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Sound Decisions: Moving forward with Acoustics

Co-teaching in (refurbished) flexible learning spaces: Promoting quality acoustics for learning and collaboration

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ABSTRACT

The modern learning environment revolution is well underway. Government investment in new and refurbished educational spaces is at an all-time high, but how are we equipping teachers with the necessary skills to use these spaces? In particular, how can teachers manage the commonly stated challenge of 'noise', especially in refurbished innovative learning spaces that are often configured according to pragmatic factors that do not include consideration for acoustics. Co-teaching in flexible learning environments is being encouraged, but good acoustic design and effective pedagogy and organisation are essential to allow this contemporary educational approach to prosper. This cross-disciplinary paper, co-written by an acoustical engineer and education researchers, explores the new spaces from the teacher's perspective, including how they perceive the acoustic environment. This research project goes beyond just the physical acoustic conditions of the space - it also provides evidence about how teachers' practices in pedagogy and classroom organisation can be positively informed through knowledge of acoustics, and the ways in which this can enable teachers to more effectively use the innovative learning space to support student learning and engagement.

One author of this presentation was awarded an AAS education grant in 2018 and this presentation details the resulting project.

Keywords: Modern learning environment, acoustic design, acoustic access, speech intelligibility, pedagogy, contemporary learning, hearing, listening, reverberation

1 INTRODUCTION

Schools that are seeking to embrace the challenges of providing education and learning experiences to support students for future workplace and social capacities are increasingly looking to innovatively designed learning spaces. In contrast to teacher-centred 'chalk and talk', single, enclosed classrooms, these contemporary, innovative approaches to teaching and learning, have large learning spaces with multiple teachers and utilise technology and peer collaboration as key approaches for learning (see, for example, Byers, Imms, & Hartnell-Young, 2014).

There has also been a recognition of the importance of acoustic design in education environments, given that students spend between 60-80% of their time in speaking and listening activities. At the current time, the acoustic guidance and standards used to evaluate learning environments has not fundamentally changed over the past 20+ years. Reverberation time and background noise are still the fundamental parameters used to assess education spaces.

Whilst the bid to develop innovatively designed learning spaces in schools has led to impressive new builds, there are many schools that seek to implement innovative learning spaces in converted 'tradtional' classrooms with less than ideal, ad-hoc adaptations, for example two or more traditional classrooms with adjoining walls removed. Whilst there are acoustic standards in Australia for purpose-built flexible learning spaces, these standards are not commonly applied to re-furbished or converted 'traditional' classrooms.

As part of a research study undertaken by an educator and an acoustician, this paper has been prepared to document the results of acoustic analysis of three schools using innovative learning environments to educate primary school students. The schools are located in regional New South Wales (NSW), and are refurbished spaces which are now being used for team-teaching of multiple class groups in the same learning space.

The study involved:

- Surveys of teaching staff to investigate their perceptions of sound and noise issues in their current teaching spaces and the implications for their teaching practice and student learning
- Measurements of simple acoustic parameters in the space, and documentation of the volume, finishes and furniture layout;

The outcomes of the study are presented in this paper.

2 LEARNING IN A FLEXIBLE ENVIRONMENT

With new and emerging education facility design models, speech intelligibility is evolving to become a critical issue for children. In these contemporary flexible 'classrooms', variously referred to as Innovative learning environments (ILEs), Flexible learning spaces (FLS), Co-operative Learning Environments, 21st Century learning spaces, and open plan classrooms, multiple groups of children may talk and work together in small groups, concurrently, with groupings changing through the day, and children actively moving about the space rather than sitting at desingnated desks. Children are therefore trying to learn in environments that contain multiple sources of competing speech (Leibold, McCreery, and Buss 2017) with babble and activity noise being more disruptive to speech perception than external noise such as traffic (Prodia, Visentin, and Feletti 2013).

Team teaching is an essential feature of ILE's. This means that there are multiple adults in the classroom, conducting varied activities with students in different spaces. Organisation of timetables, resources and different learning activities is more complicated than in traditional classrooms with one teacher overseeing everything. This re-definition of teaching and learning as a collaborative process is central to education reform but it is not without it challenges. Concerns about noise are one of the most often-stated complaints with regard to flexible learning spaces, with both teachers and students affected (Blackmore, Bateman, Loughlin, O'Mara, J. & Aranda, 2011; Whitlock, 2012).

If children cannot hear the voice of the teacher and the voices of their classmates, they cannot learn effectively. Younger children typically have greater difficulty comprehending speech in noise, and participating in situations with multiple talkers. The first years of school are also critical for language development. Generally, younger children require very high intelligibility of speech, because they cannot 'fill in the blanks' from garbled words the way adults can.

3 WHAT DEFINES QUALITY ACOUSTICS IN EDUCATION SPACES?

3.1 Room acoustical design parameters for speech

Traditional cellular classrooms have in the past been characterised acoustically using Reverberation Time (RT) and Ambient noise (L_{Aeq}) as the two key acoustic design parameters. Occasionally, guidance may reference Speech Transmission Index (STI) as a third design parameter. The same parameters are generally also applied to the design of open plan spaces, despite the fact that they are very different in terms of their pedagogic use and activities.

For rooms to function as listening and communication environments, there are three main factors to consider: reverberation, ambient noise in the space, and the signal-to-noise ratio. These are described in layperson terms below.

3.1.1 Reverberation

Reverberation time is defined as the length of time required for sound to decay from its initial level, and is normally measured in seconds. AS/NZS 2107 suggests reverberation times for open plan learning spaces, depending on the volume (m^3) of the space. Reverberation is directly linked to volume, so the larger the room, the higher the reverberation time. Rooms with many hard surfaces will have longer reverberation times than those with acoustically absorptive finishes.

3.1.2 Signal to noise ratio

The concept of signal to noise ratio is effectively how loud the source of noise is above the background sound in the space. The larger the difference, the clearer the signal. Guidance from the British Association of Teachers of the Deaf and the American Speech Language Hearing Association (Building Bulletin 93; 2014) suggests that the signal to noise ratio should be at least 15dB, and preferably 20dB in the lower frequency range (125Hz-750Hz).

The direct sound from voice will dissipate with distance, so the closer the distance between the speaker and listener, the higher the signal to noise ratio. The directivity of the speech is also an important factor – a speaker who is facing away from the receivers (i.e. head is turned away from the listeners) may reduce the signal by a significant amount.

3.1.3 Speech Transmission Index

The intelligibility of speech in a room is a complex function of the location of the speaker, the location of the listener, ambient noise levels, the acoustic characteristics of the space and the loudness and quality of the speech itself. STI is an objective measure which accounts for all of the above factors.

STI is a value between 0 and 1, and the higher the value the better the speech intelligibility. The STI is a useful measure for open plan style learning spaces in particular. This is because whilst reverberation time is a primary acoustic descriptor for a learning space, many other factors also need to be considered.

3.2 Recommended Design Sound Levels and Reverberation Times in Open Style Learning Spaces

The performance criteria below list recommendations for open-style learning spaces in primary schools for children without hearing impairment by professional organisations. For students with hearing impairments, more stringent performance targets should be adopted.

Table 1: Open plan learning environments recommended parameters

Parameter	Value	Reference
Ambient noise levels Unoccupied internal	35-45dBA ≤40dBA <NC35	AS/NZS 2107:2016 AAAC V 2 2018 WELL rating tool for Comfort Noise Criteria in Schools
Speech Transmission Index (within groups - open plan style learning spaces)	0.70 ≥0.60	AAAC V 2.0 2018 UK Guideline Acoustics of Schools: a design guide (Nov 2015)
Reverberation time T_{mf} Unoccupied	Curve 3 ≤0.6	AS/NZS 2107:2016 AAAC V 2 2018

3.3 Teacher factors

Quality acoustics in education spaces is inextricably linked to human behaviour within those spaces, and teachers are obviously a key mediating influence. The decisions teachers make about how they work in the space and manage student behaviour, their planning for lessons and learning activities, and the choices they make, for example about how group work operates, or the way they utilise technology (e.g. electronic whiteboards, digital devices etc) also has a significant part to play in determining the quality of an acoustic educational environment.

Contemporary teaching methods entail teachers moving throughout the space talking to small groups separate – particularly in ILE's teacher mobility is crucial. Additionally, the shift towards group work and other collaborative approaches means that being able to hear the voices of other children is equally important to learning, as hearing the voice of the teacher.

Yet few studies have evaluated key factors, such as noise generation and the impact on collaborative activities, or teacher use of technologies and behavioural and organisational approaches to improve acoustics in flexible learning spaces (Robinson & Munro, 2014).

4 SURVEYS IN SELECTED SCHOOLS

4.1 Online survey

An online survey was designed to investigate the concerns of teachers working in re-furbished ILE's in relation to noise, acoustics and the implications for teaching and learning. The survey also sought to determine strategies implemented by teachers to manage these concerns. The survey, consisting of closed response and open-ended questions, was completed by 21 primary school teachers working in five schools in regional towns in north east NSW. The schools were purposively selected from one educational jurisdiction, based on willingness to voluntarily participate. Further, the schools were implementing ILE's in various guises, and the teacher respondents had to be currently working in a co-teachng model in a re-furbished ILE. In evaluating the research design of this survey, it is important to note that it does not purport to be a validated instrument and the small number of respondents and sites is a further limitation. The results can only be viewed as a 'glimpse' into the perceptions and experiences of the participating teachers.

4.2 Attended survey

Acoustic and pedogogical surveys were undertake in three schools in regional New South Wales. These three schools were a subset of the sample of schools participating in the survey, being those willing and able to accommodate this attended survey. As part of the acoustic survey, a noise logger was located in each of the classrooms for a period of up to one week. In addition to measuring the activity sound and background noise level in the space, the reverberation time in each space was also recorded during the attended inspections. Information on the room volume, finishes and furniture layout was also noted.

Observations were made of teaching practices and student reactions in each of the spaces.

5 ONLINE SURVEY RESULTS

5.1 Context description

The 21 survey respondents, all currently teachers in re-furbished ILE's, had worked as teachers from 2 to 45 years, although all had been working as co-teachers in ILE's for 5 years or less. They worked in all primary school grades (K-6), with the greatest number teaching in Years 3 and 4 (students aged 8-10). The most common feature of the described refurbished ILE's was traditional classrooms walls removed between adjacent classroom, or that there were moveable room dividers, such as concertina doors which remained open. One ILE was previously a school hall of large volume. Most descriptions mentioned flexible seating options such as moveable tables and small clusters of desks positioned for group work, and a range of flexible furniture including floor cushions, tiered seating and 'white board' desks for writing on. The number of students in each learning space varied form 26 to 70, with a median group size of 45, and 2-4 teachers. All teachers reported that there were students in their 'class' who experienced hearing loss or auditory processing problems, with a median rate of 10% (broadly consistent with reported prevalence).

5.2 Impact of noise sources in ILE's

In a set of questions about acoustics in an ILE, using a 7-point likert scale (1=not at all, 7=very much so), most respondents reported that the acoustics **within** the space had negatively impacted either their ability to teach, or their students' learning (mean of 4.33). Noise generated from **outside the learning space** (playground, corridors etc.), although less of a problem (mean 3.88) was still a perceptible concern, but noise from **outside the school** did not have a notable impact (mean 2.29).

Descriptions of disruptive noise within the space frequently focused on 'working noise' from students and teachers nearby, back ground noise levels rising, teachers having to raise their voice to be heard, or not hearing students' responses. Several respondents also noted that higher noise levels in the learning space made it more difficult for them to determine if students were actually on task or not. Many descriptions of noise problems within the space were about teachers trying to do different types of activities at the same time, for example, not being heard when giving instruction on the mat (floor) due to an activity in an adjacent space that requires student to student discussion.

Overall, respondents rated the worst source of noise problems as noise from within the learning space and the majority noted problems hearing students speak clearly. Ambient sounds, for example from fans or air-conditioners, was not reported as disturbing by most respondents. Transition times (changing activities), mat work and other whole-group instruction contexts were indicated as times when the teachers most often needed to raise their voice. Some teachers said they always have to speak in a raised voice and most said that they often needed to elevate their voice to be heard clearly, leading to voice strain.

5.3 Teacher knowledge

In an item asking about what was affected the listening quality of the room, the most-selected option, nominated by a third of the respondents was 'Noise level produced by the students is too high'. Two other frequently selected options were 'The organisation / set up of different teaching & learning activities' and 'open plan style room'. In response to the question 'To what extent do you believe improved acoustics could affect pupils' learning?' 71% of respondents endorsed the view that improved acoustics would have a positive impact on students' learning, whilst 29% thought that improved acoustics would be unlikely to make a difference to students' learning. Most respondents asserted that they did not know what is necessary to improve the 'acoustic quality' of a refurbished flexible learning space.

In responding to questions about strategies for managing or mitigating noise in ILE's the majority of responses related to **organisational factors within the realm of teacher work**. These included:

- teacher positioning self optimally when they speak;
- using visuals to support instructions;
- strategic seating of students;
- arrangement of learning areas and grouping of desks;
- timetable activities to minimize noise for the whole group at set times;
- try and coordinate activities in the different learning spaces;
- taking a group outside to work;
- organising activities to ensure that sound levels are low at the same time across the rooms;
- organising work spaces so one is for quieter individual work, one for group work etc.;
- if an activity is going to generate higher noise levels then the doors have to be closed.

Some related to **managing student behavior**

- encourage use of quieter voices;
- ensuring all students are facing you when instructions are given ;
- headphones on during individual work activities.

Some related to **environmental modifications**

- use of soft furnishings;
- closing of dividing doors when necessary;
- open the windows;
- carpeted notice boards would help to absorb some of the sound.

Of the environmental modifications, almost all were considered ineffectual if and when implemented.

6 SURVEY RESULTS

The acoustic measurement results for each of the sites are provided in Table 2. For ease of reference, the target values suggested in AS2107 are included for each parameter.

Images of the ILE space interior are shown in Figure 1 – 4.

School 1

School 2 – Yr 3-4 space

School 2 – Yr 3-4 space

School 3

Figure 1-4: Interior views of ILE spaces where acoustic measurements were taken

School		Approx Volume	Finishes	Parameter			Notes
				Background Noise (L_{Aeq} dB)	RT (mid frequency) (s)	Activity Noise (L_{Aeq} dB)	
				35-45	0.6		
1	Yrs 3-4 with 3 teachers and 1 teachers aide approx 64 students across 3 classrooms separated by operable walls (which were open).	300m^3 / room (900m^3 in total across three rooms with all OWs open)	C- Plasterboard F- Carpet W- Glazing, exposed brickwork	30-35	0.7 - 0.9	60-70	Space included lots of furniture. Split system AC units (not operating)
2	Yr 3 classroom with two teachers and one teachers aide. Approx 34 students in class (can be up to 38)	265m^3	C- Painted concrete F- Carpet W- Glazing, exposed brickwork	35-40	0.7	75-80	Space included lots of furniture, but no absorptive finishes. Noise from quadrangle outside
	Yr 6 classroom with two teachers. Approx 50 students in double class space that can be divided by operable wall (OW open)	432m^3	C- Concrete painted soffit F- Carpet W- Glazing, exposed brickwork	30	1.0	70-80	Space included lots of furniture, but no absorption. Noise from quadrangle outside
3	Yr 6 classroom with two teachers. Approx 60 students in double class space that can be divided by operable wall (OW open)	300m^3 / room (600m^3 in total across both rooms)	C- Plasterboard soffit F- Carpet W- 6 or 9mm acoustic panel to every available surface (approx. 60-70% coverage); plasterboard / glazing elsewhere	30	0.6	60-70	Space included lots of furniture and wall absorption.

7 OUTCOMES OF SURVEY

7.1 Online survey

The results provide information about teacher knowledge of issues associated with acoustic quality in their classrooms and how this contributes more broadly, to issues of pedagogy and practice in ILE's. It must be noted that, because of the small sample size and purposive sampling, these results cannot be generalised. Nonetheless they make a valuable contribution to what is only scant existing literature about teachers perspectives on the pressing issue of noise problems in ILE's.

Notable findings include that respondents expressed consdierable concern about disruptive noise in these refurbished ILE', consistent with the existing literature, with noise coming from withn the learning space being the greatest concern. Many respondents indicated that this negatively impacted on their work as teachers and on students' learning. Concerns were expressed about noise coming from adjacent groups or spaces and that having different types of activites conducted concurrently was a common cause of noise problems.

Organisation of learning activities and timetable, and managing student behaviour are important aspects of teachers work and these were common approaches reported for managing noise. Although some of the responses indicated that the teachers' organisation and pedagogical approaches could in fact be the cause of the concerns (e.g. poor planning in having a quiet activity next to a group work task, lack of co-ordination between teachers), the range of strategies listed showed that often the teachers recognised these concerns and implemented solutions. However, in light of the fact that the majority of respondents suggested 'student noise' was the main problem, more support for teachers may be required in this regard. When working in ILE's teachers need to ensure that their pedagogical and organisational approaches are appropriate, in particular to make sure that they are not overly relying on traditional 'chalk and talk' approaches and that they are effectively co-planning with other teachers in their team.

Of concern were the environmental strategies the respondents described, as they often would not have been effective. A further concern was that one third of respondents thought that the acoustics of a learning space would not have much effect on student learning. Taken together with the strong response that most teachers asserted that they did not know what is necessary to improve the acoustic quality of the learning space, this suggests that more needs to be done to educate teachers about acoustics in learning environments.

7.2 Acoustic survey

Only one ILE space across the three schools achieved background noise levels and reverberation times below that recommended by the guidance in Table 1. Additionally, the ILE space that did achieve the recommended criterion was the only one to incorporate any absorptive acoustic treatment to the walls of the space. None of the ILE spaces incorporated acoustic treatment to the soffit, with some having painted concrete soffits. The spaces being used for ILE's appear to be traditional style classroom spaces that have been converted to have larger groups of students combined with multiple teachers.

During the acoustic surveys, it was observed that the students were distracted and seemingly off task or having difficulty concentrating. Teacher difficulties in communicating with students were also evident. Whilst this is not an objective measure, it provides an observable indication of teaching and learning difficulties in poor acoustic spaces.

It was evident that the acoustic environment was a large factor in the pedagogical practices used in the space. In one ILE, this lead to:

- Students being divided into smaller groups and/or relocating to another area
- Teachers undertaking activities that require less instruction (such as use of headphones and ipads for teaching activities).

8 SUMMARY

With the prevalence of ILE's or open plan learning spaces, better communication and support is required for education bodies on the acoustic environment. Currently, spaces which may not have acoustic environments to support team teaching or group activity work are being 'converted' to ILE spaces. This can lead to the pedagogy being driven by acoustic needs.

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