An investigation into the acoustic variation between seat locations tested in classrooms of higher education sites

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Abstract:

This project investigated the acoustic variation between 70 seat locations tested in four classrooms in two higher education sites. The project aimed to identify seat locations with potential acoustic weaknesses using standards UK BB93, US ANSI S12.60-2002 and NZ Classroom Acoustics.

A pilot study was conducted measuring the difference in speech intelligibility between classroom seat locations and a TalkBox emitting a STIPA tone was used to imitate a teacher's voice. The intelligibility of the STIPA signal was measured using a head and torso simulator. A loudspeaker was used to emit distracting background noise to reduce STIPA intelligibility.

Testing showed STI varied between individual seats. This variance changed according to classroom. Some classrooms showed a variance between left and right ear STI data; however each classroom had an average STI rating above the BB93 standard. Testing proved noise distraction negatively impacted the STI rating.

Introduction:

Primary and secondary schools in the United Kingdom are built to standards specified in *Building Bulletin 93* (BB93). BB93 contains performance standards for the key factors that affect room acoustics, such as:

- Room and floor/ceiling insulation
- Background noise
- Reverberation time
- Speech intelligibility

Lacklustre room acoustics adversely affect the academic work of students and the vocal fatigue of teachers [BB93. 2015]. Poor or unnatural sounding rooms may affect speech intelligibility which will in turn impact ability and desire to effectively communicate [NTi Audio. n.d].

Schools and colleges in higher and further education and universities are advised to conform to the acoustic standards laid out in BB93, but this is not a requirement.

Aims and Objectives:

The aims and objectives of the pilot study were to test:

- Variance in STI value between individual seat locations in a classroom.
- Variance in STI value between left and right ear in individual seat locations.
- Whether the presence of a distracting noise source would hinder STI performance.
- If higher education sites featured poor acoustics as a result of the lack of requirement to follow the BB93 standard.

A method of further testing was created using data collected from the pilot study. The aims and objectives for further testing were to:

- Collect data from a wider range of classrooms and higher education sites.
- Create a more comprehensive classroom STI testing method.
- Improve the method for testing the effect that distracting noise has on STI.

References:

[1] BB93. 2015. *"Building Bulletin 93: Acoustic Design of Schools – Performance Standards"*. Department for Education, Education Funding Agency

[2] NTi Audio. n.d. *"How to: Measure Speech Intelligibility"*. NTi Audio. Available at: https://www.nti-audio.com/en/applications/evacuation-systems/speech-intelligibility-stipa

[3] Brüel & Kjær. n.d. *Head And Torso Simulator 4128-C Frontview*. [image] Available at: https://www.bksv.com/-/media/Images/Products/Transducers/Head-and-torso-simulators-and-ear-simulators/HATS/Type-4128C/HATS_Type4128-C_600x600.ashx?

Methodology:

An NTi TalkBox was positioned where a teacher would stand (i.e. besides a lectern) and angled towards the assumed direction they would face (i.e. towards the students) during a lesson. A head and torso simulator (HATS) was placed at seat locations within a classroom. A STIPA signal was emitted from the TalkBox and STI was measured by the HATS. Using this method, STI data was recorded in seats all around the room, measuring how well the left and right ears perceived the STIPA signal.

Testing was repeated using a loudspeaker emitting a broadband pink noise signal that aimed to measure if the presence of a distracting noise would negatively affect STI data.

Figure 1: B&K Head and Torso Simulator [B&K. n.d]

Results:

Figure 2 shows the frequency response of the 4 classrooms tested compared to the BB93 standard of 0.6 s (black dotted line).

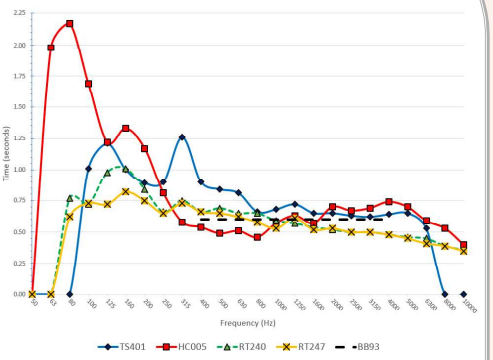

Figure 2: Frequency Response of Pilot Study Classrooms

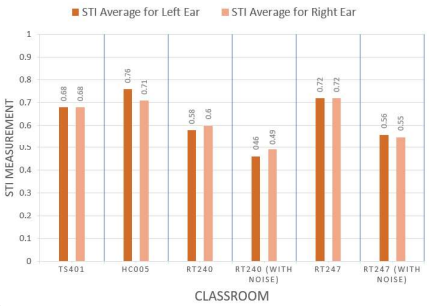

Figure 3 shows that all 4 classrooms passed the STI standard of 0.6 set by BB93. With the presence of a distracting noise, all tested classrooms failed to meet BB93's STI standard.

Figure 3: Average STI Values of Pilot Study Classrooms

Conclusion:

Data collected from the pilot study shows that the following factors affect the STI of seat locations within a classroom:

- The location and speaking direction of the teacher.
- The location and angle of the seat location.
- The presence, location and direction of a distracting noise source.

Data from the pilot study also shows STI variation between seat locations within individual classrooms, and STI variation between left and right ears measured in the same seat. In certain situations, STI data between seats showed differences of up to 14%, and left and right ear STI difference in the same seat showed differences of up to 22% of the STI measurement scale.

The classrooms tested in the pilot study fulfilled all acoustic requirements proposed by BB93, even with higher education sites not being required to follow the standards.