Perception-based acoustic design of school environments

current research on the impact of sound on students' comfort and cognition from a soundscape perspective

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Sound as stressor in the school environment

“reduced perception of having fun and being happy with themselves”

Astolfi, Arianna, et al. "Influence of classroom acoustics on noise disturbance and well-being for first graders." *Frontiers in Psychology* 10 (2019): 2736.

“annoyance and distraction”

Massonnie, Jessica, et al. "Learning in noisy classrooms: children’s reports of annoyance and distraction from noise are associated with individual differences in mind-wandering and switching skills." Environment and Behavior 54.1 (2022): 58-88.

“linguistic and sociolinguistic patterns”

McKellin, William H., et al. "Noisy zones of proximal development: Conversation in noisy classrooms." Journal of Sociolinguistics 15.1 (2011): 65-93.

“children’s cognitive development and learning”

Klatte, Maria, Kirstin Bergström, and Thomas Lachmann. "Does noise affect learning? A short review on noise effects on cognitive performance in children." Frontiers in psychology (2013): 578.

“increased listening effort”

Prodi, Nicola, and Chiara Visentin. "A slight increase in reverberation time in the classroom affects performance and behavioral listening effort." Ear and Hearing 43.2 (2022): 460-476.

“reading and language abilities”

Thompson, Rhiannon, et al. "Noise pollution and human cognition: An updated systematic review and meta-analysis of recent evidence." Environment international 158 (2022): 106905.

“task performance”

Dockrell, Julie E., and Bridget M. Shield. "Acoustical barriers in classrooms: The impact of noise on performance in the classroom." British Educational Research Journal 32.3 (2006): 509-525.

Sound as a resource for the school environment?

Soundscape: *"Acoustic environment as perceived or experienced and/or understood by a person or people, in* ***context****." ISO 12913-1*

Environmental noise management of the acoustic environment	Soundscape management of the acoustic environment
Sound managed as a waste	Sound perceived as a resource
Focus on sounds of discomfort	Focus on sounds of preference
Measures by integration across all sound sources	Requires differentiation between sound sources
Manages by reducing sound levels	Manages masking unwanted with wanted sounds as well as reducing unwanted sounds

Indoor soundscape investigation in primary school classrooms

- 10 classrooms in 3 primary schools in Ferrara (Italy)
- Indoor soundscape assessment by primary school children (n = 130; 8-10 years old)

- Acoustic parameters measured in the ten classrooms in unoccupied conditions: background noise with windows closed ($L_{A,eq,\ 2\text{-}min}$), reverberation time T30

- **A:** historic centre (reduced vehicular traffic, anthropic sounds)
- **B:** early suburbs (quiet urban context)
- **C:** periphery (schoolyard/green area)

School	Classroom	T30 [s]	$L_{A,eq}$ (dB)
A	A1	1.18	44.8
	A2	1.58	47.9
	A3	1.14	37.6
	A4	1.18	44.6
B	B1	1.57	29.4
	B2	1.61	29.9
	B3	1.50	33.7
	B4	1.82	33.2
C	C1	1.03	30.8
	C2	1.04	30.6

Visentin, Chiara, et al. "Indoor soundscape in primary school classrooms" under publication

How can the quality of the external soundscape be assessed at the design stage to verify whether a positive internal soundscape can be provided through natural ventilation?

Should active noise systems be considered to provide masking sound stimuli or to create positive soundscapes (e.g., during workshop activities, or in school environments other than classrooms)?

Thank you for your attention

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Acoustic Design and Testing of Schools

Internal Sound Insulation

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Internal Sound Insulation – the issues

- Criteria – are they still valid after 20 years ?
- Compliance – How should it be assessed ?
- Layouts – is it realistic to expect to influence room layouts to improve sound insulation?
- Commonly arising issues
- Alternative Performance Standards – use and misuse
- Commissioning measurements – issues

None of the issues discussed here are new

Examples from the AJA website:

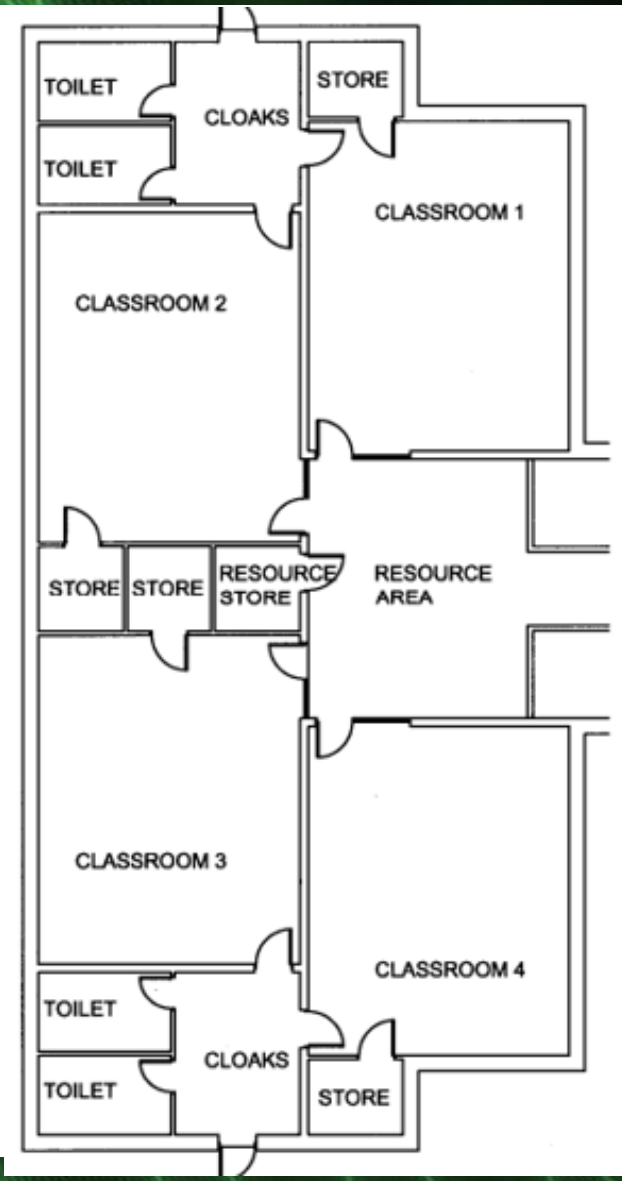
- School Acoustics after BB93 – Practical Problems and Solutions (2003)
- School Music Rooms – Designing Beyond BB93 (2005)
- When BB93 just isn't good enough – School acoustics design for excellence (2010)
- Acoustic requirements for special schools (2010)
- The Essex Study – Optimised classroom acoustics for all (2012)
- Practical acoustic requirements for teaching children with Cochlear Implants (2014)

Have we made progress ? Issues from 2003 roadshow

- Walls and floors between teaching areas are acoustically helpful
- Circulation spaces are for circulation, not teaching
- Doors between classrooms also let noise through
- So do holes and gaps in walls
- “Acoustic” folding partitions are expensive, heavy and rarely used.
- Internal glazing is nice but expensive
- We are designing for the future – not for a particular head teacher

“Common problems with sound insulation” - 2013 presentation

- Partitions do not extend up to ceiling
- Poor workmanship e.g. damaged plasterboard, screwing through resilient bars
- Impact sound not considered
- Folding partitions
- Layouts which are intrinsically incapable of providing the acoustic performance, e.g. doors linking classrooms



"When not to use BB93" - 2013 presentation

- BB93 sets minimum legal standards.
- These are not standards for excellence or even necessarily "good" standards.
- Mindless reliance on BB93 as the ONLY "Acoustic standard for schools" reduces design and ambition, and certainly widens the gap between State and Independent Sectors. (BATNEEC vs CATNIP)
- And it only applies to schools – not universities or colleges of further education.

Airborne criteria for walls and floors between rooms

Table 3a: new build performance standards for airborne sound insulation between spaces

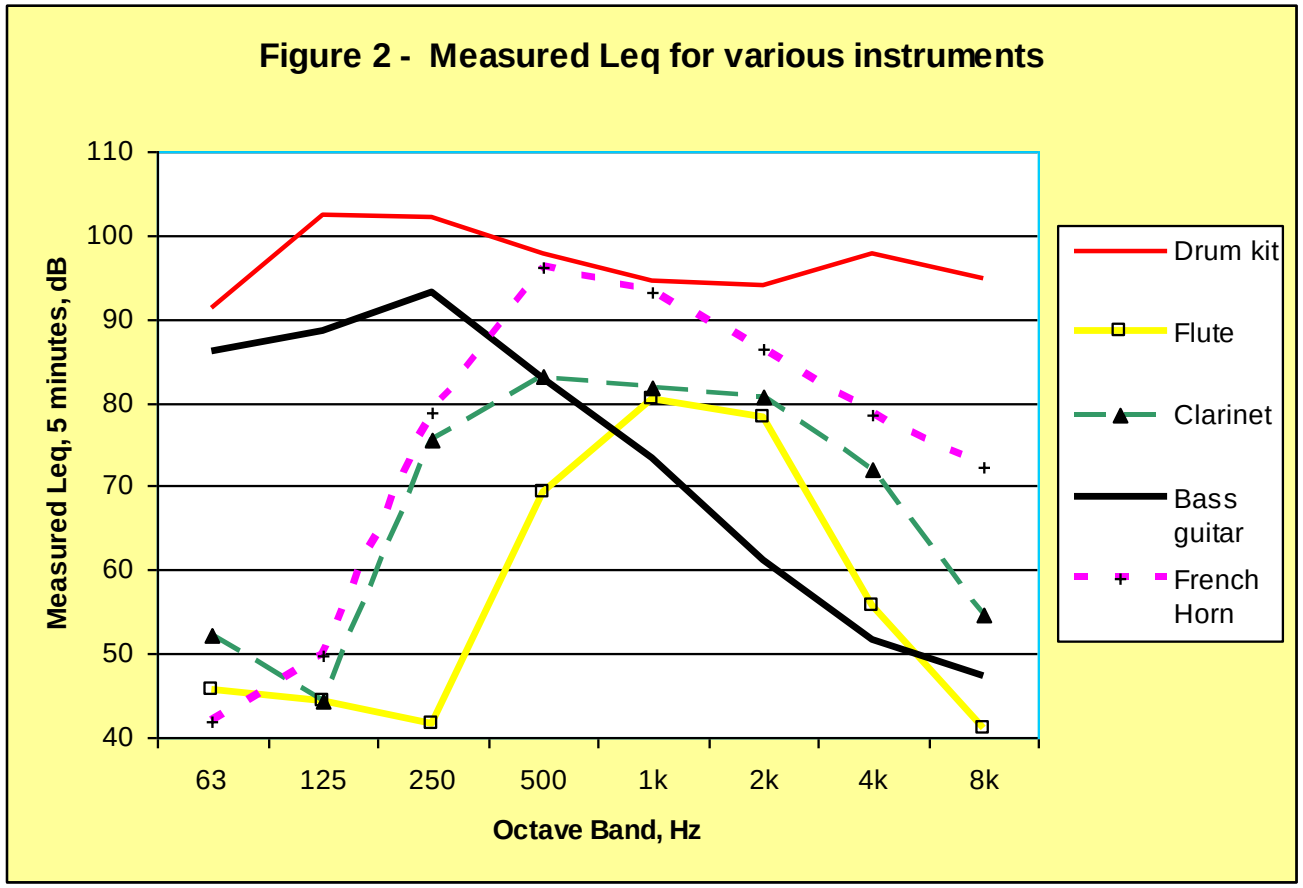
Minimum $D_{nT,w}$ (dB)		Activity noise in source room (see Table 1)			
		Low	Average	High	Very high
Noise tolerance in receiving room (see Table 1)	High	Not applicable	35	45	50
	Medium	40	45	50	55
	Low	45	50	55	55

- Is this methodology still applicable ?
- Are the numbers necessary and sufficient ?

My thoughts on this :

- The “Matrix” methodology remains logical and still works
- Most of the numbers are still OK
- 45 dB DnT,w between classrooms is sufficient and necessary
- Higher values between teaching areas and offices are sometimes needed
- Standards for non-teaching areas should be requirements, not just recommendations
- The same standards should apply to refurbishments as to new buildings
- These are minimum standards, especially for music and drama accommodation. Higher standards are and should be specified by the acoustics consultant using knowledge of the noise levels, rather than relying on BB93.

Higher standards for different types of music room



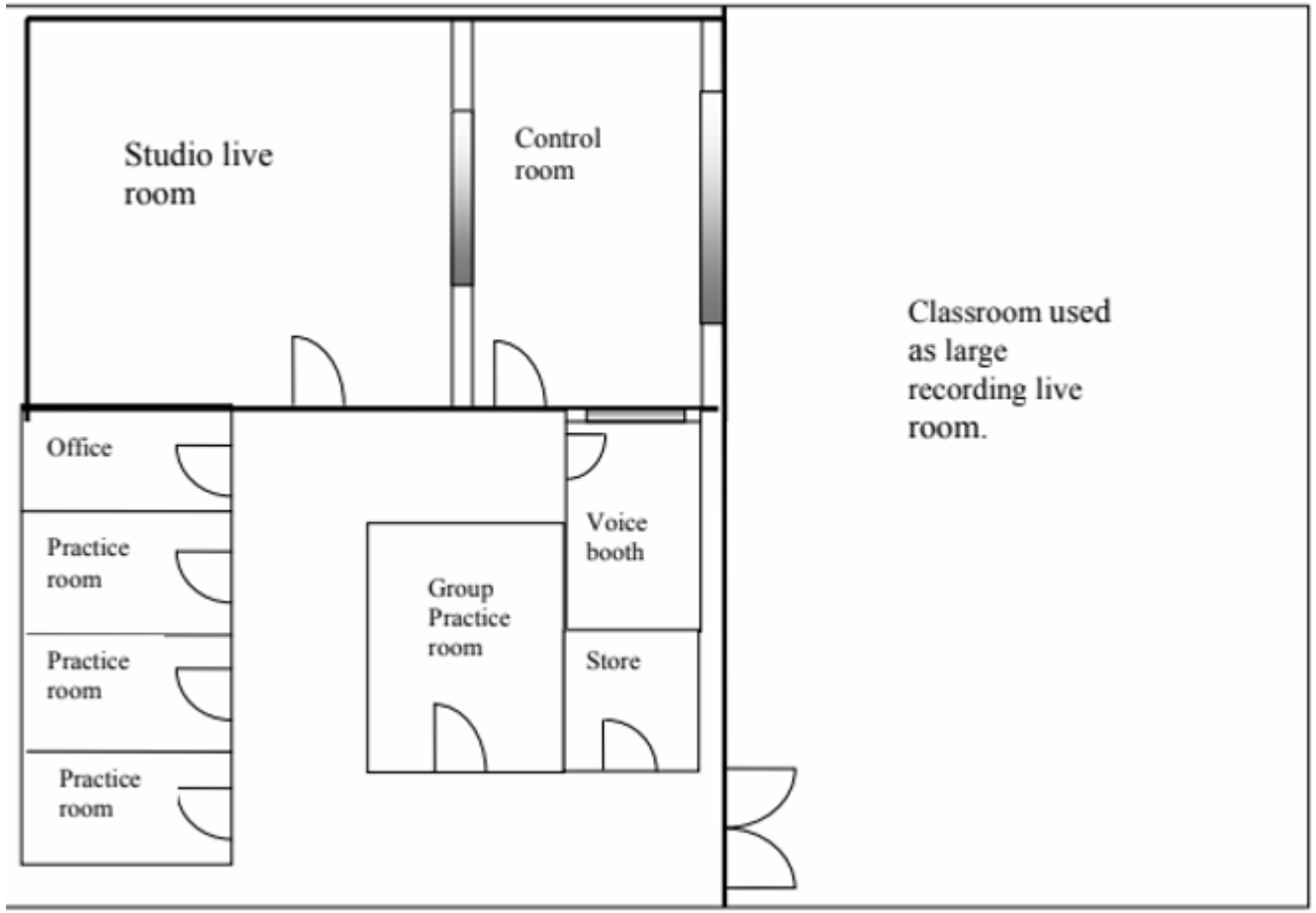
We should not be surprised that practice rooms for brass and drums require higher sound insulation than those for woodwind and strings.

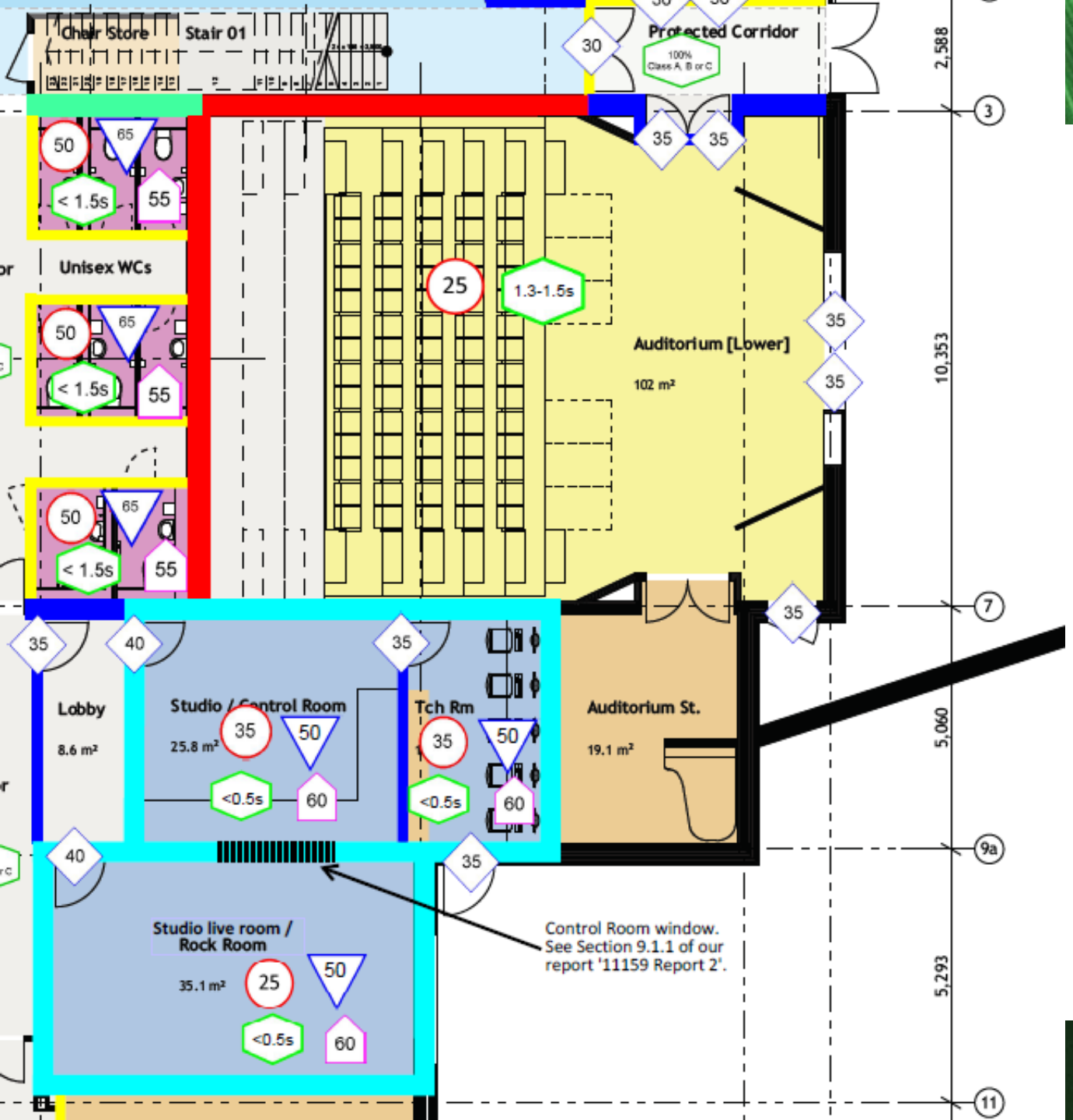
Section 1.1.2 of BB93 states :

"Music rooms – the levels of sound insulation between some music rooms may not be sufficient for particularly noisy activities and timetabling/management will need to be considered. Wherever possible music accommodation should make use of buffer spaces such as stores to increase the levels of sound insulation between rooms and to isolate rooms where very noisy activities such as drum practice will take place. If timetabling/management or isolation is not possible the levels of sound insulation should be increased".

Keep reading the documents !

A school music studio layout that works





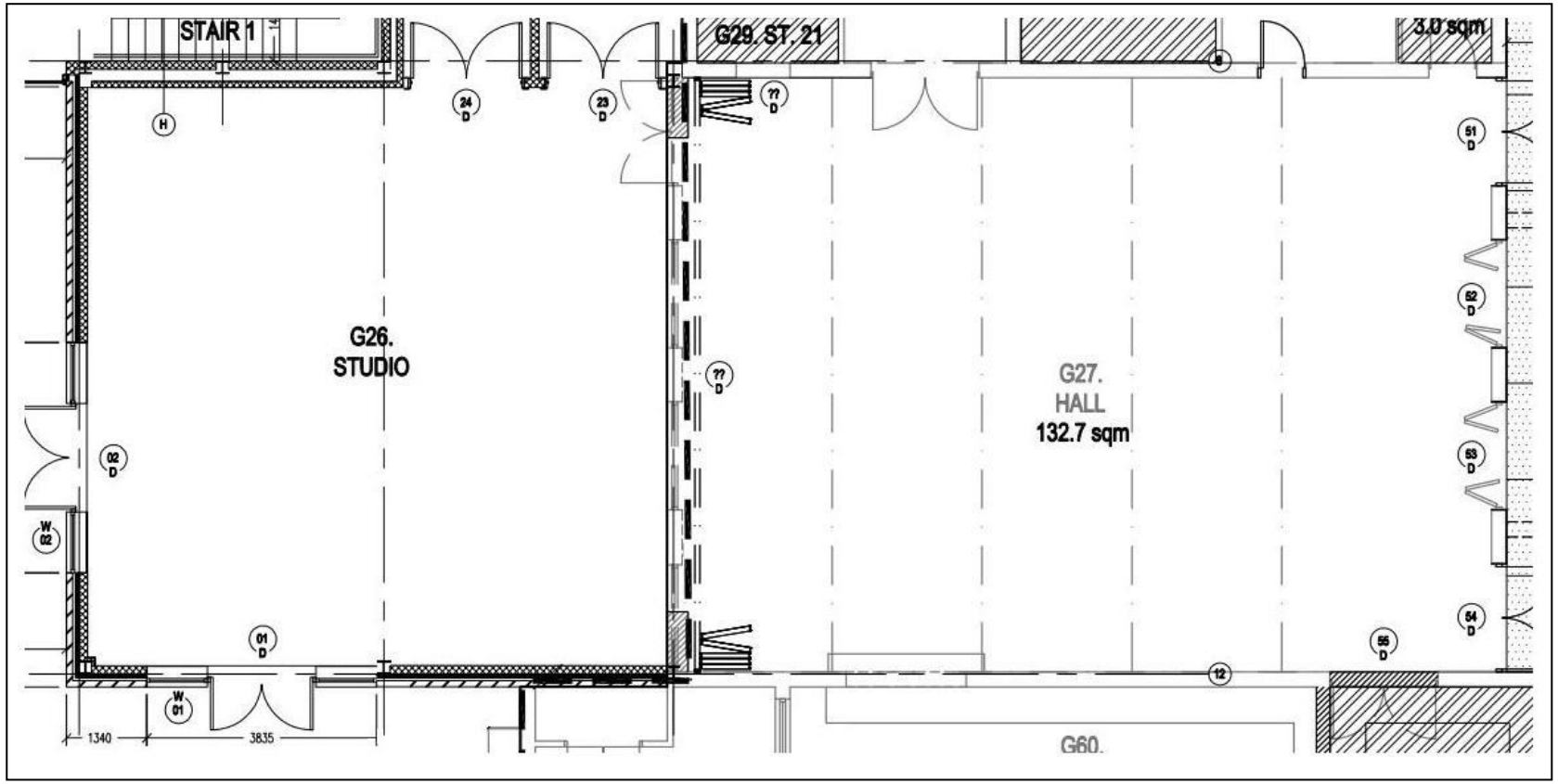
Q - Can we mandate room layouts ?

A – only if on the design team at an early stage

Internal Sound insulation : Common exceptions

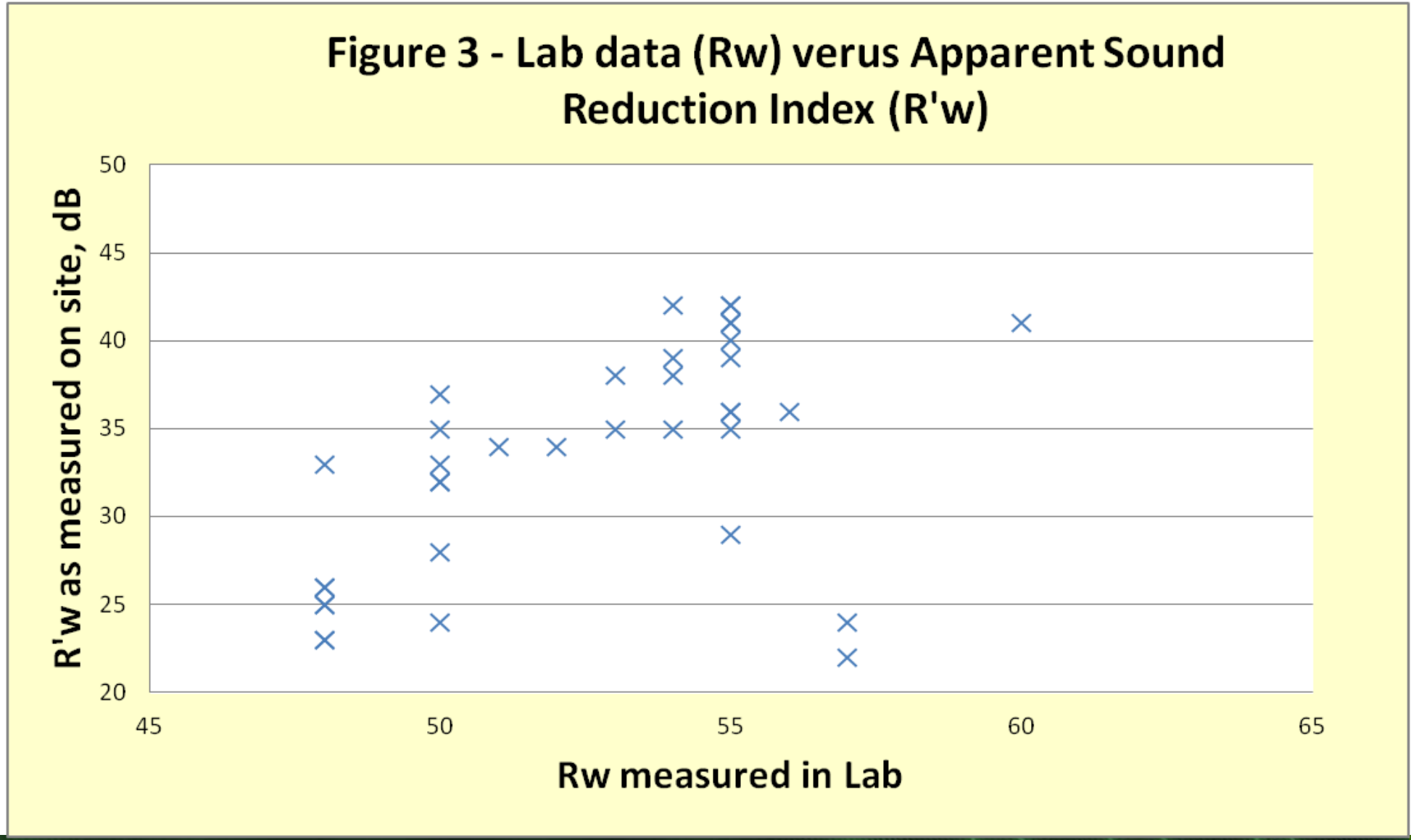
- Serving hatches between kitchens and halls where inevitable – at least 18 dB Rw serving hatches
- Interconnecting doors between classrooms where essential for operational or safety purposes – at least 35 dB Rw doors
- Realistic standards for control room windows in auditoria and recording studios (BB93 requires 45 dB Rw, in fact 50 or even 55 is achievable)
- Folding partition between teaching areas and halls must achieve 40 dB DnT,w and users must be warned that it “may not facilitate simultaneous independent use of the spaces on either side” ***
- *** assuming that you have access to the end user……

Folding partitions – will 40 dB DnT,w be enough here?



Folding partitions

Practical v theoretical performance



Airborne criteria for walls between rooms and corridors

Type of space used by students	Minimum R_w dB		
	Composite R_w of wall and glazing with no ventilator		Doorset
	New build	Refurbishment	
Secondary school music room Control room – for recording Drama room Multi-purpose hall Teaching space intended specifically for use by students with special hearing or communication needs	45	40	35
Primary music classroom All other rooms used for teaching or learning	40	35	30

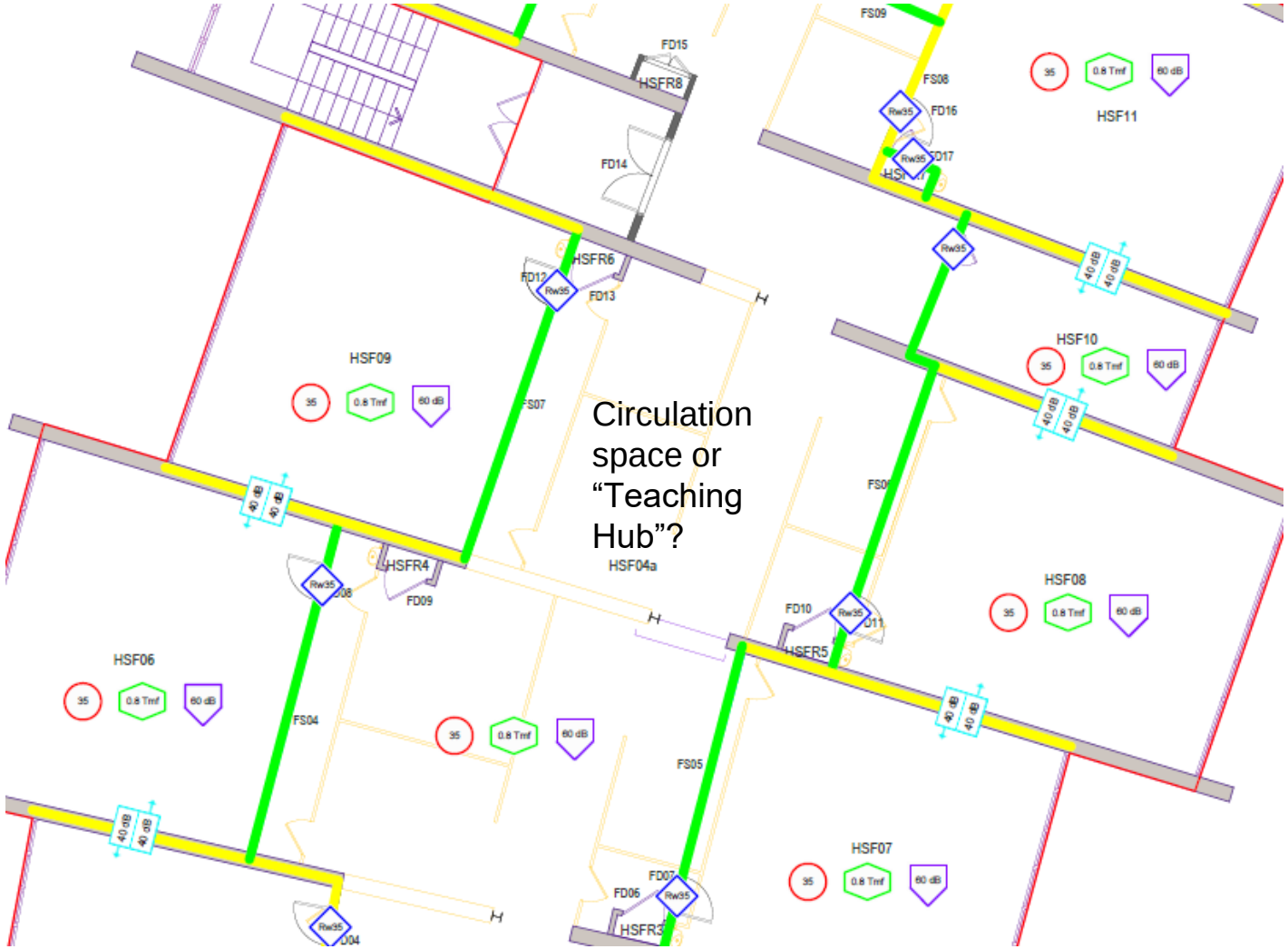
- Is this methodology still applicable ?
- Are the numbers necessary and sufficient ? (Provided corridor is not used as a teaching space or “hub”)

Glazed partitions in schools

- Relocatable office partitions don't normally work around classrooms
- They are also really expensive
- Guess who has to tell the architect ?

…But this arrangement seems to work if properly detailed.

Is natural light more important than sound insulation ?



Should we upset our clients by questioning this kind of arrangement ?

"We are not the acoustics police" (EC)

But whose job is it to ensure that schools comply with the School premises Regulations ?

Type of space used by students	Minimum R_w dB			Alternative to composite R_w of wall, glazing and ventilators dB, provided values in Table 4a are provided by wall, glazing and doors
	Composite R_w of wall, glazing and ventilators dB		Doorset	Minimum $D_{n,e,w}$ – 10 lg N dB for ventilators
	New build	Refurbish-ment		
Secondary school music room Control room – for recording Drama room Multi-purpose hall Teaching spaces intended specifically for use by students with special hearing or communication needs	38	35	35	37
Primary music classroom All other rooms used for teaching or learning	33	30	30	32

Impact sound criteria

Table 5: performance standards for impact sound insulation of floors

Type of room (receiving room)	Maximum impact sound pressure level $L'_{nT,w}$ dB	
	New build	Refurbishment
Teaching space intended specifically for students with special hearing or communication needs (See Section 0.4)	55	60
Primary school: classroom, music classroom, class base, general teaching area, small group room *Secondary school:* classroom, general teaching area, seminar room, tutorial room, language laboratory Open plan teaching and resource area Library Lecture room Science laboratory Drama studio Design and technology - resistant materials, CadCam area, electronics/control, textiles, food, graphics, design/resource area, ICT room, art room,	60	65

Probably sufficient, could it be relaxed ?