Sustainability and Classroom Acoustics

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Classroom Acoustics
an Art or Science?

- An emerging Technology??
- An established Technology!!!
- Standards are not new to acoustics
  - ASTM (American Society of Testing & Materials)
  - ANSI (American National Standards Institute)
  - ISO (International Standards Organization)
  - ASHRAE (American Society for Heating, Refrigeration & Air Conditioning Engineers)
- Technical literature is full of support for good acoustics in classrooms to enhance learning
  - 1928 Knudsen UCLA article
Sustainability and Classroom Acoustics

- **Sustainability**
  - A new focus
  - Similar to the energy conservation focus of the mid ’70’s
  - A search for common ground and mutually agreeable criteria
  - Right now “everybody’s doing it”
Sustainability Concepts

- Cradle to Cradle
- Federal, State, local efforts
  - ANSI Classroom Acoustics (ADA)
  - CHPS (California High Performance Schools)
- Healthcare analogy
  - Finding a direct link between good design and better health (learning)
Sustainability
Acoustics - General

- Replenishable resources
  - Bamboo
- Reusable resources
  - Salvaged wood
- Managed resources
- Indigenous resources
  - Minimize grass re: mowing / noise
Professional responsibility
- Project must be successful
- Project and materials must meet criteria
- There should be no surprises
- Test data must be provided for evaluation
- Acoustics is a science – not an art!
Project Types

- **Education** (University, College, High School, Grade School)
- Performing Arts: Theaters, Auditoria, Entertainment
- Corporate: **Offices**, Boardrooms, Training rooms, Health and Recreation, Dining
- Healthcare: **Hospitals**, medical office buildings
- Sports and Recreation: Gymnasia, Arena, Stadia
- Hospitality: **Hotels**, Resorts, Conference Centers
- Public Assembly: Convention Center
Classroom Acoustics
Design Team

DESIGN
- Client/School District
- Architect
- Engineers (Mechanical, Electrical, Plumbing, Structural)
- Consultants (Acoustics, Audiovisual, Technology, Food, Signage)

CONSTRUCTION
- General Contractor
- Subcontractors (Mechanical, Electrical, Plumbing, etc.)
- Specialty Contractors (Audiovisual, Telecommunication, Security, Food)
Acoustical Consulting

- **Room Acoustics**
  (Size, Shape, Proportion, Finishes)
- **Sound Isolation**
  (Exterior-Environmental Noise Control; Interior-Occupied Adjacencies)
- **Noise and Vibration Control**
  (Building Systems – HVAC; Plumbing)
- **Audiovisual Systems**
  (Voice Amplification; Music; Playback, Video / Projection, etc.)
**Terminology**

**Concepts and Sustainability**

- **RT** (Reverberation Time)
  - Sound absorption … requires small particles with many voids to absorb sound energy

- **STC** (Sound Transmission Class)
  - Sound isolation… requires density, mass and impervious materials

- **NC / NCB / RC** (Noise Criteria)
  - HVAC background noise… requires control of excess noise and vibration
# Maximum Reverberation Times in the ANSI Standard

<table>
<thead>
<tr>
<th>Volume &amp; Type of Learning Spaces</th>
<th>Max (mid freq) Reverb Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core spaces (classrooms)</td>
<td>0.6 seconds</td>
</tr>
<tr>
<td>volume (10,000\text{ft}^3)</td>
<td></td>
</tr>
<tr>
<td>Includes the standard California classroom</td>
<td></td>
</tr>
<tr>
<td>Core spaces (classrooms)</td>
<td>0.7 seconds</td>
</tr>
<tr>
<td>Volume between 10,000\text{ft}^3</td>
<td></td>
</tr>
<tr>
<td>Oversized classrooms, art rooms and labs</td>
<td></td>
</tr>
<tr>
<td>Core spaces (classrooms)</td>
<td>Not specified-but limits are recommended &amp; very important</td>
</tr>
<tr>
<td>volume (&gt;20,000\text{ft}^3)</td>
<td></td>
</tr>
<tr>
<td>Lecture Halls and Auditoriums</td>
<td></td>
</tr>
<tr>
<td>All ancillary learning spaces</td>
<td></td>
</tr>
</tbody>
</table>
Sustainability Acoustics - Floor Plane

- Carpet
- Wood
  - Replenishable sources / managed forests
  - Salvaged / reusable
  - Indigenous sources
- Underlayment
  - For carpet
  - For hardwood and tile
  - For isolating mechanical equipment
  - For isolating impact and high sound levels

Underfloor air distribution...and its related affects on other building systems.
Sustainability Acoustics – Wall Plane

Sound absorbing wall treatments
- Natural / agricultural products

Gypsum board for sound isolation; and acoustical privacy
- Recycled gypsum board
- Increased airspace and resilient channels in lieu of additional layers of gypsum board
# Background Noise Levels for Learning Spaces in the ANSI Std

<table>
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<tr>
<th>Learning spaces: (unoccupied; furnished)</th>
<th>Max one-hour-avg A-weighted steady state noise levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core learning space: Volume&lt;10,000ft³</td>
<td>35 dBA</td>
</tr>
<tr>
<td>Core learning spaces: 10,000ft³&lt;vol&lt;20,000ft³</td>
<td>35 dBA</td>
</tr>
<tr>
<td>Core learning spaces: vol&gt;20,000ft³ &amp; all ancillary learning spaces</td>
<td>40 dBA</td>
</tr>
<tr>
<td>Corridor not used for formal learning</td>
<td>45dBA</td>
</tr>
<tr>
<td>Acoustical critical spaces (e.g. auditoria, lecture &amp; training rooms)</td>
<td>25-30dBA</td>
</tr>
</tbody>
</table>
HVAC Systems Noise & Vibration Control

- Setting the appropriate criteria
- Early planning can help avoid costly solutions/fixes
  - Location of noisy equipment
  - Duct distribution
  - Diffusers/air entrance conditions
- Careful coordination with the mechanical engineer, structural engineer and architect
- Review of final construction to review implementation
- Optional acoustical measurements (commissioning)
Sustainability
Acoustics – Building Systems

- Electrical
  - Energy efficient electronic ballasts
- HVAC
  - A challenge
  - Underfloor air distribution
  - Cogeneration
- Plumbing
  - Waterless urinal !.....no plumbing pipes
Exterior Noise

- Varies in time and frequency
  - Assessment difficulties
  - Description difficulties
  - Not the same as HVAC background noise
  - Sound transmission via exterior building envelope (windows)
Hourly Leq
August 8 - 11, 2003
Environmental Noise

Level Time History
August 8 - 11, 2003
Exterior Windows

- Open—they allow noise intrusion
- Closed—they typically represent the weakest component in the building envelope

  - Note: CHPS promotes window for natural ventilation, day lighting and better indoor environmental quality (IEQ)

- Glazing Configurations
  - Single glazed 1/4’ plate glass: STC 30
  - Common thermopane: STC 35
  - Acoustic Windows: STC 40-50+

- Special Windows are required for high noise level environments (i.e. near airports, highways, industrial areas)
  - Check with planning agencies
  - Acoustic Site assessment
  - Cost vs. criteria

- Other
  - The window frame
  - Laminated glass
Sustainability

Acoustics - Glazing

- Fenestration
  - Fresh air – exterior noise transmission
  - Use of laminated and double glazing
- Daylight
  - Natural light – glass; sound reflective
- Interior shading
  - Shades for sun/heat control; and acoustical absorption
- Minimize size; limit glazing
Special Cases

- High noise level environments (e.g. near airports, highways, etc.)
- Special educational programs (e.g. hearing impaired, blind, cultural diversity)
- Design and sustainability issues (e.g. glazing for daylight and natural ventilation)
Sustainability Concepts Apply to Acoustics

- Think full cycle
  - Where does it come from?
  - What is it made from?
  - How will it be used?
  - What will happen to it later?
  - How does it affect other aspects?
- Preserve resources
- Reuse materials
- Minimize material usage