New generation learning environments: creating good acoustic environments - policy to implementation

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ABSTRACT

'A poor acoustical environment is an architectural barrier to students with hearing loss as much as a set of stairs might be a barrier for a child in a wheelchair.' Roy (2006)(58)

The introduction of new technologies in schools has resulted in a paradigm shift in the way educational spaces are created and used. Today's learning environments are flexible speaking and listening spaces where collaboration, group work, complex problem solving, digital information gathering and publishing occur. Changes in technology and legislation have highlighted the need for equitable access to learning environments. Good acoustic design is essential. This cross-disciplinary paper co-written by an acoustical engineer and an educator discusses the importance of good acoustic design within new generation learning environments to promote inclusive teaching and learning.

This paper argues that design of open plan learning environments in schools and government policy implementation must address issues of acoustic design and noise control in an effort to comply with the Australian Disability Discrimination Act 1992, the Building Code of Australia, the Disability Standards for Education 2005 and Australian Education Bill 2012. Recommendations are provided on policy changes, which will help reinforce this position across all educational spaces, from early learning centres to adult education.

Keywords: New generation learning environment, acoustic design, equitable access, acoustic access, speech intelligibility, pedagogy, contemporary learning, hearing, listening, auditory processing, cognition, reverberation

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1. INTRODUCTION

Traditional school environments are being redesigned and redeveloped into new generation learning environments. Poor acoustic standards in new teaching and learning environments continue to pose barriers to learning. These barriers include cognitive fatigue, reduced access to speech and language acquisition skills, increased anxiety and poorer learning outcomes (1-4). There is an urgent imperative to review the acoustic design standards based upon emerging evidence that poor acoustics in open plan environments are far from inclusive and potentially contravene the Disability Discrimination Act 1992 (DDA) (5) requirements. In addition, designers need to understand the connection between policy, design practices, implementation and how these impact the individual in the new generation learning environment.

This paper discusses the background in how education spaces are changing, and the importance of policy implementation to ensure that the spaces being created are fit for purpose and able to achieve the intent of the new hearing access legislation.

2. NEW GENERATION LEARNING ENVIRONMENTS

The futurist Alvin Toffler (1994) predicted some 20 years ago that the literate of the 21st Century are not those who can read and write, but those who can learn, unlearn and relearn.(59)

2.1 What is a new generation learning environment?

We are living in a time of transformational change due to technology innovations. Nations are transforming workforces and moving towards employment of people who can collaborate, communicate, solve complex problems, innovate and create new opportunities, businesses and monetary pathways (6, 7). As a consequence the education sector has undergone a phase of rapid change in response to 21st Century technology innovations. This has resulted in the development of new pedagogies, defined as teaching methodologies, beliefs and practices.

Traditionally, schools and classrooms have been based upon a ‘cells and bells’ design; long hallways leading to a series of uniformly shaped rooms (8). Most classrooms were composed of four walls, a door, furnished with one desk, one chair per 30 students. Traditional classroom design is driven by the older pedagogical model that children predominantly remain seated whilst the teacher at the front talks and reinforces information via visual and written representations, with an expectation that students will produce a written interpretation as evidence of learning. The design of the traditional style classroom reflects the outdated design brief; a teacher-directed learning space with ‘kids-on-grids’.

Today educators are required to teach students using technology in preparation for new and emerging workskills. This has led to learning environments being remodelled into open-plan collaborative spaces to accommodate technology and 21st Century skill development (9, 10).

The new pedagogical model is supported by technology rich environments with mobile and fixed devices, and focuses on student-centred personalised learning. This model requires very different teaching practices, as opposed to the previous generation of teacher-centric methods. The diversity of the newer spaces, along with the diversity of students and teachers, creates numerous challenges for teachers, students and designers (11). Strategic monitoring of these practices, research and evaluation will ensure the performance standards of the built environment enhance this new learning.

2.2 Technologies in new generation learning environments

Many of our current school practices were designed by educators who were constrained by technological limitations. In the 1970’s schools transformed into open plan environments, but by the end of the 1980’s many schools had reverted back to cellular classrooms attributing excessive noise and poorer student learning outcomes as the reason for the reversal (8, 12, 13).

A recent large scale survey of children in semi-open plan schools found that children perceive themselves to be adversely impacted by noise which affects their ability to hear the teacher in critical listening situations (14). Few studies post 2008 have evaluated open plan learning environments, and in particular noise generation in these environments; the adequacy of current acoustic standards on the ability to participate in collaborative activities; the proper use of open-plan spaces by teachers; or the utilization of assistive technology tools in open plan spaces.

Emerging technological innovations offer new opportunities in education. Emergent technologies such as the Apple iPad now provide an accessible mobile communication platform in the learning environment that can be used to reinforce visual and auditory information. The iPad is becoming a powerful tool in the education sector. A variety of technologies continue to make learning more accessible. Millet (15) advocates using other technologies such as classroom amplification systems in a universal design model to enhance access to hearing and listening. Classroom amplification systems (sound field systems) are designed to clarify and evenly distribute teacher and student voices throughout the space (16). This technology can be integrated with Information and Communication Technology (ICT) and assistive listening devices to meet recently upgraded hearing access legislative requirements. Universal design is an approach to designing environments, products and communications that are useable by all people to the greatest extent possible without the need for adaption or specialized design (17).

The acoustic environment must be appropriate to support these emerging technologies. Research on a range of benchmark standards aimed at reducing noise, increasing hearing accessibility and enhancing learning in schools is limited. Innovations in acoustic design, building materials, and legislative demands that broaden the scope of hearing access continue. Whilst the legislative changes go largely unnoticed and unaddressed by education facility planners, building design continues often using outdated models, resulting in facilities that may preclude hearing accessibility to occupants.

For example, children with hearing loss are largely managed by hearing aids, cochlear implants and personal FM assistive listening devices (18). Many electrical consultants specify induction hearing loops as the preferred hearing augmentation system in schools, however a significant number of younger students cannot access such systems as they do not have compatible assistive listening devices. Furthermore, even if hearing aided students have activated devices (“T” switches) so they can access compatible induction hearing loops, the physical environment may be acoustically poor and very reverberant, precluding students from receiving intelligible speech via this system.

2.3 Who is impacted by noise in new generation learning environments?

Current research indicates a significant number of students with hearing difficulties in schools. Australian Hearing (AH) is a statutory authority constituted under the Australian Hearing Services Act 1991, reporting to the Minister for Human Services. AH provided services to **68,296** eligible children and young Australians with hearing loss during 2012 – 2013 (19). An overwhelming majority of students with hearing loss attend mainstream schools in their local communities (20, 21).

In addition AH introduced a new service in 2012. AH now diagnoses Central Auditory Processing Disorder (CAPD). Students and teachers diagnosed with CAPD find concentrating on speech and other cognitive tasks in the presence of significant background noise difficult, even though they might not have a diagnosed hearing loss. In particular cases students may have poor attention switching abilities exacerbated by noisy environments (22-24). CAPD impacts at least10% of the indigenous population and 64% of adults over 55 years of age (12). Further, the Australian Association of Audiologist in Private Practice (AAAPP) estimates approximately 15% of the Australian population may have an Auditory Processing Disorder (APD) described as a listening in noise difficulty with or without the presence of a diagnosed hearing loss (22, 25, 26).

Additional studies have linked young children experiencing middle ear infections with fluctuating conductive hearing loss and CAPD (3, 27). Other research indicates that younger students experience greater levels of hearing difficulties as the auditory network pathway responsible for decoding auditory verbal information continues to develop up to the age of 15 years (28). Given this, in the broader context, more students and teachers may suffer hearing difficulties than currently reported by

Australian Hearing. Research also indicates that students for whom English is a second language, those with speech and language difficulties, learning difficulties, cognitive disorders, attention disorders and behavioural problems also have difficulties listening and interpreting speech in noisy environments (14, 26, 28-31). **This collective group represents approximately 25-30% of every class in some schools or districts are greatly disadvantaged by noisy learning environments.**

2.4 The acoustic environment for new generation learning

The importance of acoustics in the new environment is paramount. Flexible learning spaces are trending towards open plan environments, multiple groups using the space at the same time, and heavy use of new technologies in the space.

Acoustic design parameters commonly used to describe open plan learning environments are the ambient noise level and reverberation time. The current design guidance available in Australia for open plan learning environments is shown in Table 1.

Table 1 – Acoustic design parameters for open plan classrooms (32-38)

Reference	Date	Description	Recommended acoustic design criteria for open plan classrooms		
			Internal design sound level, $L_{A,eq}$	Reverberation time, T_{mf}	Speech Transmission Index, STI
AS2107:2000	2000	Teaching space primary	35-45dB	0.4 – 0.5s	
		Teaching space secondary	35-45dB	0.5 – 0.6s	
AAAC	2010	Open plan teaching areas	40dB	<0.8s	>0.6
		Teaching spaces – hearing impaired	30dB	<0.4s	>0.6
Vic	Oct 2011	Open learning areas	30-35dB	0.6s	
SA	Feb 2009	Open plan learning areas	45dB	0.4 – 0.5s	
WA	Mar 2012	General learning area	35-45dB	0.4 – 0.5s	
NSW	July 2012	No reference	Nil	Nil	
Qld	July 2011	Teaching space primary	35-45dB	0.4 – 0.5s	
		Teaching space secondary	35-45dB	0.5 – 0.6s	

The design criteria differ by state yet federal legislative requirements are universally enforceable across Australia. In some circumstances the state response to acoustic standards and hearing accessibility in learning spaces is incongruent with current national legislative requirements outlined in the BCA (39) and DDA.

For example, research demonstrates that Northern Territory students have one of the highest incidences of Otitis Media with Effusion (OME) or ‘glue ear’, which is a condition that impacts hearing and has been found to influence the development of English literacy skills (22, 40, 41). However, at the time of writing this paper no published acoustic design guidelines are available for the

Northern Territory. Queensland policy states: *"Where specifically briefed, teaching spaces for students with special hearing needs, learning difficulties and students with English as a second language, shall have reverberation times lower than the nominated minimum level* ***and shall have sound-field augmentation systems"*** (38). Soundfield systems may not be an appropriate hearing augmentation solution for all learning spaces (42).

Across all states and territories, the BCA provides minimum hearing access requirements in education spaces where there are inbuilt amplification systems. There is no reference in the BCA to acoustic performance standards for the physical environment or certification processes to uphold the recommended acoustic performance in Table 1.

There is a wide variance in the recommended design standards for open plan learning environments, from internal sound levels of 30-45dB L_{Aeq}, and reverberation times ranging from 0.4s-0.8s. Only one guideline references speech intelligibility parameters such as Speech Transmission Index (STI). STI describes the clarity of speech in a space taking account of the space's acoustic characteristics and the background noise level and other noisy activities that may be occurring(34). Perception of speech intelligibility depends on a variety of factors, including message content and complexity, the listener's attention, knowledge and processing skills (28). Predicting speech perception from speech reception is difficult and involves many variables. The younger the child, the more critical these skills are (3).

Recent studies recommend a maximum reverberation time of 0.3-0.4 seconds for open plan learning spaces(15, 43). Applying previous design standards to a new generation learning environment may not adequately address the issues of noise control in technology rich open plan collaborative environments.

To achieve the optimal listening and speaking in any educational environment, key factors must be considered, as indicated in Figure 1.

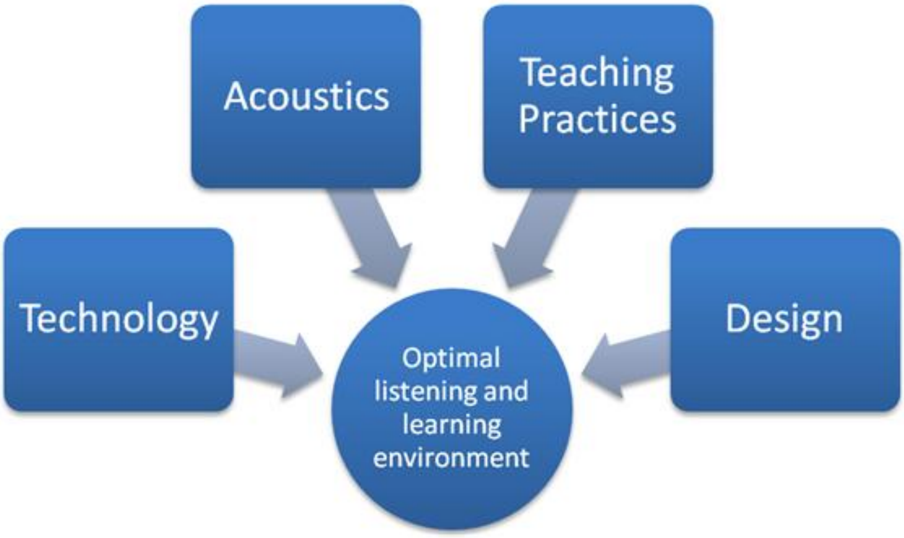

Figure 1: Optimal learning environment

3. CURRENT AUSTRALIAN DESIGN STANDARDS AND POLICY

“Governments decide they know best and they're going to tell you what to do. The trouble is that education doesn't go on in the committee rooms of our legislative buildings. It happens in classrooms and schools, and the people who do it are the teachers and the students. And if you remove their discretion, it stops working.” Sir Ken Robinson (2013) (60)

3.1 Introduction

In order to understand how the construction industry and designers inform their projects, it is relevant to consider current design documents and their status. The documentation falls into two categories: those that are recommended but not enforceable, and those that provide minimum legislated requirements, and are enforceable.

The BCA (now known as the National Construction Code (NCC)) is a federally legislated building code that explicitly outlines the minimum standard required to meet building compliance. Regulatory bodies are expected to enforce the Code. Building surveyors perform the certification process and issue certificate of occupancy signally that the built environment has met all the mandated minimum standards for construction outlined in the BCA.

The current BCA stipulates all Class 9b buildings must now provide hearing augmentation systems, also known as hearing access solutions, where there is an **inbuilt amplification system**. Examples of Class 9b buildings include public spaces such as kindergartens, childcare centres, schools, TAFE colleges, universities. The BCA outlines hearing augmentation minimum requirements that **must be met** to comply with the code. The Building Commission of Victoria in interpreting the BCA advised that an inbuilt amplification system in a learning space included the following:

- A non-portable public address system (i.e. a fixed or inbuilt public address system) in a classroom or indoor collaborative open plan learning space.

- A fixed ceiling or wall mounted data projector or LCD screen or interactive whiteboard within a classroom or indoor collaborative open plan learning space, with a sound source and speakers that amplify sound to the space (44)

When a definition such as ‘inbuilt amplification’ is not clarified, the Building Certifier determines a definition, interpretation and subsequent compliance to the BCA. At the time of writing this paper The Australian Institute of Building Surveyors (AIBS) have no guidelines for members regarding definition of inbuilt amplification in Class 9b buildings or advisory notes on minimum acoustic standards that allow hearing augmentation to be achieved (45).

Figure 2 is a flow chart that shows the relationship between educational design standards and policy, and how the policies or guidelines relate to hearing access solutions(46). Legislated requirements are shown in red.

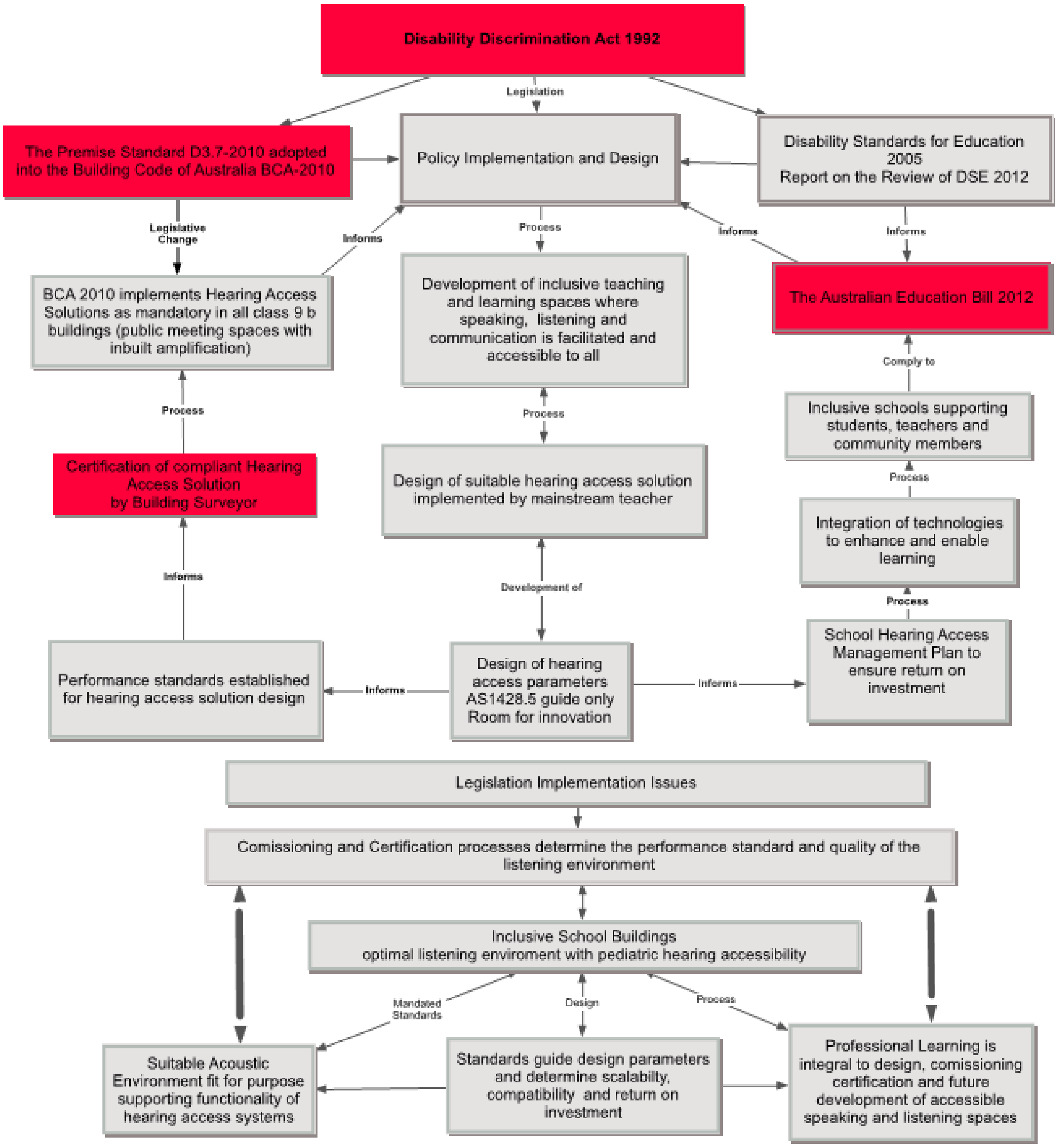

Figure 2 – Flow chart showing hearing access policy document inter-relationships

3.2 Integral links between legislative policies and the impact on the individual

The Disability Standards for Education (DSE) came into effect in August 2005 (47). The Standards were designed to clarify the rights of disabled students to access and participate in education and training. The Standards also give educators guidance on how they can meet their obligations under the DDA. The DSE 2005 and the Report into the Disability Standards for Education 2012 (48) informed the Australian Education Bill (AEB) (49).

The AEB is a legislative framework that ensures all children can equitably access high quality education. Key initiatives include developing and implementing a national plan for school improvement and needs-based funding arrangements. The reform directions intend to ensure all schools will be supported in undertaking key reforms and therefore are funded appropriately.

Transparency and Accountability and **Meeting Student Needs** are key areas of reform outlined in the Bill that relate to the hearing and listening quality of the built learning environment. Educational institutions must **account** for the quality of services provided, in terms of quality of education (effectiveness), value for money (efficiency), equity and access (49).

Building compliance and legislated regulations can be used effectively to **Meet Student Need**, for example, provision of appropriate hearing access solutions and listening environments for hearing impaired students and students with additional sensory needs such as autism (50-52). It has been demonstrated in the UK that the introduction of legislation for acoustic design standards for schools has been effective in improving the acoustic environment in schools (53).

4. DISCUSSION

Ken Kay (2010), Partnership for 21st Century Skills, asserts it is unfair and unproductive to expect students to meet new and higher expectations in 21st century learning spaces if the supporting infrastructure is not there.

Learning spaces are auditory verbal environments where the primary information exchange occurs through speaking and listening activities (54). The federal legislative requirements discussed above support the urgent need to implement an independent certification process to ensure all Class 9b buildings comply with hearing accessibility standards, codes and acoustic measures. The scope of these standards and codes extends beyond the implementation of hearing augmentation requirements. The appropriate acoustics of the spaces are critical in supporting the implementation of hearing augmentation ensuring inclusivity of participants with hearing difficulties. Furthermore, good acoustic standards uphold occupational health and safety legislation by protecting the teacher’s communication assets – voice and hearing (55).

When changes to the BCA were introduced in 2010, a one year grace period allowed designers to understand and implement the change. In December 2012 the Victorian Government Department of Education and Early Childhood Development (DEECD) published a notification in the Herald Sun newspaper inviting expressions of interest and stakeholder input regarding Draft Guidelines for Hearing Augmentation Standards for Learning Spaces (56). This consultation process commenced in 2012. Currently, no official guidelines or Victorian government policy documents have been publically released to guide and inform designers in responding to federally upgraded hearing accessibility requirements. This is in spite of the public consultation process commencing two years prior, and one year after the legislative upgrades became mandated.

Current anecdotal evidence suggests that hearing access solutions are poorly understood by educators, facility planners and designers. Statutory bodies and certifiers indiscriminately interpret legislation or providing solutions that are inappropriate for the use of the spaces. It is paramount to consider that *"The acoustic environment can be the most important factor in allowing children with hearing impairments to participate within mainstream classes"* (44). Further research and policy guidelines regarding the appropriateness of hearing access solutions and acoustic standards in new generation learning environments are urgently required.

5. CONCLUSION

"*Education is the most powerful weapon which you can use to change the world" Nelson Mandela (62)*

Educational spaces can be improved through appropriate acoustic design, opening up a world of opportunity through better educational outcomes for hearing impaired students. Change can only come about through education, and fully understanding the breadth of problems associated with poor acoustics and hearing accessibility in learning environments. Hearing access solutions enhance inclusivity of those with hearing difficulties. Improvements to hearing accessibility can be gained through better acoustic conditions, and universal design elements that support speaking and listening.

Recommendations to ensure consistency across the current policies include:

- acoustic design standards that provide optimal acoustic conditions to be mandatory and incorporated into Building Code of Australia, resulting in a nationally consistent standard
- mandatory certification of the nominated acoustic standards in conjunction with hearing accessibility solutions
- development of universal strategies (57) for accessibility in learning spaces which incorporates hearing access technology as a fundamental requirement in all learning spaces with inbuilt amplification

The evidence presented in this paper demonstrates the need for greater enforcement and certification of acoustic design parameters and nationally consistent guidelines for hearing accessibility in new generation learning environments.

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