Acoustics Beyond the Science: What Will That Really Sound Like?

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THE GREENBUSCH GROUP, INC.

“Sound is as much a part of man’s man-made environment as heat or light.”

Vern Knudsen

But…Acoustics is that invisible thing

- It doesn't affect:
  - Thermal comfort
  - Lighting levels
  - Structural Integrity
- Minimally affects:
  - Visual impact

Acoustics often goes unnoticed

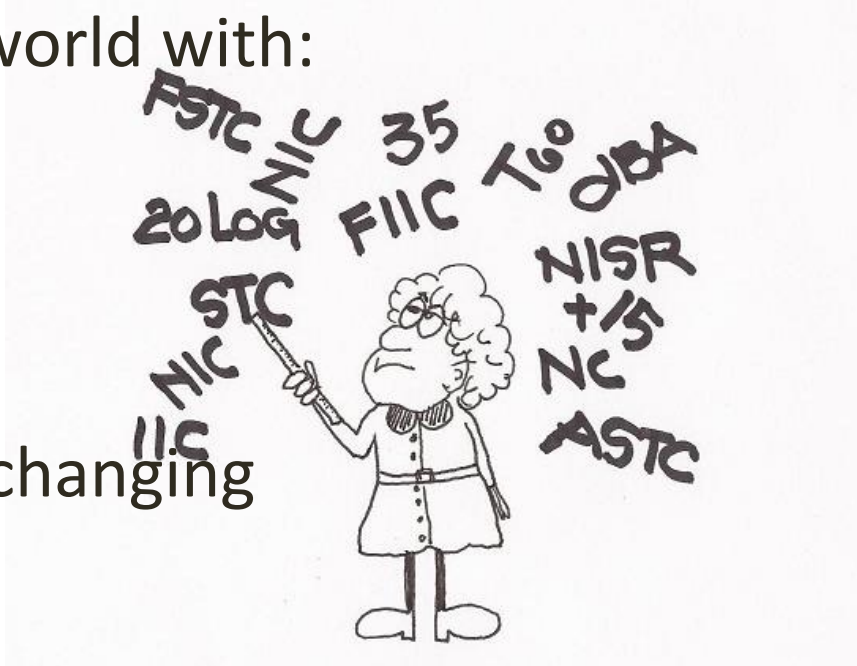
- But, the inconvenient truth is:
  - Poor Classroom acoustics result in:
    - Impacts to learning:
      - Tangible
      - Lifelong

Children in noisy classrooms

- Trouble with word discrimination
- Cognitive delays
- Developmental delays
- Loss of concentration
- Tend to give up faster when challenged

And so… the engineering world

- Does what we do best
- Bombards the design world with:
  - Numbers
  - Descriptors
  - Acronyms
    - Which we keep changing



It is not our intent

- To perpetuate the barrage of numbers

However, a few basic concepts

- Defined for full understanding
- Quickly
- As painlessly as possible

Ready?

Terminology

The human ear is a remarkable device

- range of 1 to 10,000,000,000,000
- bathroom scale with same sensitivity
  - human hair to 30 story building
- numbers proved unmanageable

More Terminology

- The solution was the Decibel, dB
- logarithm to the base 10
- log 1= 0
- log 10,000,000,000,000 = 13
- human ear 100 discrete steps
- multiplied log by 10 to account for this
- range extended 0 to 130

More Terminology

- Zero decibels
  - threshold of human hearing
- normal (young ears) hearing
  - 20 Hz to 20 kHz
- decibel scale is logarithmic
  - doubling of energy increases 3 dB.
  - human ear perceives 3 dB as barely audible
  - 10 dB (or 10 times the energy) perceived twice as loud

More Terminology

- dBA
  - human ear less sensitive outside the speech frequency range.
  - a “filter” approximate human perception
    - referred to as “A weighted” or “dBA.”
  - conversational speech 60 dBA at 3 feet.
  - good classroom 40 dBA
  - busy street 80 dBA

Hang in there…almost done

- **Impact Insulation Class, IIC**
  - insulation of a floor-ceiling from impacts
- **Noise Criteria, NC**
  - maximum permissible background noise
- **Reverberation Time, T60**
  - how rapidly sound decays in a room
- **Signal-to-Noise Ratio, S/N**
  - voice level of the instructor/background
- **Sound Transmission Class, STC**
  - overall Transmission Loss (TL) characteristics

OK..moving on to our topic

- Teaching and Learning
  - Rely on speaking and hearing

And in most classrooms listening are:

- Some students with hearing impairment
  - some undiagnosed
- Students with temporary hearing loss from ear infections
- non native English speakers
  - speech perception accuracy similar to children with hearing losses

- You can simulate this level of hearing loss by listening with your hands placed over your ears

Research has shown

- **1 out of every 6 words**:
  - not understood by 1st graders
  - in classrooms with poor acoustics

Canadian Language & Research Network Study (Bradley 2005)

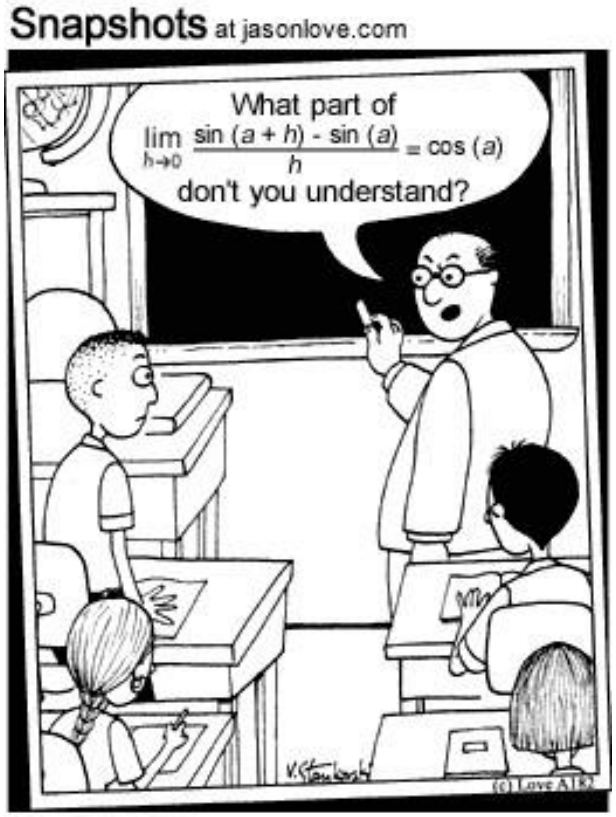
Research has also confirmed

- Students under age 13 are the most challenged

- The auditory physiology is immature until secondary school.
  - As late as high school for some students
  - Listening to Learn in a Sea of Noise: The Insidious Effects of Classroom Acoustics on Student Performance (Anderson 2007)

Adult Perception

- Teachers, administrators and parents are more skilled at listening in poor acoustical conditions



Young students also

- Lack the vocabulary needed to fill in the blanks when they don't hear accurately

"Class, I've got a lot of material to cover, so to save time I won't be using vowels today. Nw lts bgn, pls trn t pg 122."

So…What is classroom acoustics?

- More than just acoustical tile

- Quality of the sound in the room
- Isolating sounds from adjacent spaces
- Background sounds
- Vibration

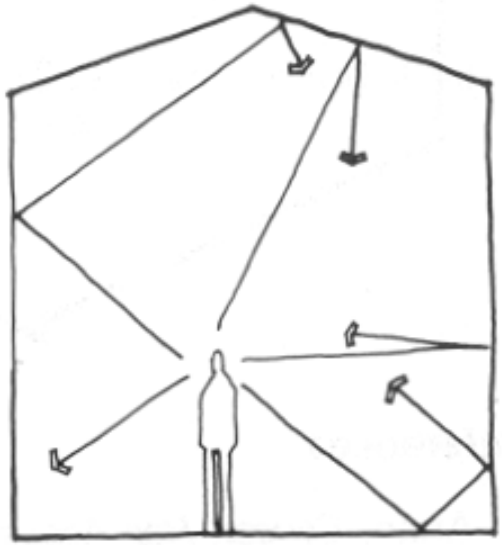
Standard Criteria

- ANSI S12.60 – 2010 Part 1 & 2
- LEED for schools 2009
- Most agree for optimal classrooms:
  - Reverberation 0.6 to 0.7 seconds
  - STC 50
  - Background noise
    - 35 dBA (ANSI)
    - 40-45 dBA (LEED)

Let's start with Quality of Sound

- Sets the baseline for the listening condition
- Affects speech intelligibility
  - ability to understand what is said
- Determined by:
  - reverberation
  - reflected sound
  - room finishes
  - room shape

Reverberation



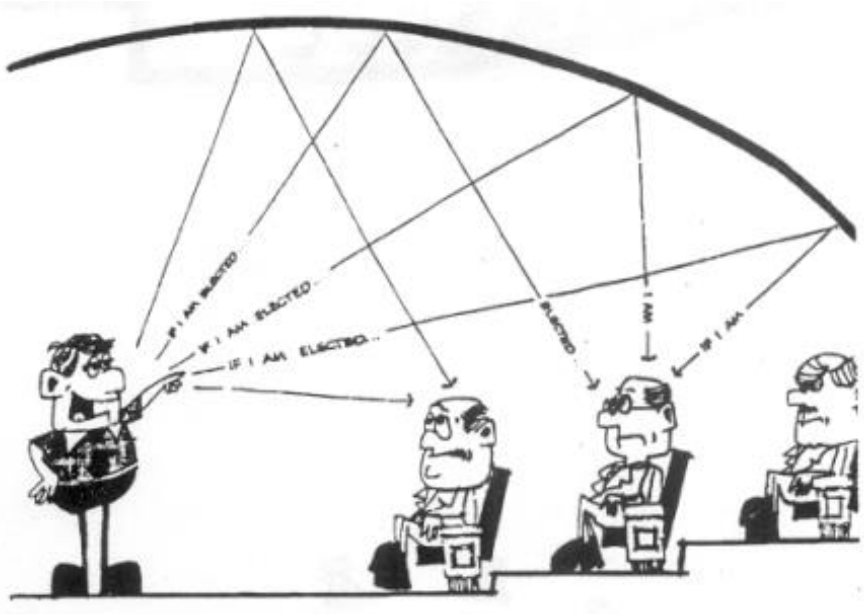
- Reverberation plays a critical role in the ability to understand speech.
- Highly reflective surfaces = more reverberation.
- Sound, in a highly reverberant room, increases in level creating a noisy environment.

What does that sound like?

- Audio demonstration

Reflected Sound

- sound strikes hard surfaces before hearer's ears.
- In a performance space
  - reflected sound is desirable.
- In classrooms
  - reflections annoying
  - increase overall noise level



What does that sound like?

- Audio demonstration

Moving on to Sound Isolation

- We often hear the term “soundproof”
- This is a misnomer - nothing is completely “soundproof” (or any other kind of “proof”)
- Another misconception is that insulation is key to reducing sound transmission.
  - Mass
  - Composite Elements
- operable partitions are especially challenging for amplified rooms

Sound Transmission Class, STC

- Guidelines cited above recommend STC 50 for demising walls for classrooms
- But, the Guidelines assume no amplification
  - Many classrooms now have enhanced audio

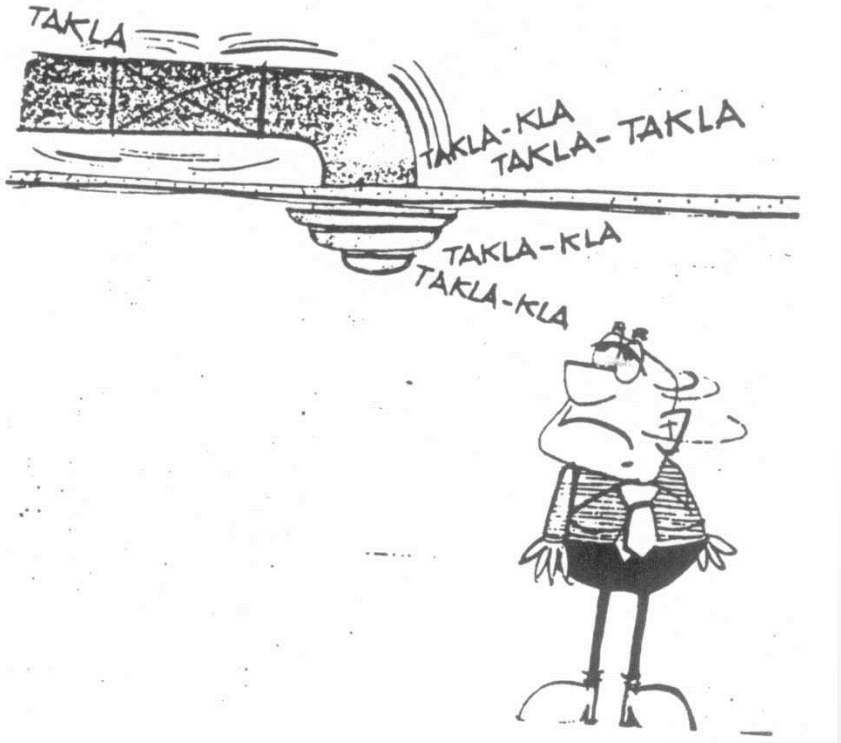
- Published STC goals will not be satisfactory for every condition.

What does that sound like?

- Audio demonstration

Background Noise

- Important?
  - Kids are noisy
- Mechanical systems dominant source of sound and vibration
- Or they used to be….



Background Noise

- LEED building often include passive systems for temperature control.
  - Lower background noise levels
    - Passive system may be 25-30 dBA.
    - Standards 35-45 dBA
  - Quiet is a good thing.
  - Too quiet is NOT.

- Sounds from adjacent spaces are now more apparent

Background Noise

- Environmental sources can also add to classroom noise

What does that sound like?

- Audio demonstration
- Spelling test

How does the teacher respond?

- loud will NOT overcome high noise
  - even students paying attention

- average teacher 2 sick days/year
  - vocal strain

So… now what do we do?

- The current trend
  - amplification in every classroom

Amplification everywhere?

- Well, maybe not…
- It may be appropriate, if:
  - Room is large (over 50 or so seats)
  - Room is noisy (full of computers)
  - hearing impaired, non native speaker, etc.
  - Not improve listening conditions in all classrooms

Its all about Signal to Noise

- **What noise?**
  - Mechanical and computer noise
  - Intruding noise from outside the classroom
  - Reverberation and echo
  - Student noise
- **Goal is 15+ dB signal to noise**
  - Make signal louder, or
  - Make noise quieter

"Use your *inside* voice, Tarzan."

A Quick Test

Visual Analogy Representing Speech Perception Challenges Due to Background Noise

I see some beautiful flowers.	+20
Big dogs can be dangerous.	+15
I like to go to school.	+10
It is lunch time soon.	+5
Walk to the library now.	0
Your brother is not here.	-5

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And… then there is Vibration

- Typically from mechanical systems
  - Distracting if tactile
  - Transfer through structure-then audible sound
  - Degrade image on projection screen
  - Worst case physiological reaction
  - No standard criteria
- Can also be human activity
  - IIC
- Adequately evaluate and isolate

What does that sound like?

- What does that look/feel like?

Poor Acoustics…

- Contribute to diminished understanding
- Lack of understanding can affect
  - speech perception
  - attention
  - behavior
  - overall performance

In summary

- For 28% of schools in USA
  - Noise is #1 problem
- It doesn’t have to be that way

Questions?

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