agenda (2002) Peterson et al. (2001)
19. Making Schools Smaller Is The Ultimate Reform	Ayers et al. (2000)



DESIGN DIRECTION INDICATED BY RESEARCH FINDINGS:

1. Smaller schools serve education more effectively than larger schools.
2. Elementary schools of 300-400 and high schools of less than 1000 achieve small-school benefits.

Summary of Research

- Indoor Air Quality has a direct affect on attendance and performance.
 - *The temperature range most conducive to learning is 68 - 74 degrees F.*
 - *The humidity range most conducive to learning is 40-70% RH.*
- The physical environment affects the performance of both teachers and students.
 - *Temperature has a direct affect on attendance, performance, and learning.*
 - *Humidity has a direct affect on attendance, performance, and learning.*
 - *Teachers should have the ability to control the classroom's physical environment.*



Summary of Research

- Special attention must be given to optimal classroom lighting levels.
 - Daylighting (natural light) improves Student Achievement.
- Special attention must be given to optimal classroom noise levels.
 - Less than 35dB is optimal.
- Good physical facilities result in good student achievement.
 - New or Renovated Facilities can be a good investment in education.
- Smaller schools serve education more effectively than larger schools
 - Elementary Schools of 300-400 and High Schools of less than 1000 achieve small-school benefits.

Summation



- There is a volume of proven research that shows facility design does impact student and teacher performance
- More studies continually being done on a variety of subjects
- Use the research to educate your clients.

- Owner's Project Goals Drive the Design
 - Discussion with the Owner
 - Initial Cost Impacts from our experience
 - Benefits

- Design
 - Integration of Owner's goals and our expertise
 - What is best for teaching and learning
 - In-house HVAC symposium on displacement ventilation, etc.

- Specifications
 - We have "greened" our specs to LEED minimums

- Continued commitment
 - Recent In-house LEED workshop



Student
Centered
Sustainable Design™

what is
Sustainable Design?

what are
High-Performance Schools?

what is
Student-Centered Sustainable Design™?



“Meeting the needs of the present
without compromising the
ability of future generations
to meet their own needs.”

Have Eight Key Benefits

1. Increased Student Performance
2. Increased Student/Staff Attendance
3. Increased Teacher Satisfaction
4. Reduced Operational Cost
5. Reduced Liability Exposure
6. Reduced Impact on the environment
7. Opportunity for the school building as a teaching tool
8. Support Community Values



Sustainable Design

Broad Environmental Issues

High-Performance Schools

Schools that exhibit the results of applying sustainable design principles

Student-Centered Sustainable Design™

Those "green" issues that most affect teaching and learning

Integrated Daylighting and Electrical Lighting Systems

Indoor Air Quality

Energy-Efficient HVAC Systems

Environmentally-Preferable Building Materials

Eco-Education



- Student-Centered Sustainable Design™
 - Those items that most affect teaching and learning, according to actual research
 - Thermal Comfort
 - Lighting
 - Indoor Air Quality
 - Acoustics
 - Building Quality
 - School Size



Increased Student Learning and Teacher Performance

Creating Places to Learn



Rating Systems

CHPS



???

Green Globes™



ENERGY STAR



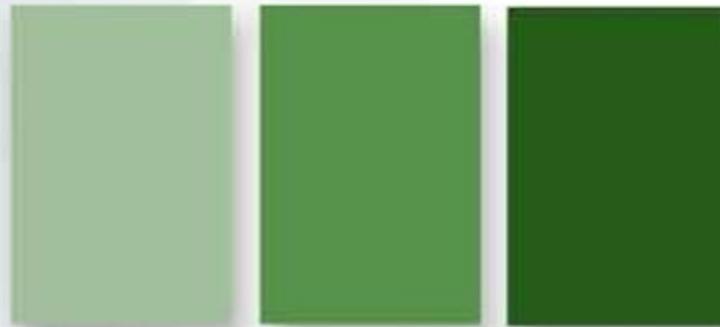
LEED®



Sustainable Design

Creating Places
to Learn

Shades of Green



- Sustainable Site Planning and Landscape Design
- Transportation and Community Integration
- Water Conservation
- System Commissioning and Maintenance Programs
- Energy-Efficient HVAC Systems
- Energy-Efficient Building Shell
- Renewable Energy Resources
- Environmentally- preferable Building Materials
- Indoor Air Quality
- Construction and Occupancy Waste and Recycling Systems
- Integrated Day Lighting and Electrical Lighting Systems
- Eco-Education

Student-Centered Sustainable Design™ focuses on those areas that most affect teaching and learning.

- Integrated Daylighting and Electrical Lighting Systems
- Indoor Air Quality
- Energy-Efficient HVAC Systems
- Environmentally- preferable Building Materials
- Eco-Education

- Related Areas include :
 - *Energy-Efficient Building Shell*
 - *System Commissioning and Maintenance Programs*
 - *Sustainable Site Planning and Landscape Design*
 - *Transportation and Community Integration*
 - *Water Conservation*
 - *Renewable Energy Resources*
 - *Construction and Occupancy Waste and Recycling Systems*

Three Shades of Green

category 1 – Light Green
Basic Good Design Principles

category 2 – Medium Green
Good Value through Good Payback

category 3 – Dark Green
Longer Payback Period



Improving Student/Teacher Performance

Educational Research

TOPIC	# OF STUDIES
INDOOR AIR QUALITY	13
THERMAL COMFORT	6
LIGHTING	7
ACOUSTICS	13
BUILDING QUALITY	19
SCHOOL SIZE	42

Do School Facilities Affect Academic Outcomes?

National Clearinghouse for Educational Facilities

Summary Data Collated by Michael E. Hall, AIA, REFP, LEED® AP
From National Clearinghouse for Educational Facilities
Booklet "Do School Facilities Affect Academic Outcomes?",
by Mark Schneider, November 2002



category 1 – Light Green

Basic Good Design Principles

- Improve U-value of Envelope
- Natural Lighting
- Light-colored Roof
- No CFC Gasses
- Energy Recovery
- Air and Waterside Economizer
- Variable Frequency Drives
- Water-conserving Cooling Towers
- High-efficiency Lighting
- Building Purge Cycle
- Dry-type Transformers
- Occupant Lighting Control
- Water-conserving Plumbing Fixtures
- Building Management Systems
- Operable Windows
- Using Recycled Materials
- Using Local Materials
- Using “Green” Materials
- Construction Waste Management

Our basic design approach includes these items

category 2 – Medium Green

Good Value through Good Payback

- **Daylighting**
- **Air Quality Monitoring**
- **Building Commissioning**
- LEED Certification
- Storm Water Reclamation
- CFD HVAC Modeling
- Central Plant vs. Alternate Systems
- Natural Ventilation
- **Thermal Storage**
- Gas or Steam Chiller
- Electric Vehicle Recharging
- DOE Measurement and Verification
- Ground-source Heat Pumps
- Displacement Ventilation
- Roof Rainwater Collection

Items in bold normally included

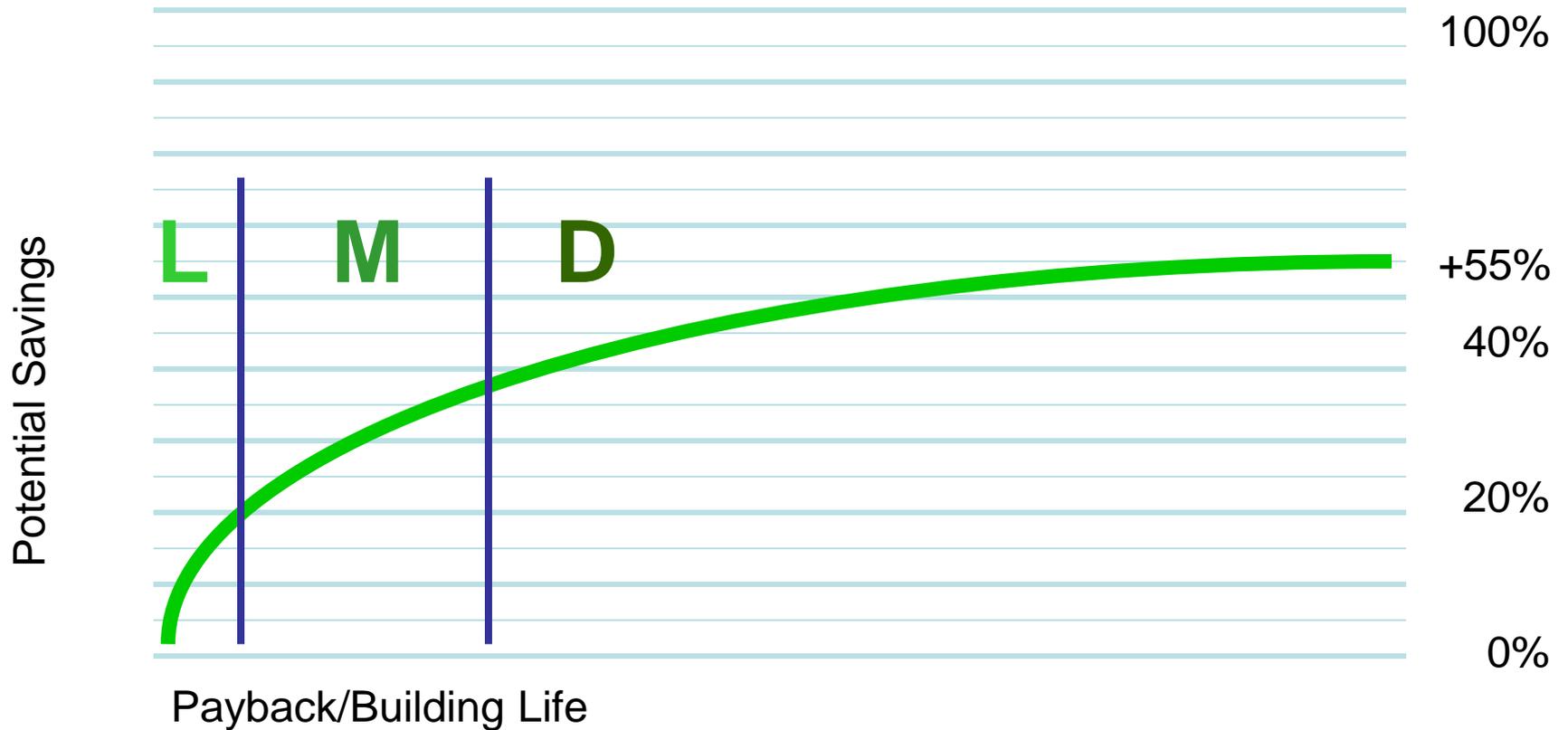
category 3 – Dark Green

Longer Payback Period

- Photovoltaics
- Solar Domestic Hot Water
- Fuel Cells
- On-site Waste Treatment
Living Machine
- Transpired Solar Air Collector
- Green Roof
- Radiant Ceilings or Slabs
- Seawater Heat Pump
- Grey Water Recycling
- Increased Levels of
 - Renewable Energy
 - Water Conservation
 - Renewable Energy
 - Recycled Content
 - **Local Materials**
 - Day Lighting
 - Waste Management
- **Redevelop Existing Building**
- Reclaim Existing Site

Items in bold normally included

Hypothetical Cost Benefit Curve

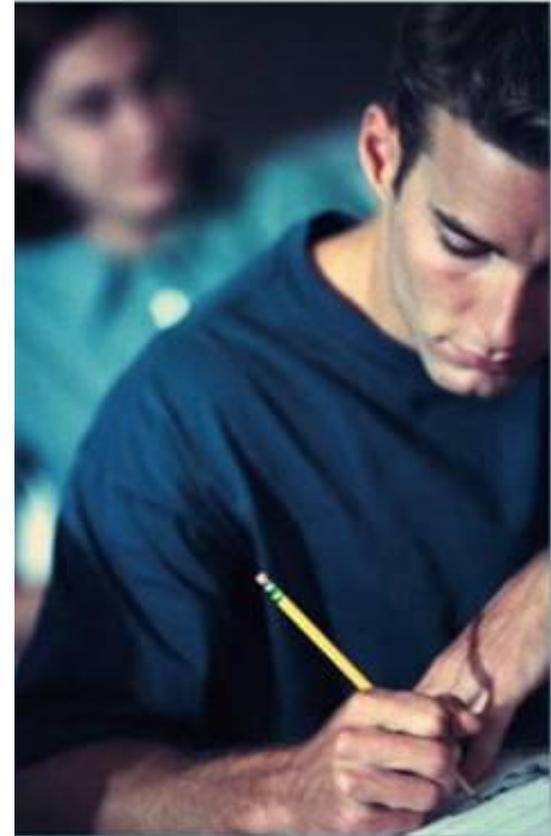


Application in the Real World



Setting Goals

- Have clear Board of Education support
- Develop written Board Policy
- Prioritize items based on educational impact (teaching and learning)
- Communicate Board Policy to the entire design team (staff, consultants, public, etc.)
- Involve Principal, Staff, and Maintenance representatives in design



Setting Priorities

- Choose items that have the greatest impact on teaching and learning
- Set a realistic construction budget
 - Light Green – 0% increase
 - Medium Green – 5% increase
 - Dark Green – 9% increase
- Evaluate operating costs



- The US Department of Energy (DoE) estimates that schools spend more than \$6 billion annually on energy, and that they **could save at least 25% of this amount through better design** (even in renovated older buildings) through the use of energy-efficient and renewable energy technologies, and improvements in operations and maintenance.

- TESTIMONY BEFORE THE SENATE ENVIRONMENT AND PUBLIC WORKS COMMITTEE

Hearing on High-Performance Schools, October 1, 2002

Presented by: Alex Wilson, President, BuildingGreen, Inc.

The Benefits

- Using sustainable design practices, they calculate that their schools consume 30,000 to 45,000 BTUs of energy per square foot compared to typical schools that consume around 100,000 BTUs per square foot.

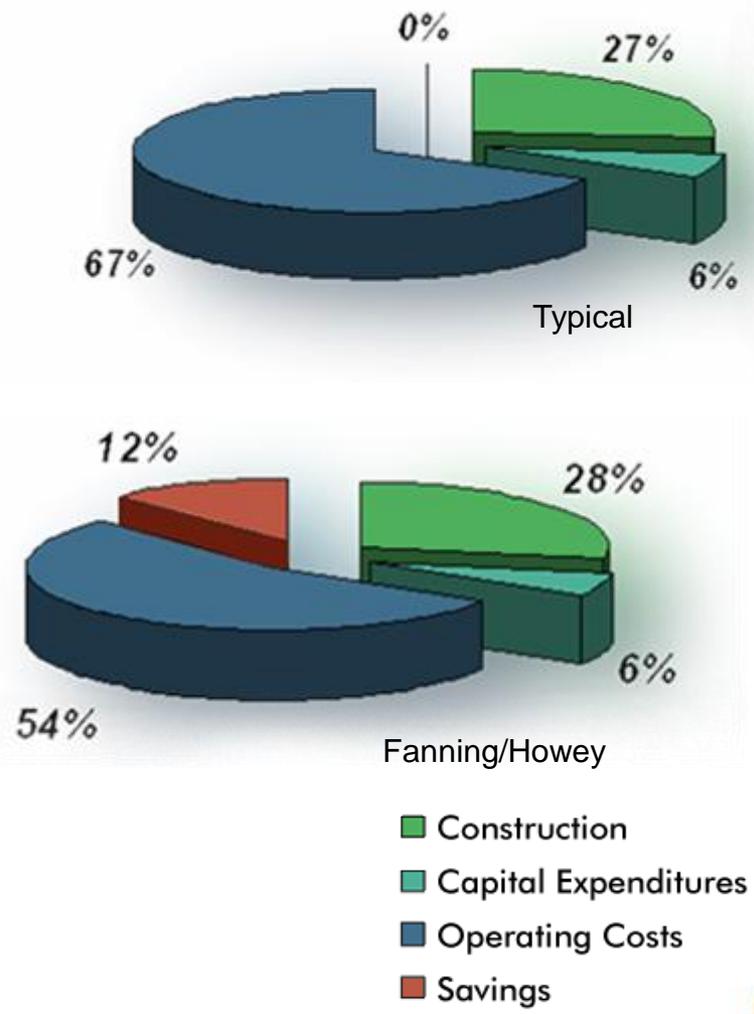
(Nicklas and Bailey, 1995)



Impact on Operating Costs

Operating cost data from completed projects, u gas, and electric) :

- Typical school expends about **\$1.26/sf/year** with addition of air conditioning.
- Novi, MI, is expending **\$1.05/sf/year**.
- Lima, OH, is expending about **\$0.98/sf/year**.
- Rooftop HVAC systems are expending **\$1.68/sf/year**



- Set Goals for **Medium Green**
 - Daylighting
 - Indoor Air Quality
 - Thermal Comfort
 - Water Reclamation
- Budget Reality – **Light Green**
 - Daylighting Alternative
 - Lighting Controls
 - Indoor Air Quality
 - Thermal Comfort
- Impact on Students and Staff Prioritized

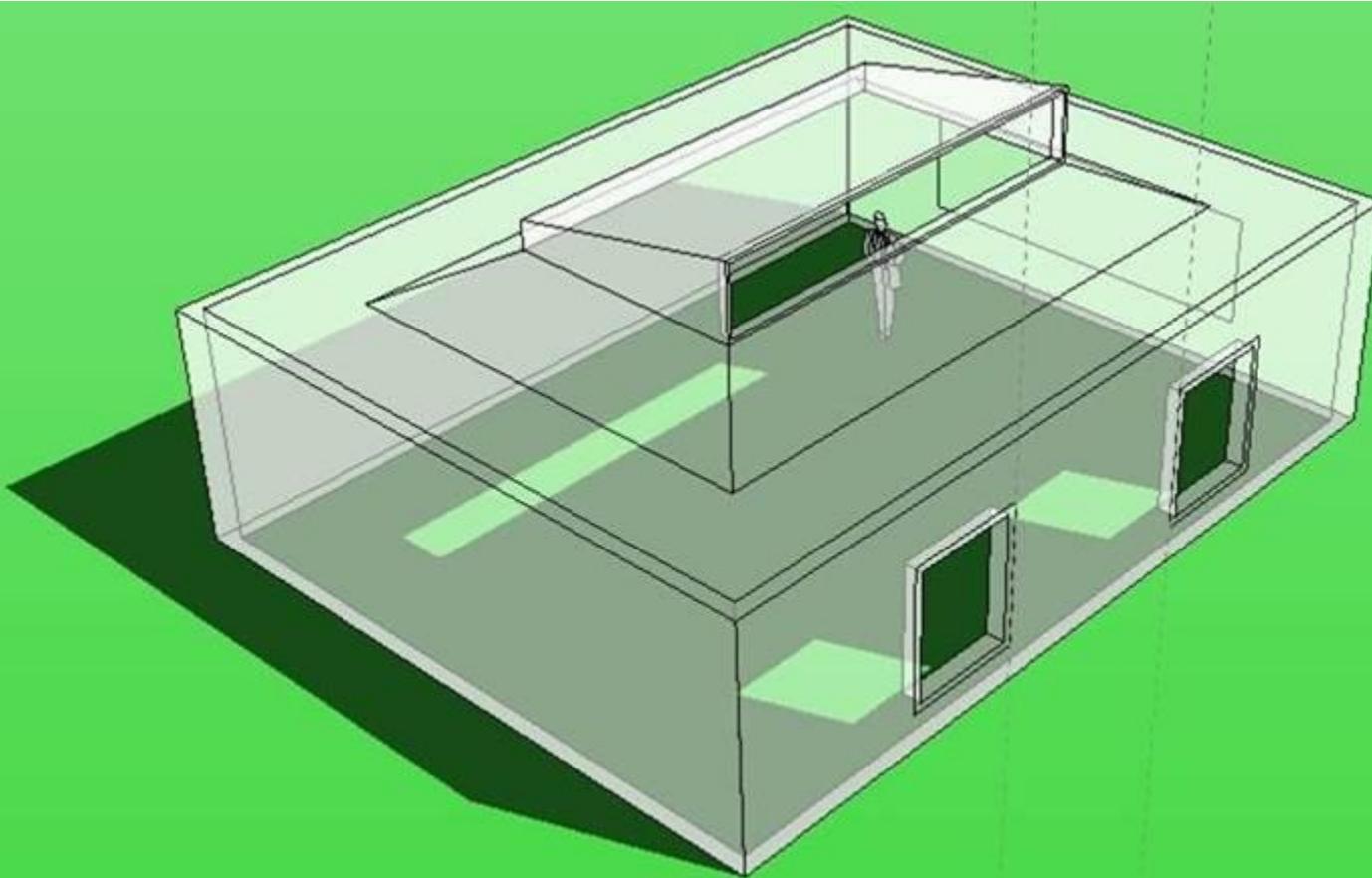


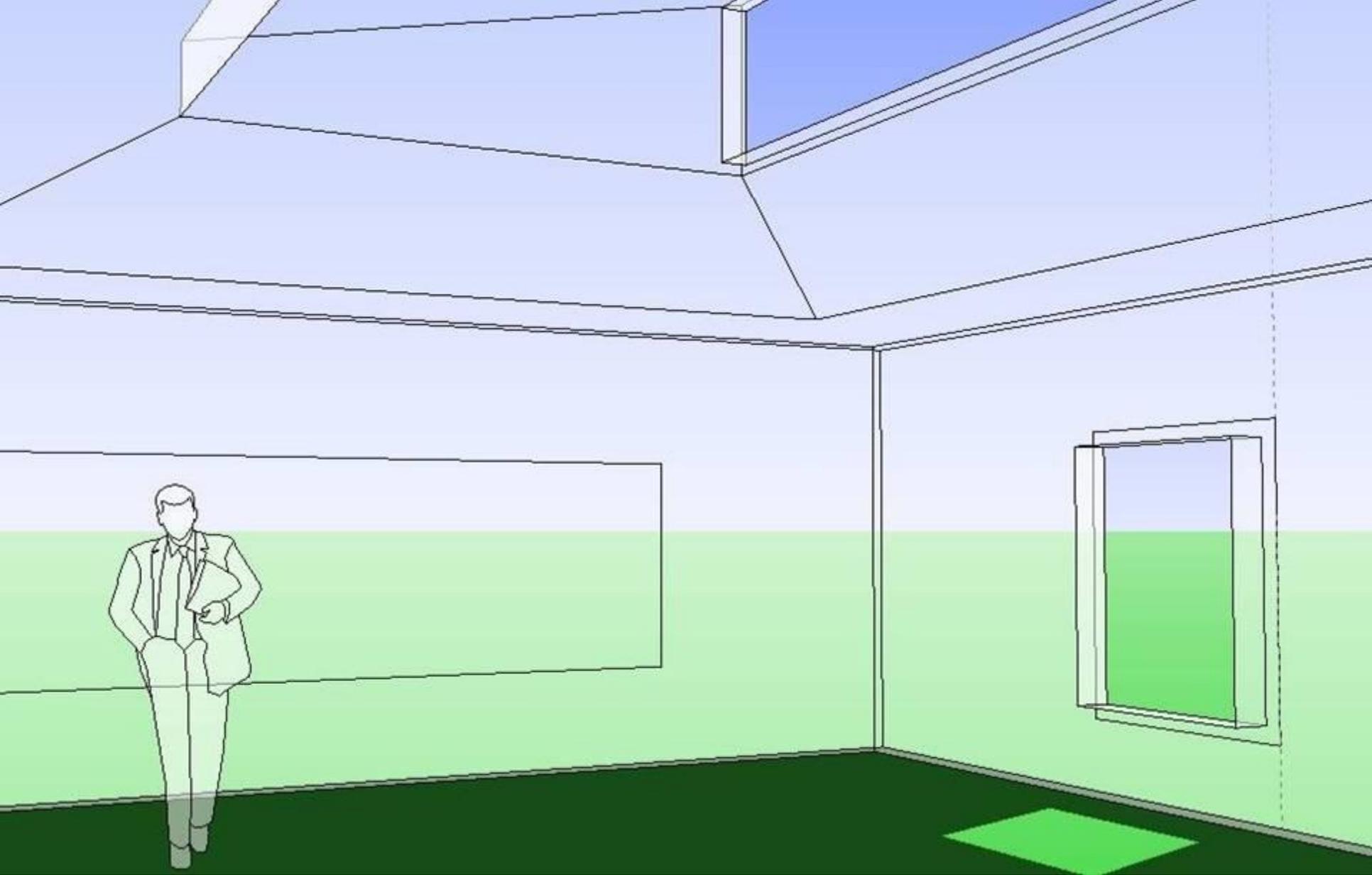
• *Dayton Public Schools* is committed to enhancing our students' ability to learn by providing environments that support teaching and learning most effectively. We believe the research supports school design practices that include:

- *integrated daylighting,*
- *improved indoor air quality,*
- *energy-efficient building systems,*
- *environmentally-preferable building materials,*
- *improved classroom acoustics, and*
- *design approaches that allow the building itself to be used as an instructional tool*

• We believe that these practices assist in providing superior learning environments, while reducing life-cycle costs through conservation of energy, and we embrace these student-centered sustainable design practices as the most appropriate means to achieve our goals.

Graphic Modeling Tool: *SketchUP*





Daylighting: Top & Both Sides



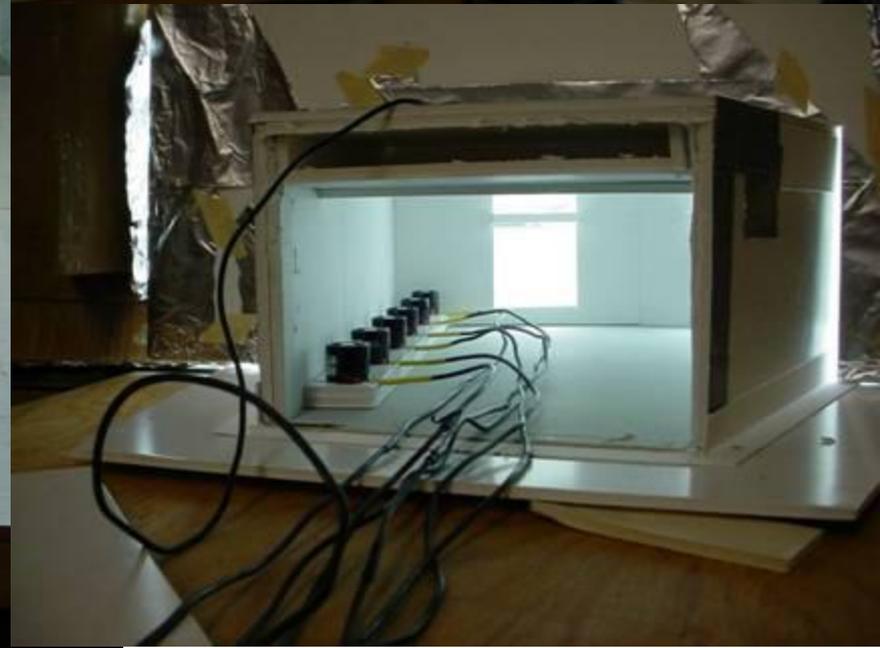
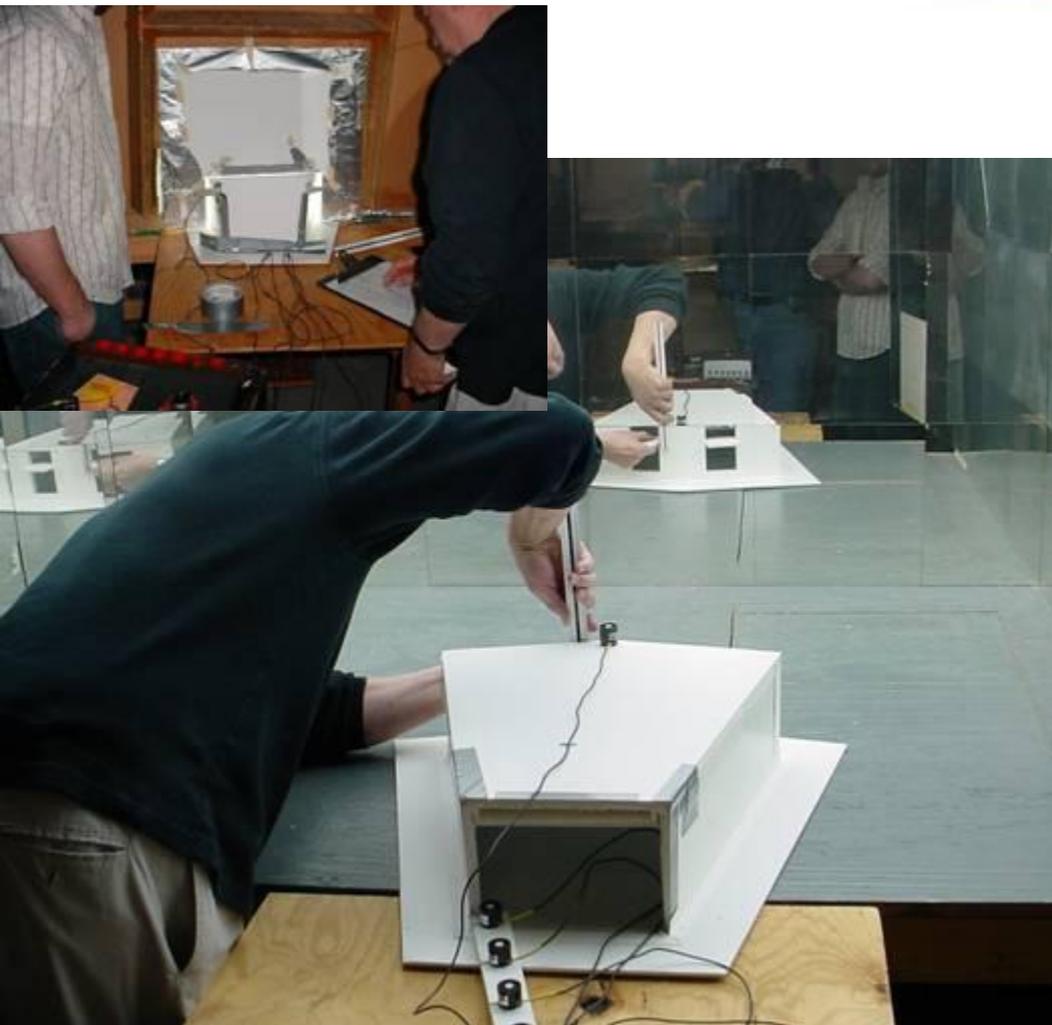
Modeling and Evaluation

- Ball State University, Muncie, Indiana
- Center for Energy Research Education and Service (CERES)
- Robert Koester, Director
- Robert A. Fisher, Resident Fellow, CERES
- Jeff Culp Operations Manager, CERES
- Zach Benedict, Architecture Student
- Tools:
 - Sensors: Li-Cor Model LI-210SB Photometric Sensor
 - Skybox: Mirror Box Artificial Sky





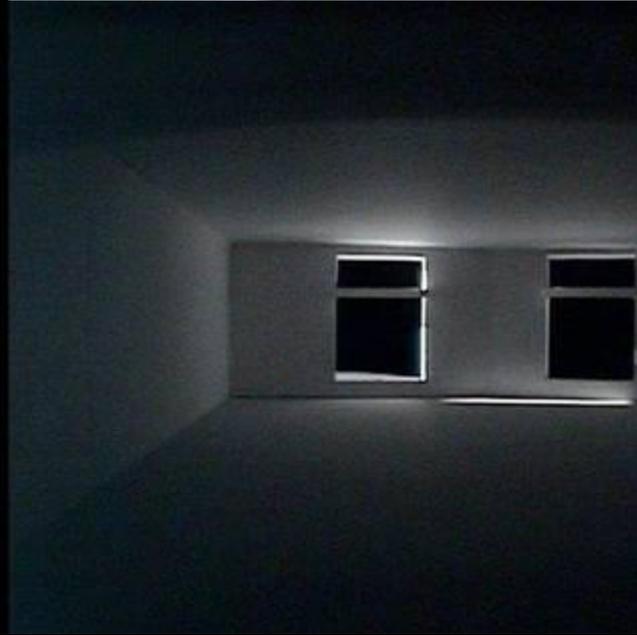


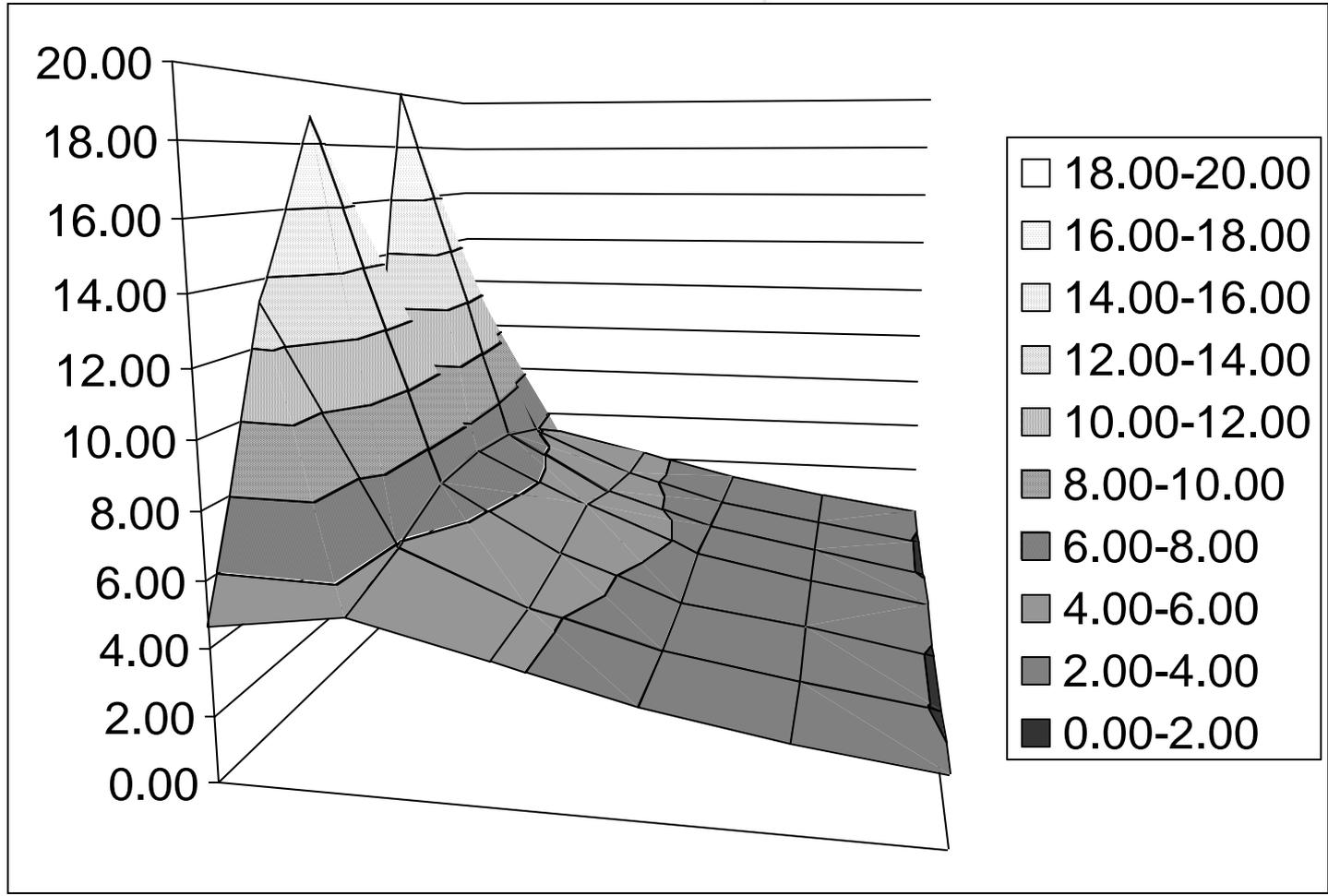


Modeling by Ball State University CERES research staff

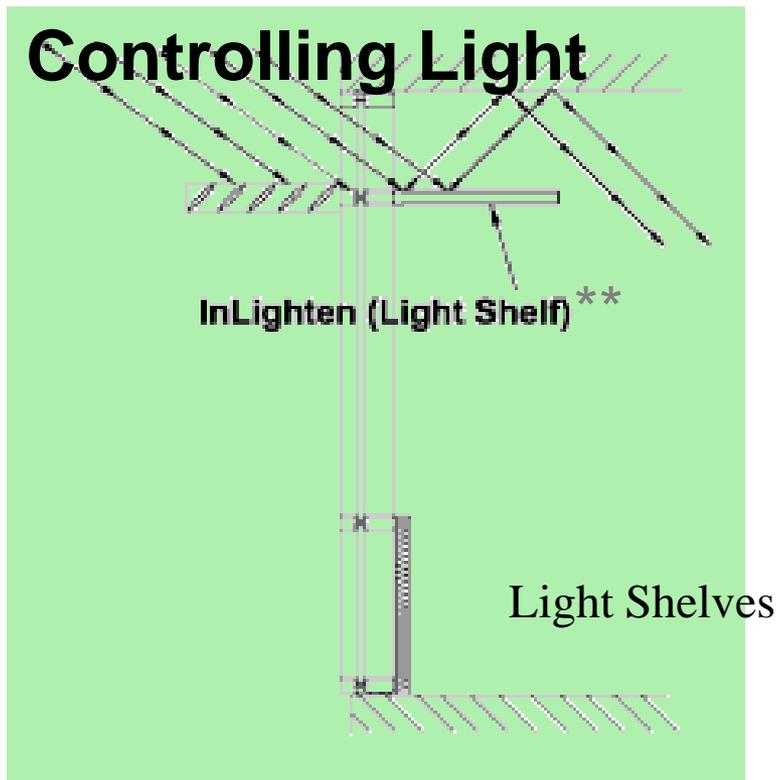
Creating Places
to Learn





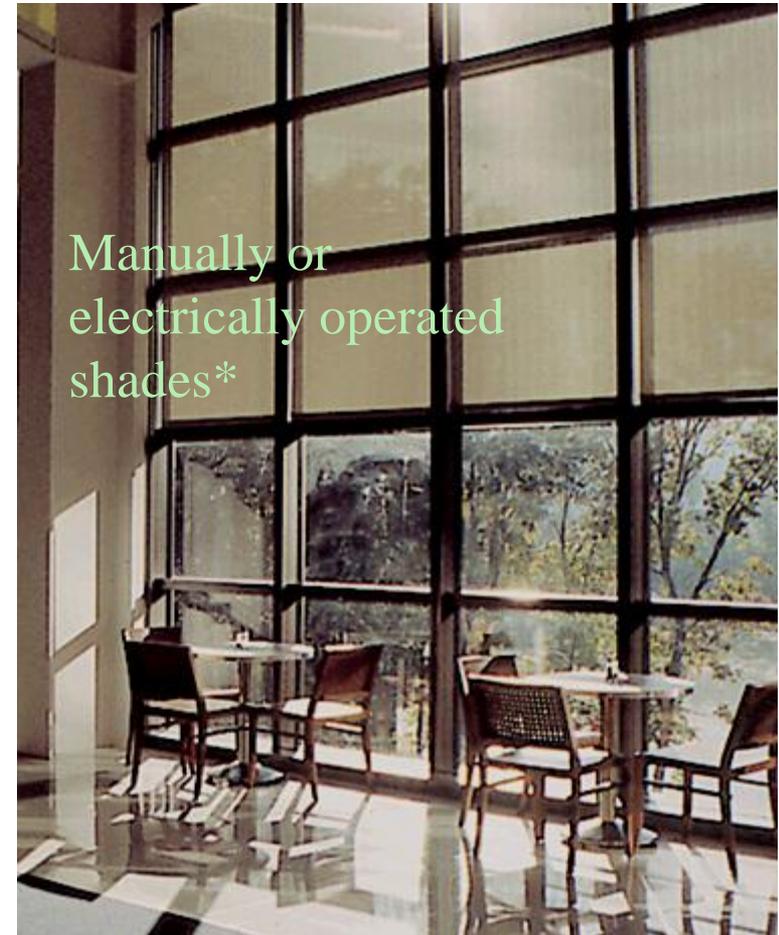


Controlling Light



•MechoShade

** Kawneer



Manually or
electrically operated
shades*



High Performance Features:

Overhead Daylighting:
Monitors

Skylights

Oversized Shaded Windows

Light Colored Roofs

Green Roofs

Grey Water Management

Indigenous/Low Maintenance Landscape

Exterior Massing Concept

■ "It is not our goal to be a green building. It is not our goal to be an energy-efficient building. **Our goal is to be an educational facility and be the best educational facility we can be.** Green buildings, energy-efficient buildings, are strategies to reach that goal."

(Ohrenshall, 1999, p.1)."

■ *These words, spoken by Bill Dierdorff of the North Clackamas School District in Oregon*



Q & A