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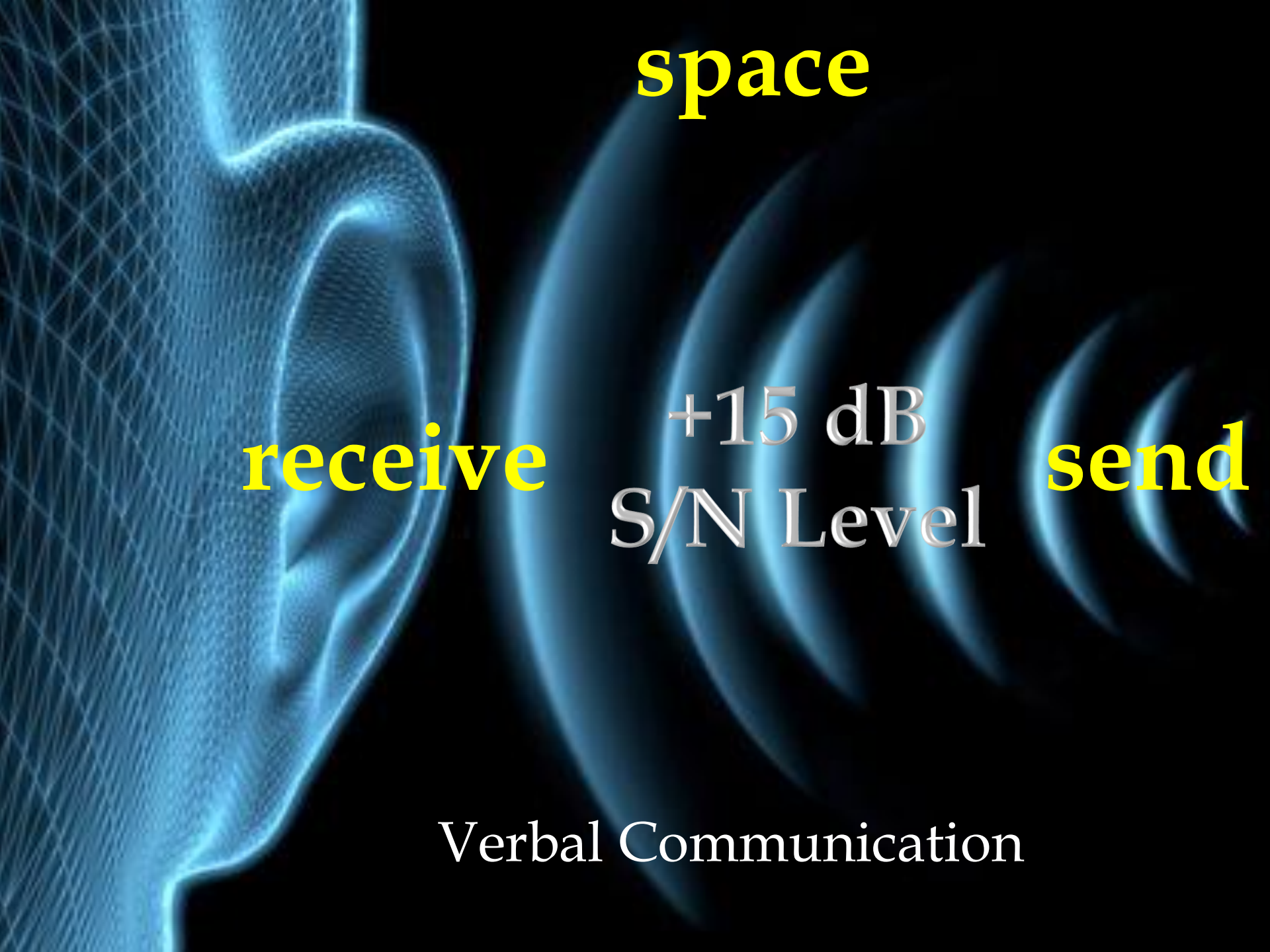
Noise research: Saving education, one classroom at a time

Thesis title: Noise level and Reverberation in Urban Singapore Preschool Classrooms



Verbal Communication

ANSI 2010 Guidelines for Classroom Acoustics

- Classroom of less than 10,000 ft^3
  - Maximum ambient sound level (unoccupied) of 35 dBA
  - Maximum reverberation times of 0.6 sec
  - Recommended minimum S/N level of +15 dB (normal hearing) & +20 dB (hearing impaired)

Many classrooms failed to meet the above criteria
(Crandell, 1991; Crandell & Smaldino, 1994; Knecht et al., 2002)

Profile of Preschool Learners (age 5 to 6)

- Poorer ability to fill in speech gaps than older kids
- Frequent hearing issues (e.g. ME infections, glued ears)
- More young kids diagnosed with special needs than before (e.g. hearing impairment)
- Loses attention easily
- Generates more noise than older kids
- Coincides with sensitive age period for SLA
- Requires strong foundation of literacy for P1 (bilingualism)

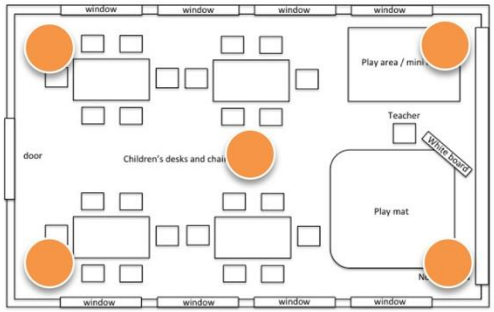
Key question:

Do our preschool classrooms meet established acoustic standards in facilitating verbal communication between teacher and students?

Study Hypotheses

- The mean reverberation time of Singapore's preschool classrooms is more than 0.6 s.
- The mean baseline ambient sound level of Singapore's preschool classrooms is more than 35 dBA.
- The mean signal to noise level of Singapore's preschool classrooms is poorer than +15 dB.
- The majority of measured preschool classrooms do not meet 2 out of 3 above acoustical parameters against ANSI (2010) recommendations on classroom acoustics.

A. Test-Retest Reliability



- 5 measurement locations per room
- 3 measurements taken at each location

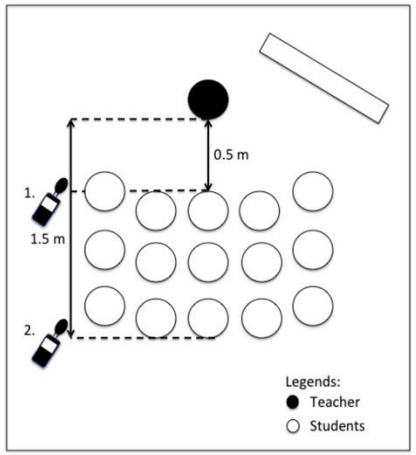
B. Ambient Sound Level

- Unoccupied + HVAC ON
- Unoccupied + HVAC OFF
- Occupied + HVAC ON
- Occupied + HVAC OFF
- Short-term measurement (LAeq60s)
- Averaged to find **"Ambient sound level"**

C. Classroom Reverberation

- For unoccupied room only
- Impulse test signal (balloon pop)
- Values recorded for 4 frequencies (500Hz, 1000Hz, 2000Hz, 4000Hz)
- Average to find **"RT60"**
- Compute with volume of classroom to find **"Critical Distance"**

D. Teacher's Speech Level



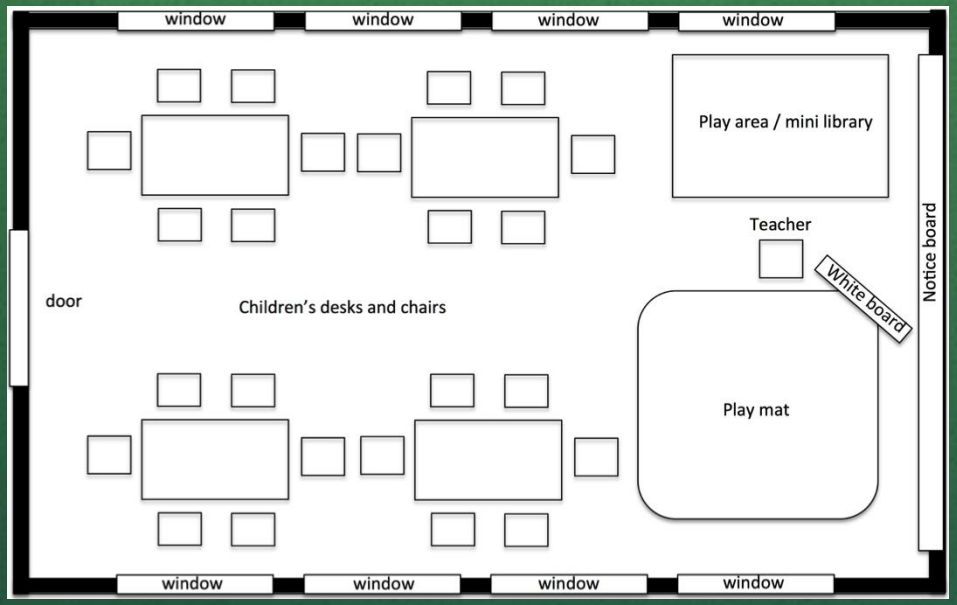
- Measured when teacher is addressing the class, and students are relatively quiet
- Three 10 sec timed samples

Adapted from ANSI Classroom Acoustical Survey Worksheet (J.J. Smaldino et al, 2005)

General information of participating Preschool Centers

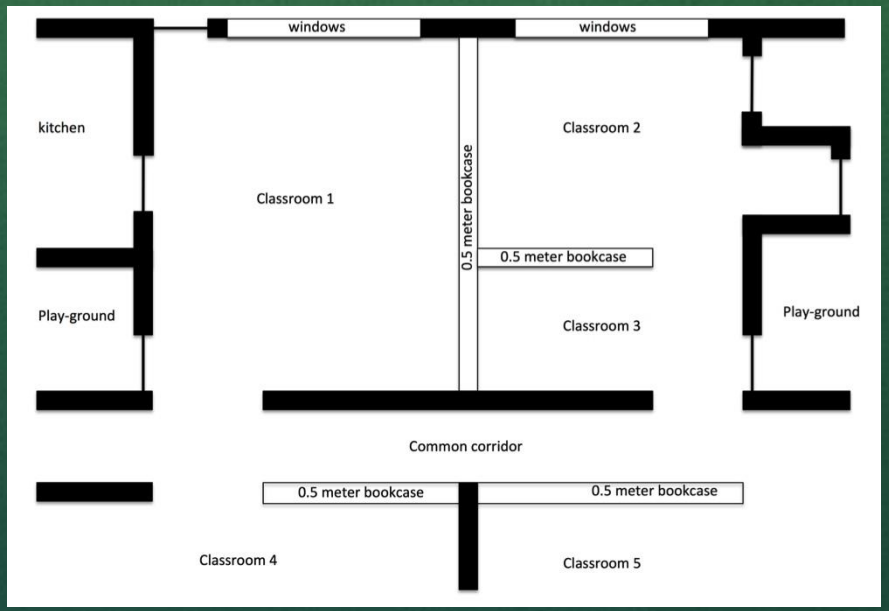
- 3 Preschool centers, built between 1989 to 2013
- 18 classrooms (12 open-plan, 6 enclosed)
- Mean height of classrooms: 2.7 m
- Mean volume of classrooms: 124 m^3 (4380 ft^3)
- Mean number of students per class: 13.8 students
- All classrooms fitted with ceiling fans, have playgrounds nearby, main roads within 10 m
- Location of centers varies: Two standalone buildings, One under HDB void deck
- Conducts formal lessons for pre-nurseries, K1 and K2

Floor plans of preschool classrooms



Enclosed Layout

Open-plan Layout



Descriptive Statistics

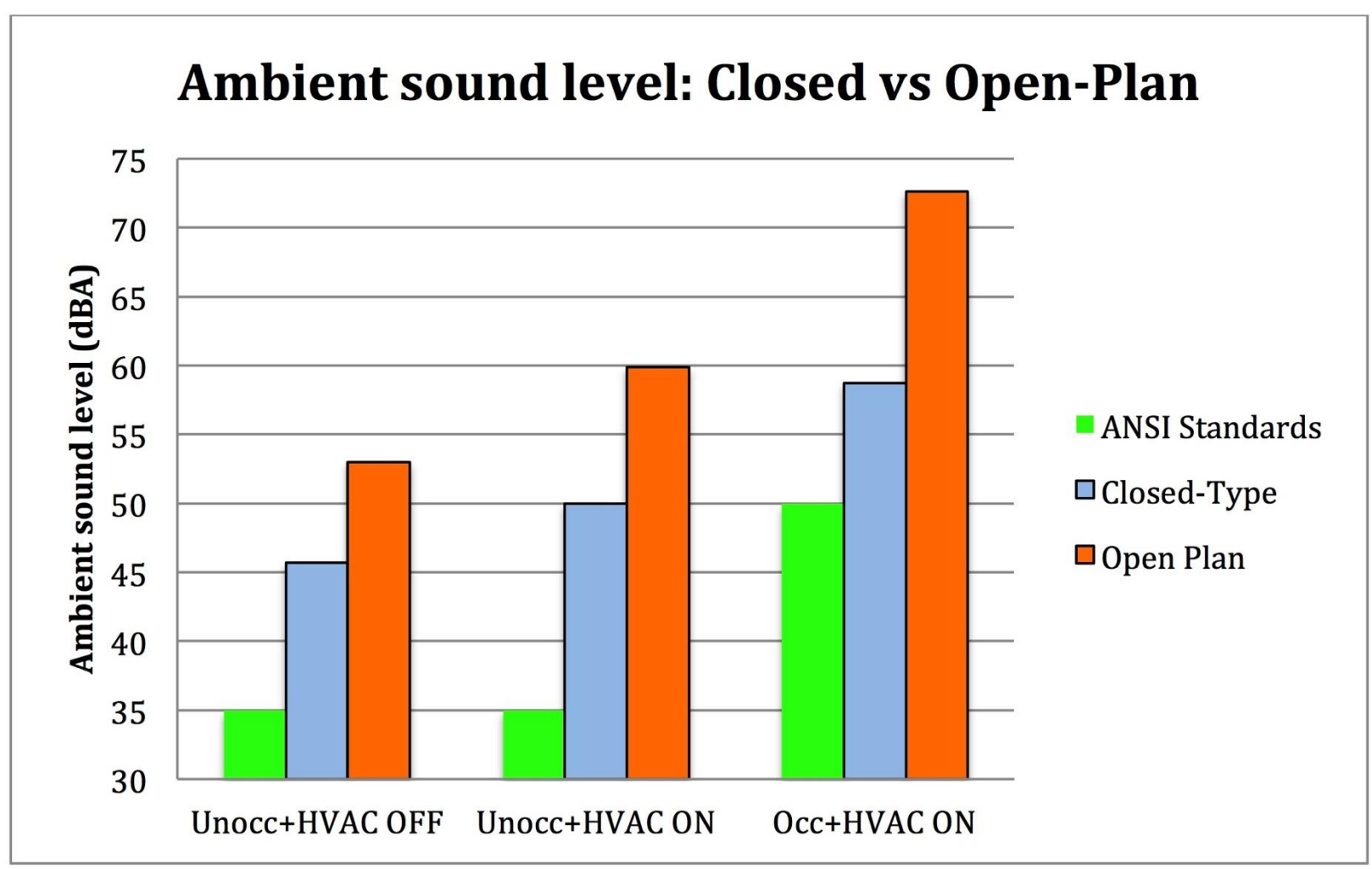
Parameters measured	Average (dBA)
Ambient sound level: Leq60s (Unoccupied + HVAC OFF)	
Mean	50.8
SD	6.2
Range	**41.7 - 64.5 dBA**
Ambient sound level: Leq60s (Unoccupied + HVAC ON)	
Mean	56.9
SD	5.8
Range	**44 - 66.9 dBA**
Ambient sound level: Leq60s (Occupied + HVAC ON)	
Mean	67.8
SD	7.8
Range	**55 - 79.5 dBA**
Speech levels: Leq10s	
Mean	71.3
SD	3.4
Range	**64.2 - 79.4 dBA**
Speech-to-noise level (S/N level)	
Mean	3.5
Range	**-4.5 to 15.6 dB**
Room reverberation (RT60), seconds	
Mean	**0.9**
SD	0.3
Range	**0.4 to 1.3 s**

*Note: SD = Standard deviation; HVAC = Heating, Ventilation or Air-Con systems

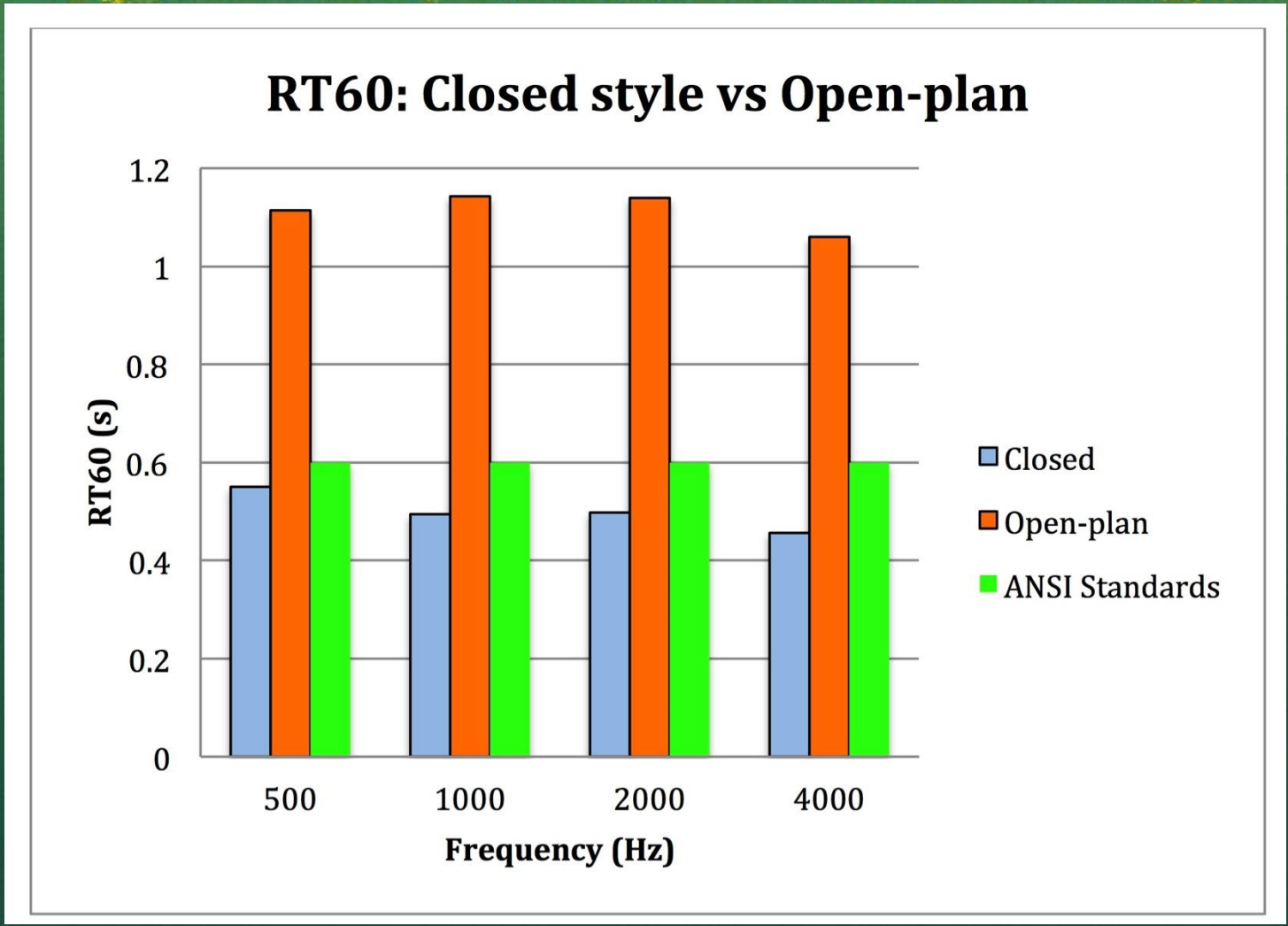
Comparison by countries

Countries	Ambient Noise	RT60	S/N level
Singapore	53 dBA (open-plan) 46 dBA (enclosed)	1.1 s (open-plan) 0.5 s (enclosed)	+0.2 dB (open-plan) +10.2 dB (enclosed)
Canada	59 dBA (enclosed)	0.35 s (enclosed)	+13 dB (enclosed)
UK	53 dBA (open-plan)	0.64 s (open-plan)	-
N. America	72 dBA	0.4 to 1.25 s	-7 to +5 dB
Hong Kong	68 dBA	-	+8.4 dB
New Zealand	77 dBA	0.57 s	+10 dB
Australia	42 dBA (open-plan) 35 dBA (enclosed)	0.7 s (open-plan) 0.5 s (enclosed)	+0.8 dB (open-plan) +15 dB (enclosed)
ANSI's standards: 35 dBA		0.6 s	+15 dB (normal hearing) +20 dB (hearing impaired)

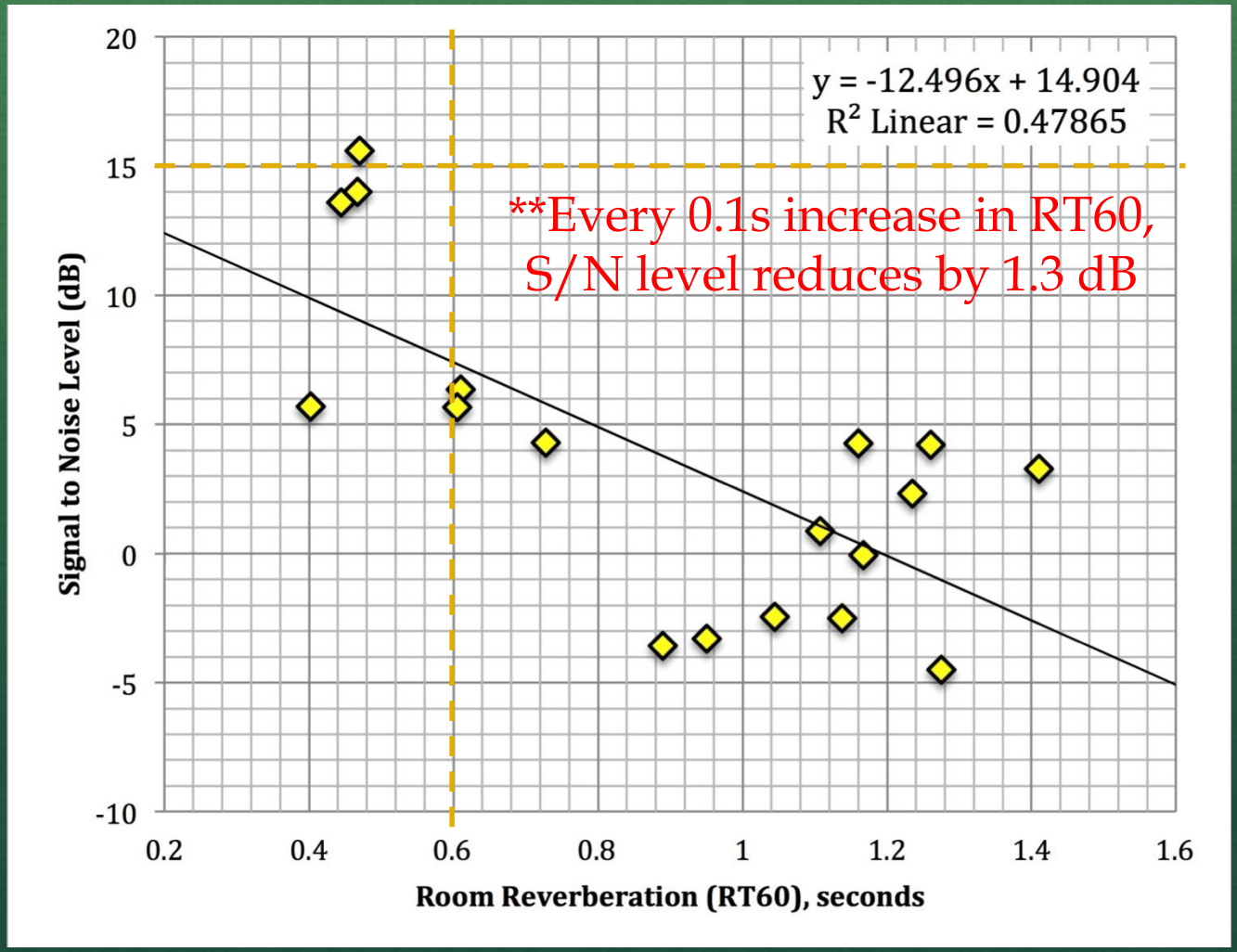
Ambient sound level: Comparison to ANSI's standards between open-plan and enclosed classroom configurations



Reverberation: Comparison to ANSI's standards between open-plan and enclosed classroom configurations



Signal to Noise level vs Reverberation



Study Hypotheses (Re-cap)

- 14 out of 18 (77.8%) classrooms had their reverberation time above 0.6 s.
- All classrooms (100%) had their baseline ambient sound level above 35 dBA
- 17 out of 18 (94.4%) classrooms had their signal to noise (S/N) level poorer than +15 dB.
- 1 classroom (5.6%) was able to meet 2 out of 3 above acoustical parameters against ANSI's 2010 recommendations on classroom acoustics.

Open-plan classroom, w/o acoustic treatment

- Higher ambient sound level
- More reverberant
- Poorer S/N level
- Unable to meet acoustic standards

Poorer Teaching & Learning Outcome

Enclosed classroom, with acoustic treatment

- Lower ambient sound level
- Less reverberant
- Better S/N level
- Meets most acoustic standards

Better Teaching & Learning Outcome

Preschool Learners

Acknowledgements

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