New Generation Learning Environments: Are Students With Hearing Difficulties Included? A Multiple Case Study of Students With Suboptimal Hearing Abilities

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Abstract

New generation learning environments (NGLEs) are proliferating in schools worldwide, driven by technology innovations and globalisation (Griffen, Care & McGaw, 2012). Between 2008 and 2012 in the state of Victoria, Australia, numerous schools were built and/or refurbished embracing the principles of open-plan design in the State and Catholic sectors under a Commonwealth-funded initiative entitled Building the Education Revolution (BER). While an increasing body of research is exploring how teachers and students utilise the affordances of such spaces, there exists a dearth of research about their provision of quality educational environments for students with learning differences (disabilities).

In mainstream learning environments a significant number of students have suboptimal hearing abilities attributed to transient or permanent auditory disorders, including hearing loss and auditory processing disorders. There are no known studies that have accounted for the prevalence of school-aged children in this cohort, however it is postulated that the proportion of students with suboptimal hearing is between 7–10% (Tomlin, 2014; Wake & Poulakis, 2004).

Flexer and Smaldino (2012) stated that hearing is a sense and listening is a skill. This suggests that measuring the capacity of a particular person to hear sounds, as represented on an audiogram, is just a small fraction of what matters in the whole scheme of listening and learning. Therefore it is important to consider how the changing elements in NGLEs help or hinder equitable access to learning opportunities and inclusion for students with suboptimal hearing abilities. Little is known about the performance standard of fully operational NGLEs. Indeed, there is virtually no research on how students and teachers maximise NGLE characteristics towards a positive effect for students with suboptimal hearing abilities.

This project utilised a mixed method design, blending building acoustic measurements with qualitative data collection techniques, including semi-structured interviews, focus groups and photo elicitation, to empirically investigate student perceptions of inclusion in communicative experiences in a single sampled NGLE. Three students with suboptimal hearing abilities were treated as case studies, allowing focused exploration of the affective and effective impact of pedagogy, spatial design, building acoustics, and technology on their inclusion in learning activities. Other participants included teachers and the school principal.
The research design enabled baseline measurement of the acoustic qualities of the learning spaces to be collected, exploration of how the students inhabited the spaces and participated in learning activities to be undertaken, and investigation into how teachers intentionally or unintentionally manipulated the physical properties of the space while teaching.

The mixed methods approach led to the discovery of the value of ‘nooks’ (sensory reduction zones within the learning environment) and ‘the trusted other’ (a person the case study students identified as a good peer who could aid their learning). Coupled with access to technology tools for listening and learning, the students reported feelings of inclusion in communicative experiences. Noisy spaces with high reverberation times precluded the case study students from accessing clear speech; however, it was found that when student agency was given, self-advocacy and self-regulation mechanisms were exhibited by students i.e. the students explored their environment, finding spaces, places and multimodal platforms that supported their learning.

Whist speaking and listening remain the central mode of communication in schools, this project highlighted the urgent imperative to evaluate the inclusion of students with hearing difficulties in various learning environment types – especially NGLEs of varying designs. The challenge for future research in this field is to engage with cross-disciplinary approaches that account for the relationships between students with suboptimal hearing abilities and the learning environments they inhabit, to develop new knowledge about how the principles of inclusive education can be enacted. While this study was limited to the analysis of a limited sample of students and teachers in one NGLE, its results carry significant implications for the further research into the design and use of NGLEs.
Declaration

This is to certify that the thesis comprises only my original work towards the Master of Education by Research.

Due acknowledgement has been made in the text to all other material used.

All research procedures reported in the thesis were approved by the University of Melbourne Human Ethics Committee.

Signed................................................ Date.........................................................
Preface

My desire to evaluate inclusion in new generation learning environments evolved after teaching physical education and science in a mainstream high school. There were 1,200 students, of which 25 were hearing aided.

Originally built in the 1960s, the school buildings had been refurbished and reshaped several times over the decades. The science labs and gymnasium were acoustically appalling, both prior to and after refurbishment. I struggled to speak and listen in these noisy, reverberant (echo-like) environments. This led me to think, are students with suboptimal hearing abilities included?
Acknowledgements

I would like to acknowledge the following:

Dr Wesley Imms and Dr Ben Cleveland, whose collective knowledge is immeasurable. Thank you for your support, insights, patience, and faith in me. I am truly humbled and grateful for your supervision.

The participant students and teachers, as this research would not be possible if we did not have the willingness and trust to let others put us under the microscope.

Amanda Robinson of Marshal Day Acoustics Melbourne for acoustic testing, equipment and expertise.

David Huggins for the prompt to undertake this study.

Professor Field Rickards for additional support, insights and supervision

The Catholic Education Melbourne.
Dedication

To my long-suffering family, Peter, Georgia, Zoe and Lachie, your enormous understanding and love is very much appreciated.

To Dianne Yvette Thornton, visiting teacher of the deaf, mentor, mum to Em and dearly loved friend 1953–2014 who passionately declared:

Mediocrity and bureaucracy, bar-hum-bug, our kids deserve better!
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Chapter 1: Introduction to the Study

Chapter Overview

In recent times, numerous schools in Victoria and around Australia have been built and refurbished using open-plan design principles. The stimulus was a joint State and Commonwealth funded initiative known as the Building the Education Revolution (BER) 2008–2011 (DWEER, 2011). The newly designed learning environments aimed to encourage learning in a social contest, in a technology-rich learning environment. The educational building fund also intended to stimulate the economy and as such, was delivered in a very short timeframe. Little is known about the performance standards of these buildings in terms of supporting access to speaking and listening activities.

In mainstream learning environments, a significant number of students have suboptimal hearing abilities due to transient or permanent auditory disorders. For the purpose of this study suboptimal hearing abilities is a term applied to a person who has a diagnosed permanent or transient auditory disorder, or hearing loss, that impinges on the ability to access communicative experiences involving speaking and listening in a learning environment. There are no known studies that have accounted for the actual prevalence of school-aged children in this cohort; however, it is postulated between 7–10% (Tomlin, 2014; Wake & Poulakis, 2004).

Suboptimal hearing abilities in children arise from a range of conditions including transient ear infections such as otitis media or ‘glue ear’ that commonly affects school-aged children in the early learning years, to more severe permanent conditions such as conductive and sensorineural hearing loss. Other conditions include auditory processing disorders, which are neurological-based deficits characterised by an apparent difficulty in comprehending speech in the presence of noise, and short-term verbal memory difficulties, which control attention and information processing (Boudreau & Costanza-Smith, 2011). The American Speech Language Hearing Association (ASHA, 2005) define APD as a deficit in the perceptual processing of auditory stimuli and the neural biological activity underlying that processing, which lead to deficits in various auditory functions.
Flexer and Smaldino (2012) state that hearing is a sense, listening is a skill, contending that measuring the capacity of a particular person to hear sounds, as represented on an audiogram, is just a small fraction of what matters in the whole scheme of listening. Furthermore, the ability to pay attention is of critical importance with regard to listening, cognition and learning. Recently, it became clear that even minimal hearing loss (16–25 decibels) could affect academic achievement (Spencer & Marschark, 2010).

Very little is known about the experiences of children with suboptimal hearing abilities in open-plan learning environments, and in particular, their perceptions of inclusion in communicative experiences. It is therefore important to consider how the myriad of changing elements in new generation learning environments (NGLEs) help or hinder equitable access to learning opportunities and inclusion for students with suboptimal hearing abilities.

The convergence of pedagogy, spatial design and technology provides a framework with which to address a host of issues associated with designing learning spaces (Obliger, 2006). This framework provides a starting point in the interrogation of a primary school new generation learning environment and in particular, whether the environment facilitates the inclusion of three case study students with suboptimal hearing abilities.

Radcliffe’s (2009) Pedagogy-Space-Technology (PST) Design and Evaluation Framework, which demonstrates how these elements interplay in the learning environment, grounds the study. The key questions for evaluating learning spaces are framed within this. Figure 1 visually represents this idea.
Figure 1. The New Generation Learning Environment and tensions arising from the interrelationship of pedagogy, space and technology, adapted from Radcliffe’s 2009 Learning Environments Evaluation Framework.

The Problem Statement

Many factors have been identified as agents of change within education systems. Technology particularly has changed the way educational spaces are designed and used. Today, learning environments are being designed to support a mix of speaking, listening and communication areas, where collaboration, group work, complex problem-solving, digital information-gathering, and publishing occur. These innovations, as well as recent changes in legislation, have highlighted the need for equitable access to learning environments for students with learning differences (disabilities).

In designing NGLEs there must be confidence that they are fit for purpose, account for diversity, and ensure that speaking, listening and communication are accessible. These new spaces must support quality teaching and learning while catering for the needs of all occupants.
NGLE design intends to support pedagogies based upon the Vygoskian premise that learning is constructed in a social context. These spaces reflect a social constructivist approach, which argues that humans generate knowledge and meaning from interactions between their experiences and their ideas (J. Creswell & Plano Clark, 2011). These environments typically allow for a degree of visual connectedness and are assembled as such that they can be configured flexibly and utilised for a myriad of learning activities and experiences that involve various degrees of teacher direction and student agency.

In the research literature a gap exists in the evaluation of NGLEs in terms of the identification of affordances that enable inclusivity of students with a range of learning differences (disability). An ‘affordance’ is a quality of an object, or an environment, which allows an individual to perform an action (Gibson, 1977; Wright & Parchoma, 2011).

**Aims and scope**

The primary aim of this project was to:

(i) investigate the affordances of the physical learning environment that enhance inclusion for students with auditory disorders

(ii) investigate factors that enable hearing accessibility for students with hearing difficulties in open-plan NGLEs.

The subsidiary aims are to:

(i) investigate the built learning environment’s technology and acoustical considerations to determine what indicators should be adopted as best practice initiatives in an open-plan new generation primary school

(ii) investigate 3 teachers and 3 students preferential use of places to communicate within the learning space to determine how open-plan environments can be best utilised for optimal access to speaking and listening activities.

**Key research question**

*What affordances are required for inclusion of students with suboptimal hearing abilities in open-plan NGLEs?*

Inclusion is defined as the action or state of including or of being included within a group or structure (Furlonger, Sharma, Moore, & Smyth-King, 2010).
Given that a core function of a learning environment is to support speaking and listening, educators must be assured that the environment in which they teach enables the enactment of the principles of inclusive education.

**Overview of the study construct**

In the context of this study construct refers to the framework in which the study was built.

The study’s construct encapsulates:

(i) **new generation learning environments**

(ii) **habitation**

(iii) **hearing abilities**.

The new generation learning environments encapsulate the interplay between pedagogy, spatial design elements and technology. Within this construct, spatial design, the acoustics of the environment, technology, and the teacher’s manipulation of spaces for learning are elaborated. Figure 2 depicts the scope and construct of the study and the emergent themes under investigation.

![Figure 2. Construct of the study](image)

The term **habitation** refers to the fact of living in a particular place; it is the lived experience of the individual in the learning environment. Within the construct of this study, the organisational structures and the culture the research school sit within habitation.
Hearing abilities pertain to the child’s communication modalities, self-advocacy and self-awareness. The functional hearing abilities of the child are not the focus of this inquiry. The child’s adaptabilities, preferences and choices that enable a communicative experience to occur remain the central focus of this study. Note: For the purpose of this study the term ‘hearing difficulty’ and ‘suboptimal hearing abilities’ are used interchangeably for ease of reading.
Chapter 2: Literature Review

A handicapped child represents a qualitatively different, unique type of development...If a blind or deaf child achieves the same level of development as the normal child, then the child with a defect achieves this in another way, by another course, by another means; and, for the pedagogue, it is particularly important to know the uniqueness along the course he must lead the child. This uniqueness transforms the minus of the handicap into the plus of compensation (Vygotsky in Sacks, 1995).

Chapter Overview

The importance of this research is highlighted by literature that collectively indicates that a significant number of students in mainstream school settings experience permanent or transient hearing difficulties in their educational settings (Anderson, 2004; Furno, 2012; Massie & Dillon, 2006; Smaldino & Flexer, 2012). Recently it became clear that even minimal hearing loss, 16–25 decibels (dB) can affect academic achievement (Spencer & Marschark, 2010b).

In reviewing the literature, much consideration is given to the depth and breadth of information pertaining to students with a range of auditory discrimination and hearing difficulties. There are many causes of hearing difficulties in school-aged children, resulting in various degrees of impairment that may be permanent or transient. Conductive hearing loss, which can be permanent or transient, occurs when there is a problem conducting sound waves from the outer ear, tympanic membrane (eardrum), through to the middle ear (ossicles). Loss caused by dysfunction of the sensory cells in the cochlear and/or nerve cells in the auditory nervous system is known as sensorineural hearing loss, and is typically permanent. Otitis media is an inflammation of the middle ear, colloquially referred to as an ear infection, can cause varying degrees of permanent conductive and/or sensorineural hearing loss.

Students With Suboptimal Hearing Abilities

In their early learning years, children commonly experience mild to moderate ear infections due to ‘otitis media with effusion’, also known as ‘glue ear’ (Anderson, 2001; D. Howard, 2007; Smaldino & Flexer, 2012). Aboriginal children have a higher prevalence of glue ear compared with non-Aboriginal children (D. Howard, 1991, 2007; Massie & Dillon, 2006). Studies also link
young children experiencing middle ear infections with fluctuating conductive hearing loss and auditory processing disorder APD (Flexer, Smaldino, & Crandell, 2005; C. Howard, Munro, & Plack, 2010).

During 2012–13, Australian Hearing — a statutory authority constituted under the Australian Hearing Services Act 1991 — reported it provided hearing services to 68,296 eligible children and young Australians with hearing loss (The Office of Hearing Service Commonwealth Government of Australia, 2013). Byrne (2011) and Vosganoff et al. (2011) report that an overwhelming majority of students diagnosed with hearing loss attend mainstream schools in their local communities alongside their hearing siblings and peers.

**Auditory processing difficulties**

Hearing difficulties extend beyond hearing losses. In 2012, Australian Hearing introduced a service that diagnoses (central) auditory processing disorder ((C)APD), a subset of auditory processing disorder (APD). The American Speech Language Hearing Association (2005) define APD as a deficit in the perceptual processing of auditory stimuli and the neural biological activity underlying that processing, which lead to deficits in various auditory functions. These functions are important for listening and comprehending spoken language. Individuals with APD experience a range of difficulties with lateralisation, localisation, auditory discrimination, auditory pattern recognition, and other temporal processes (Chermak & Musiek, 2006a).

Children diagnosed with APD find concentrating on speech and other cognitive tasks in the presence of background noise difficult — even though they may not experience hearing loss. In particular cases, students may have poor attention-switching abilities, exacerbated by noisy environments (The Hearing Cooperative Research Centre, 2014; Nelson & Soli, 2000; Wallach, 2011). Estimates of prevalence of APD in the general population range from 2–15% (Bamiou, Musiek, & Luxon, 2001; Chermak & Musiek, 1997; Moncrieff, Wilson, & Wilson, 2009; Musiek, Baran, Pinheiro, Baran, & Pinheiro, 1990). Tomlin (2014) concurs with a postulated estimate of APD of 3–7% of primary school children as a reasonable estimate of prevalence of children being diagnosed with APD using current definitions and criteria.

Other studies indicate that younger students experience greater levels of hearing and listening difficulties as the auditory network pathway responsible for decoding auditory verbal information continues to develop up to 15 years of age (Smaldino & Flexer, 2012).
**Co-morbidity of hearing abilities and learning differences**

Generally, patients diagnosed with APD attending audiology clinics are children with listening problems in the classroom who also present with learning disorders (Bellis, 2002). Of particular concern for educators is the co-morbidity of learning disorders noted by clinicians in reading, spelling, articulation problems, difficulty following directions, and significant challenges regarding communicating and comprehending (K. J. Rowe, Rowe, & Pollard, 2004). Furthermore, it has also been noted that APD is more common in boys and in children with a history of otitis media (Bellis, Chermak, Weiheing & Musiek, 2011).

The generalisability of much published research regarding auditory processing disorders is problematic (Katz et al., 2002) because many audiologists do not concur on evaluation, assessment criteria, diagnosis and management of APD problems (Lucker, 2007; Wilson & Arnott 2013). While literature sources continue to debate in essence ‘is it the brain or the ear that hears?’ (Bellis et al., 2011; K. Rowe, Rowe, & Pollard, 2004 ; Smaldino & Flexer, 2012; Wallach, 2011 ), it is widely acknowledged that the phenomenon of processing speech in noise can interfere with perception, reception and processing of information for a significant number of people.

Escalating concern for children who find listening in noise difficult are psychoacoustic studies that have shown that children are more affected by noise than adults (Johnson, 2000; Klatte, Hellbruck, Seidel, & Leistner, 2010). Most of these studies were conducted in laboratory settings, however, the listening tasks children face during school lessons are a lot more complex, involving identification, plus short-term storage and mental processing of spoken information (Kalatte, Lachmann, & Meis, 2010; Shield, Greenland, & Dockrell, 2010; Smaldino & Flexer, 2012).

**Cognition and hearing abilities**

Literature in the field of neuroscience and psychology has begun shedding light on the physiological aspects of the brain related to detecting speech, the cognitive processes involved in identifying, ordering and retaining auditory information, and the working memory (Baddley, 2003; Bear, Connors, & Paradiso, 2001; Chermak & Musiek, 2006a; Smaldino & Flexer, 2012; Zillmer & Spiers, 2001).

The literature offers empirical evidence regarding the brain’s neuroplasticity and associated brain functions regarding auditory processing and cognition. Of great concern is
agreement across the literature that hearing difficulties impact acoustic access to speech and other sounds and this affects the speed at which one can cognitively process verbal information. Studies with adults have shown that even under conditions of perfect speech intelligibility, background sounds and reverberation impair memory for spoken items, listening comprehension, and memory for spoken lectures (Kalatte et al., 2010; Ljung, Sorqvist, Kjellberg & Green, 2009; Shield & Dockrell, 2003). Similar effects have been reported for children and attributed to reduced cognitive resources available for storing and processing information due to increased listening effort, or to the background sounds specifically interfering with short-term memory representations (C. Howard et al., 2010; Klatte, Hellbruck, et al., 2010; Shield & Dockrell, 2003). A body of evidence suggests school-aged students with hearing difficulties generally perform below the benchmark compared with students of normal hearing abilities (Rowe et al., 2004; Vosganoff, Paatsch & Toe, 2011).

Hearing abilities, oral language and literacy

Children who are susceptible to ear infections in their early learning years experience interruptions to learning opportunities involving speaking, listening and oral-language development. This consequently impedes the development of phonological awareness — an early literacy skill that provides a platform for understanding the sound structure of words (Flexer et al., 2005; Munro, 2011). Spencer and Marschark (2010) state that:

If children with hearing loss are not provided rich visual language models that they can process, or special programming and assistive listening devices that allow effective access to auditory-based language input, they can reach preschool and even primary school years with severely impoverished (if any) language skills (p. 49).

Such findings escalate the importance of Early Learning Centre designs; for example, paying attention to supporting infrastructure that enables accessibility to speaking and listening activities.

An emerging breadth of evidence demonstrates a very clear literacy-learning advantage for the child who arrives at school with age-appropriate language skills (Spencer & Marschark, 2010a). Munro (2011) highlights strong connections between oral-language development and developing literacy skills in the early learning years. The literature is yet to document accessibility to oral language and the subsequent impact on the development of speaking, listening skills and literacy outcomes for a range of learners in a variety of learning
environments. It is evident that if a child cannot access the phonemes in words due to hearing difficulties or the presence of noise masking the sounds, it negates opportunity for participation (Smaldino & Flexer, 2012). Given this, the delivery of any oral-language program must be considered in the context of the environment in which students — including very young ones — learn. This draws attention to the importance of considering the design elements required to enable accessibility to clear speech within the learning environment. Alternatively, students who require additional oral-language support potentially will be relegated to semi-segregated settings to access service. Invariably, the learning space becomes a facilitator of the program — or a hurdle to giving the student opportunity for successful participation. (G. Chermak & Musiek, 2006b; Munro, 2011; K. J. Rowe et al., 2004; Spencer & Marschark, 2010b).

Research on school-aged children with auditory processing disorders has examined various brain functions including working memory, verbal processing speed, retention, and information recall (Baddley, 2003; Bellis, 2002; G. Chermak & Musiek, 2006b; K. J. Rowe et al., 2004). A breadth of data speculate upon the impacts of the disorder upon the child (Smaldino & Flexer, 2012); however, literature sources regarding school-aged children with APD have yet to elaborate on other elements that influence the child’s experience within the learning environment. For example, the influence of the teachers’ pedagogical approach, the learning environment’s spatial elements and furniture arrangements, student and teacher accessibility to technology tools, classroom organisation structures, and classroom acoustics, may all collectively influence the child’s outcomes, or at the very least, their experiences and sense of inclusion at school.

**The Learning Environment as Facilitator or Hurdle**

The imperative to look beyond traditional research pathways is in part driven by the fact that much of the prior research regarding diagnosing and managing children with hearing difficulties emanates from audiology. Audiologists measure hearing using objective and sensory-based precepts of pure tones, beeps, clicks, phonemes and more, to effectively approximate human hearing acuity (Smaldino & Flexer, 2012). These measures, however, do not account for all of the formative processes involved in listening. Smaldino & Flexer (2012) assert that ‘hearing’ is a means in which sound reaches the brain, it is a sense and is passive; ‘listening’ is a learned skill, it is active and involves cognitive effort. The ability to pay attention is critically important for listening and cognition. A study by Bradley and Sato (2008) examined
the intelligibility of speech in primary school classrooms and noted that higher noise levels decreased school-aged children’s understanding of speech in the classroom.

In addition, students for whom English is an additional language, those with speech and language difficulties, learning difficulties, cognitive disorders, attention disorders, behavioural problems and autism, generally have greater difficulty listening and interpreting speech in noisy environments above that of their peers (Massie & Dillon, 2006; Matlin, 2002; K. J. Rowe et al., 2004; Sharma, Purdy, & Kelly, 2009; Shield et al., 2010; Smaldino & Flexer, 2012; Snow & Powell, 2008).

Collectively, the cohorts mentioned so far constitute approximately 7–10% of students, which is a significant number in every class who experience hearing difficulties in the learning environment (Tomlin 2014).

**Learning environment acoustics**

Acoustics is broadly defined as the branch of physics concerned with sound properties. A room’s acoustic properties are determined by its response to sound. Sound energy reflects off solid surfaces, causing a large number of reflections to build up before the sound decays and is absorbed by the surfaces and objects in a space. Good room acoustics are associated with enabling greater access to clear speech reception (Harvey Clark, 2014; Smaldino & Flexer, 2012). Learning-environment acoustics are further elaborated in Chapter 5.

The importance of considering the environment’s impact is highlighted by medical models of inclusion that traditionally place the deficit on the child and not the failure of the learning environment to support them to learn (Abbott, 2007).

Poor acoustics in the learning environment are detrimental to all students; however, those with hearing difficulties are most at risk of not accessing clear speech (Canning & James, 2012). As a consequence, these students are more inclined to experience a sense of alienation in their own classrooms (Anderson, 2001; Bradley & Sato, 2008; Flexer et al., 2005; Shield, Conetta, Mydlarz, Dockrell, & Connolly, 2013; Shield et al., 2010; Sorkin, 2001).

Roy (2006) highlights that a poor acoustical environment is an architectural barrier to students with hearing loss, as much as stairs might be a barrier for a child in a wheelchair.

The literature on classroom acoustics broadly explores:
(i) Direct effects of background noise and reverberation on speech perception including factors that affect speech intelligibility (Anderson, 2012; Anderson, Goldstein, Colodzin, & Iglehart, 2005; ASHA, 1995; Boothroyd, 2004; Flexer et al., 2005; Sorkin, 2001; Zannin, 2009).

(ii) Indirect effects of adverse listening conditions in the classroom, including the effects of noise on health, performing specific tasks, attention, reading ability, academic performance and children’s annoyance due to noise (C. Howard et al., 2010; Klatte, Meis & Lachmann, 2010; McFadden & Pittman, 2008; K. Rowe et al., 2004; Shield et al., 2010).

Many environmental elements exacerbate noise. Of particular note is the relationship between the combined effects of noise and reverberation on short-term verbal memory and working memory. Several studies have revealed that people in classrooms with excessive noise levels are more inflexible and demonstrated inefficiency with changing task demands (Anderson, 2012; Anderson & Matkin, 2007; Bellis, 2002; Hyde & Palmer, 2010; Shield & Dockrell, 2003; Smaldino & Flexer, 2012).

It is evident in the literature that poor room acoustics preclude students with hearing difficulties from fully accessing speaking and listening activities. It is also evident that an individual’s hearing difficulty is like a fingerprint: no two people will experience exactly the same severity, nature and outcome of the difficulty. Present in many and perhaps most children with hearing difficulties is a difficulty accessing speech perception and reception in noisy environments. The outcome is unpleasant and confusing communication experiences and in more severe cases, a sense of isolation (C. Howard et al., 2010; Shield et al., 2010; Snow & Powell, 2008). Furthermore, the co-morbidity of learning difficulties is alarming (K. J. Rowe et al., 2004).

Technological innovation and communicative experiences

Much prior research regarding students with hearing difficulties does not account for the proliferation of technology and its innovative integrated use in the learning environment. The term ‘integrated technology’ refers to technological developments in a range of products and services that, when combined, offer innovative possibilities that help to provide solutions to complex problems (BECTA, 2013). Several studies have examined technological devices designed to improve students’ hearing accessibility. These studies include research on using
assistive listening devices and sound-field systems in mainstream classroom settings (Flexer et al., 2005; Furno, 2012; Heeney, 2007; Massie & Dillon, 2006; Spencer & Marschark, 2010a).

Assistive listening devices are technologies that enhance and amplify speech and other sounds for people with hearing loss and auditory disorders. The device may be personal such as hearing aids, cochlear implants and personal frequency modulation (FM) systems; the latter being an ear-level receiver, worn by a student, with a separate lapel microphone device worn by a teacher. Assistive listening devices (ALDs) are one-to-one focused, where one person talks into the ALD while only the recipient hears the enhanced signal, such as a student wearing a hearing aid.

Sound-field systems on the other hand are considered a one-to-many auditory enhancement device and are composed of a speaker(s), multi-sound source receiver-transmitter and multiple microphones. Sound-field systems are designed to distribute speech throughout a space with low-level amplification. A sound-field system overcomes an environment’s distance-to-noise ratio. The ‘distance’ is from the person talking to the listener. The ‘noise’ is the amount of background noise in relation to the talker’s voice level.

A notable difference between a sound-field system and public address system is the speaker-distribution pattern. The former is designed to deliver clear speech, distributed at a low-level volume, usually 15dB above the background noise (Flexer & Smaldino, 2012). The overall effect is that the teacher sounds as if they are standing close by when talking — regardless of where they are in the space.

Most sound-field systems have inbuilt graphic equalisers that aim to enhance particular quiet speech frequencies, such as the high frequency sounds ‘f’fff, ‘th’, ‘sss’, and the low frequency sounds ‘b’, ‘v’, ‘zzz’. These are typically soft sounds in speech that are harder to hear. By boosting signal strength to these softer speech sounds and suppressing louder mid-frequency speech sounds such as ‘a’, ‘u’, ‘oo’, the listener has a greater chance of accessing intelligible speech. Hearing all the sounds in speech is of particular significance in the early learning years when children begin to develop phonological awareness.

A number of papers that have been written on school-aged children’s use of ALDs focus on the device’s capacity to deliver speech signal as a central theme. Spencer and Marschark (2010) present a broader perspective, noting that mainstream classrooms are
varied, and that any technology consideration must be cautiously examined in light of the many other variables impacting the child’s experience in the environment.

In the same vein, Stephenson’s (2007) meta-analysis of sound-field studies found a large body of anecdotal evidence suggesting that using sound-field technology in primary school classrooms enhanced the experience of many teachers and students in the learning environment. Some of the beneficial findings included increases in speech perception, resulting in a greater change in the percentage of students reading at Grade 1 level in 12 classrooms fitted with sound-field systems, compared with 12 classrooms without them (Millet & Purcell, 2010). Massie, Theodoros, McPherson, and Smaldino (2004) reported improvements in student social behaviours and the communicative activities of Aboriginal and Torres Strait Islander children when sound-field systems were used in the classroom. Stephenson, however, cautions that overall the evidence base was not definitive enough to attribute improvements in student learning outcomes to the use of a sound-field system alone — particularly for students with severe hearing loss.

Most papers written on using sound-field systems fail to detail the teacher’s pedagogical approach, the level of embedded use in everyday classroom practices, or the integration of the sound-field system with other classroom technologies and ALDs. Furthermore, Shields, Greenland and Dockrell (2010) caution against using any amplification system in a poor acoustic environment, as this could further diminish access to speech clarity due to amplified speech reverberating excessively.

Similarly, Smaldino and Flexer (2012) state that poor acoustics undermine the learning space’s very purpose; they emphasise that the amount of information in a talker’s speech actually reaching the listener’s ear depends not only on the listener’s hearing abilities, but also the room’s acoustic properties. The breadth of contrasting literature highlights issues with the complexity and efficacy of studies regarding inclusion of students with hearing difficulties.

Literature from numerous disciplines and fields of study reflect an increasing concern that noise control is a problem in learning environments and that this leads to problems associated with the opportunity to participate in learning activities that involve speaking, listening and heightened cognitive abilities (Boothroyd, 2004; Canning & James, 2012; Clark & Sorqvist, 2012; C. Howard et al., 2010; Klatte, Bergstroem & Lachmann, 2013). Of greatest concern is that all students are impacted; however, students with hearing difficulties are most at risk.
In summary, various literature sources concur on the ramifications of teaching and learning in a poor acoustic environment and consequently make recommendations including developing and implementing suitable acoustic-design parameters for learning spaces — particularly for early learning centres and primary schools (Anderson, 2001; Canning & James, 2012; Klatte, Lachmann & Meis, 2010; Larsen, Vega & Ribera, 2008).

Learning in a social context

In the current economy, at a global systemic level, improving the learning outcomes of the child takes centre stage (Bellanca & Brandt, 2010; Griffin, Care & McGaw, 2012; Hattie, 2008). In contrast, past-century education models were suited to an industrial-production mode, before the proliferation of technology. Accordingly, education systems and schools were built at this time on the notion that students required particular skills and assets that were suited to the industrial model of society. Mass control and mass production were common themes in education (Biesta & Safstrom, 2011; Safstrom, 2011). As such, the physical design of schools appeared prison-like, designed to manage large numbers of students at once, with a series of hallways leading to cell-like classrooms. Regular bells set a universal pace for teaching and learning, signifying little regard for student learning differences.

New Generation Learning Environments (NGLEs)

More recently, societal and economic changes resulted in changes in the design of learning environments. Inspired by a social constructivist approach, which places the student at the centre of the learning experience, spaces for learning are being transformed into collaborative, flexible, technology-rich places (Fisher, 2000).

NGLEs are designed to facilitate new ways of educating the next generation of workers who need significantly different skill sets compared with those of previous generations. Consequently, government initiatives in Australia, such as the Building the Education Revolution initiative in 2008, encouraged open-plan designs that aimed to facilitate constructivist pedagogies and student-centred personalised learning strategies that incorporate using technology as a substantial learning tool (Blackmore, Bateman, Loughlin, O'Mara, & Aranda, 2011).

Blackmore et al. (2011) emphasise that the literature to date is yet to present noteworthy evidence evaluating the performance of NGLEs in terms of improving student learning outcomes. What is of particular concern is how little the research community knows
about inclusion in such learning environments. The literature consistently reports that students with hearing loss have poorer learning outcomes than their hearing peers, which has not changed in 20 years (Vosganoff et al., 2011). Given this, it is imperative to understand what affordances in the learning environment impact inclusion, and whether such affordances facilitate access to better learning experiences and outcomes.

The least restrictive environment

The principle of ‘least restrictive environment’ (Stein, 1994) is often applied to settings to define the environment that least restricts a student from obtaining optimal education outcomes (Byrne 2011). Furlonger et al. (2010) argue that old pedagogical models focusing on training teachers to work primarily with deaf and hard-of-hearing children in segregated or semi-segregated settings are outdated. However, Byrne (2010) highlights the disparity between policy and practice, citing grouping students with hearing loss under the generic field of ‘special education’ as a simplistic view, which ignores the variance of difference within the categorised student subset.

Furlonger et al. (2010) suggest that inclusive philosophies and policies, such as differentiated and personalised learning strategies, call for a wider use of consultative strategies, collaborative problem solving, planning and teaching in mainstream settings. This awareness presents an imperative for systemic change in the approach to training teachers and specialist teachers of the deaf, particularly given that Byrne’s student voice research found an overwhelming majority of students with hearing loss preferred mainstream schooling in their local community. Escalating the importance of this issue is the fact that between 7-10% of students experience hearing difficulties in their learning environment — many of which remain unsupported and unrecognised at a systemic level, not receiving any additional affordances to ensure accessibility to speaking and listening is possible.

Summary

Studies specifically on school-aged students with varying degrees of hearing loss in traditional mainstream settings have addressed issues of inclusion from various perspectives and foci. These include the influences of ALDs, captioning, visual aids, and modes of communication (Anderson, 2001; Anderson et al., 2005; Byrnes, 2011; Flexer et al., 2005; Guardino & Antia, 2012; Heeney, 2007; Hyde & Power, 2003; Rekkedal, 2012; Slobodzian, 2011; Vosganoff et al., 2011). Other studies have explored intervention programs, support services, teacher training
and pedagogical approaches in relation to inclusion in the learning environment (Brown & Paatsch, 2010; Furlonger et al., 2010; Guardino & Antia, 2012; Power & Hyde, 2003; Rekkedal, 2012; Slobodzian, 2011; Vosganoff et al., 2011).

More recently, several studies examined student perceptions of their current learning environments. This was done by evaluating student opinions regarding the setting choice, accessibility to learning opportunities and sense of connectedness to their school, and by questioning the notion of ‘mainstream’ versus ‘inclusive’ settings (Byrnes, 2011; Byrnes & Rickards, 2011; Doherty, 2010; Punch & Hyde, 2011; Slobodzian, 2011; Vosganoff et al., 2011). Key findings in this literature included overall student contentment with their mainstream setting. Many issues of inequity, however, were also reported. These included unpleasurable communication experiences with peers and teachers, poorer understanding of curriculum content and a lesser sense of social emotional well-being and connectedness to the school community compared with hearing peers.

More recently, Punch and Hyde (2011) extended upon largely quantitative research and conducted qualitative research on the social participation of children and adolescence with cochlear implants in various settings. This study noted students with cochlear implants or hearing aids, who had developed good spoken language, could conduct successful conversations in optimal conditions. However, it was also noted that students are particularly disadvantaged in situations where it is difficult for them to hear or speech-read (Punch & Hyde, 2011). Despite the fact that cochlear implants generally increase access to auditory-based language, findings to date have failed to demonstrate that they eliminate children’s delay in literacy development, which raises questions regarding the role of the physical environment and pedagogy in which children learn (Spencer & Marschalk, 2010a). This escalates the importance of understanding what constitutes an optimal condition for speaking and listening in 21st century learning environments, raising further research questions such as, can flexible, open-plan spaces be designed to enable participation in social conversations for students with hearing aids?

The evidence presented in this chapter suggests that many students experience a range of difficulties in accessing speech perception and reception in noisy environments. The inability to access intelligible speech affects cognitive abilities, verbal processing, speech and language acquisition and developing listening-in-noise abilities (ASHA, 2005; Bellis et al., 2011; Fey et al., 2011; Nelson & Soli, 2000; K. Rowe et al., 2004; Sharma et al., 2009). Together,
these studies provide important insights into the various listening abilities of students; however, little is understood about affordances in learning environments that influence the child’s learning experiences.

In a review of open-plan primary school classrooms, Shield et al. (2010) discussed appropriate acoustic modifications for learning spaces. Similarly, Whitlock and Dodd (2008) examined speech intelligibility in primary school classrooms and noted that cooperative learning activities tend to increase ambient noise levels, creating a poorer environment for understanding speech. Furthermore, Canning and James (2012) highlighted the benefits of architectural attention to the acoustic value of school buildings and the subsequent response of student and teacher. Overall, these studies highlight the problems associated with open-plan, collaborative learning environments and access to speech intelligibility. These studies do not, however, account for the collective influences of pedagogy, space and technology in relation to inclusion and opportunity to participate in personalised learning in NGLEs, nor do they account for ‘student voice’ and their perceptions of the environment.

**Subsidiary Questions**

In view of all that has been mentioned so far, and in light of new learning environment designs, there is an urgent imperative to identify the affordances in the environment that enable optimal accessibility to quality learning experiences for students with hearing difficulties. As such, this study seeks to respond to gaps in the literature by addressing four subsidiary questions:

1. **What level of noise is present in the case study students’ learning environment, and how is this mediated?**

2. **How are teachers planning the use of the space?**

3. **How is communication facilitated for, and by, the case study students?**

4. **What elements within the open-plan learning environment facilitate opportunity for case study students’ participation in speaking, listening and communication?**

   These questions are addressed within the scope of the study construct and according to themes and subthemes depicted in Figure 3.
Figure 3. Study construct and scope of themes

In summary a number of elements acting in synergy rather than isolation impact accessibility to speech perception and reception for student with hearing difficulties in open plan new generation learning environments.
Chapter 3 Methodology

To surmount a situation of oppression, people must first critically recognize its causes, so that through transforming action they can create a new situation, one which makes possible the pursuit of a fuller humanity (Paulo Friere 1970 p. 29).

Chapter Overview

This chapter commences with the theoretical construct of the mixed methods case study design (J. Creswell & Plano Clark, 2011). A brief introduction to social constructivism and critical theory is given, highlighting the researcher’s approach to understanding the environment.

The research site was selected by purposeful sampling (Yin, 1984). It is a two-year-old Catholic primary school in a growth corridor on the urban fringes of Melbourne. A description of the technology-rich open-plan design is included.

Next, three case study students with suboptimal hearing abilities, selected by purposeful stratified sampling (Teddlie & Yu, 2007), are introduced. The voices of these students are privileged. Other participants include the teachers, the principal and deputy principal.

The qualitative and quantitative methods are then elaborated. This commences with an account of the qualitative methods and procedures, which include formal and informal observations, photo elicitation, semi-structured interviews, and focus groups. Each of these qualitative methods was used to collect data from the participants. A time line of data collection is elaborated.

Following this, an overview of the qualitative acoustic methods is written in order to introduce acoustical engineering concepts to those unfamiliar with the discipline. The procedures and instruments that evaluate a building’s capacity to support speaking and listening are explained (Bradley, 2010; Canning & James, 2012).

The chapter concludes with an explanation of the qualitative and quantitative analysis techniques, elaborating on the use of building acoustic measures to corroborate and triangulate ‘student voice’ and other participants’ perceptions of inclusion in communicative
experiences in the learning environment. An overview of the study design is depicted in Figure 4.

**Figure 4. Overview of the study design**

**Introduction to the methodology**

In light of previous studies regarding the various detrimental effects of noisy classrooms on children with a range of hearing abilities, ethics approval was granted to conduct a qualitative
In recent times social constructivist pedagogies influenced by the work of Vygotsky and cognitive approaches influenced by Piaget, led to new architectural approaches in order to align space with learning in a social context, with and through others in a community of learners (Blackmore et al., 2011; Fisher, 2000; Istance, 2011). In acknowledgement of this view, the research community, in evaluating what works best in education, must look towards the relationships between factors acting in synergy, rather than in isolation (Biesta & Safstrom, 2011; Istance, 2011). Such broad approaches are supported by Kalikoff (2001) who puts the case for a mosaic approach, which involves the implementation of a series of textured and complementary evaluation strategies that aim to provide reliable and detailed information about what is being accomplished in the context of the particular environment under investigation.

**The research construct**

The construct of the study is organised into three themes: the New Generation Learning Environment (NGLE), Habitation, and Hearing Abilities, defined in chapter 1 and depicted in Figure 5 ‘The study construct’. Within these three central themes exist subthemes, as depicted in Table 1.
Table 1. Themes and Subthemes

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<thead>
<tr>
<th>Theme</th>
<th>Subtheme</th>
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<td>NGLE</td>
<td>Technology</td>
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<td>Habitation</td>
<td>Culture of school</td>
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<td>Organisational structures</td>
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<td>Hearing Abilities</td>
<td>Communication modalities</td>
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<td></td>
<td>Self-advocacy</td>
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<td></td>
<td>Self-regulation</td>
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This research project set out to map the interplay between teacher pedagogy, spatial elements and technology, to determine to what extent the three case study students with suboptimal hearing abilities perceived they were included in their NGLE.

The construct was informed by Brinkerhoff’s (2008) Success Case Methodology (SCM), which is an approach that aims to quickly uncover ‘what is working’ in order to frame lines of inquiry. In the context of this study, factors that contribute to positive communicative experiences as perceived by the child with hearing difficulties were first sought. SCM recognises that learning is a necessary, but not sufficient condition to produce outcomes; performance is the driver of impact. Brinkerhoff (2005) attempts to account for the performance management system and acknowledges the role that learning plays in it to achieve results (Brinkerhoff, 2005). The construct of the study and methodology intended to focus on ‘what is working’ as perceived by the case study students. This starting point grounded the lines of inquiry.
Building upon the notion of interrelated factors, Radcliffe (2008) developed a learning environment evaluation framework, which accounts for the relationships between pedagogy, spatial elements and technology. It is a simple framework of questions that intend to evaluate the interrelationship of elements within the learning environment that determine the quality of experiences offered by that environment. Radcliffe’s framework guides the lines of inquiry emanating from ‘student voice’. Teacher pedagogy, the spatial design, building acoustic performance, and access to technology are investigated. Interrelationships are explored as the researcher looks for the subjective meaning of participant perceptions about inclusion in the NGLE, in particular, inclusion in communicative experiences.

**Theory**

The ontological position of this study is constructionist (Bryman, 2004) with an interpretivist (Carr & Clemmis, 1986) epistemological approach (theories of knowledge). That worldview accepts that individuals construct meaning with and through others in a community of learners in a shared environment (Hart, 1990; Vygotsky, 1986). This view accepts that people actively construct knowledge through their experiences and interactions with the world (Cohen, Manion, & Morrison, 2011). This philosophical position is demonstrated in Vygosky’s account of the handicapped child:

> A handicapped child represents a qualitatively different, unique type of development... If a blind or deaf child achieves the same level of development as the normal child, then the child with a defect achieves this in another way, by another course, by another means; and, for the pedagogue, it is particularly important to know the uniqueness along the course he must lead the child. This uniqueness transforms the minus of the handicap into the plus of compensation. (Vygotsky in Sacks, 1995, preface xiii).

The research project is participatory, meaning there is a political reality in that findings are negotiated with participants who are involved in all stages, engaging in cyclical reviews and collaborative discussions. Advocacy and change are supported by the researcher’s language (Creswell, Plano Clark, 2011).

A constructionist ontology asserts that social phenomena and their meanings are continually being formed and re-formed by social actors (Cleveland, 2011, Bryman, 2004). Critical theorists, such as Habermas (1987), appropriate practical theories of developmental and cognitive psychology to underpin their particular social theory. Such an approach assumes
that participants draw from this lifeworld not just consensual patterns of interpretation (the background knowledge from which propositional contents are formed), but also normatively reliable patterns of social relations and the competencies acquired in socialisation processes (the background of the speaker’s intentions). Habermas’s approach to critical theory considers the process of growing up in a lifeworld and unpacks the notion of socialisation to discourse. This assumes that individuals reinvent, reconstruct and transform the lifeworld in the process of making themselves. In doing so, emancipation and transformation of cultural norms is a possibility (Freire, 1970).

**Emancipatory lens**

An emancipatory lens is concerned with transformative actions that intend to free the oppressed by taking a theoretical stance in favour of underrepresented or marginalised groups (Biesta & Safstrom, 2011; Freire, 1970; Hart, 1990). Safstrom (2011) asserts education without emancipation is no education at all, but rather the defining characteristics of ‘schooling’, a managerial function of the state, which distributes places and spaces in the social order in which individuals become what they already are.

Emancipatory education, as opposed to schooling, is a form of education that is liberating rather than merely adjusting and which points to new possibilities for thought and action, rather than fixate the learner to the status quo (Hart, 1990). In the context of this study, it is recognised that ‘schooling’ and what goes on in schools are different. Within schools, teaching and learning supposedly represent ‘true life’, a place for distribution of experiences that in themselves make sense of living in a particular society (Safstrom, 2011). Emancipation happens in the interplay between ‘the order of truth’ and the disturbance of that order; that is, emancipation is a break from ‘schooling’. The role of emancipation, within a philosophy of education, seeks to articulate its social value (Biesta & Safstrom, 2011; Hart, 1990; Safstrom, 2011). In the context of this study, emancipation and ‘the order of truth’ is interrogated by considering the congruency between the rhetoric of 21st Century social constructivist education policies (Blackmore et al., 2011; Istance, 2011), the enactment of such pedagogies in the NGLE and the perceptions of the child.

New generation learning environments are designed to facilitate pedagogical changes, a break from the traditional, moving towards student-centred, personalised learning in a social context. This social constructivist approach places the child at the centre of the learning process within a community of learners and approximates learning in accordance to the child’s
developmental and cognitive stages (Vygotsky, 1986). Prior research demonstrates that children with hearing difficulties in mainstream education experience higher levels of academic underachievement compared to their peers (Vosganoff et al., 2011). In the current literature, little is known about perceptions of inclusion of students with hearing difficulties or the conditions that enable learning in a social context.

Grounded theory building-like approaches, which employ an ‘intertwined’ approach to analysis of seemingly separate categories, have demonstrated the propensity for education systems to privilege students without disabilities (Slobodzian, 2011). However, recognition is given to the fact that actors operate in a time of technological innovation and rapidly changing education systems; yet, we know very little about the experiences of children with disability.

The decision to underpin the study with a critical epistemological view and use theory rather than a grounded theory building approach was taken in recognition that many of the objectives that social actors pursue do not arise from their conscious choice. Carr and Kemmis (1986) suggest that actors pursue alternatives due to the constraints of the social structures within which they are situated. Spencer and Marschark (2010) caution that it is the responsibility of all who read research reports regarding students with hearing difficulties to do so with a critical eye and to be alert for the tendency to trust something one already believes, rather than something that contrasts with pre-existing beliefs. Taking a critical theory approach benefitted the study by helping to identify the constraints that were imposed on the actors by the social structures around them (Cleveland, 2011).

**Mixed Methods Transformative Design**

Past conceptualisation of students with disability in mainstream school settings have demonstrated limited sensitivity to the extent of inequity, or personal impact upon the individual living the experience. Creswell and Plano Clark (2011) assert that the power of mixed methods research has the ability to highlight inequality. This is because such an approach intensifies the transparency of inequities; however, the power for transformational change lies in the broader context of society and economy.

Similarly, examining student-learning outcomes in open-plan learning environments sheds very little light on local and systemic inequalities associated with educating students with difference in mainstream settings. For these reasons and more, a mixed method transformative design was adopted.
Mixed methods empirically map events and happenings through multiple lenses and drill down deeper into analysis, whilst providing a context for both positivist and interpretivist perspectives (Creswell & Plano Clark, 2011; Mac Naughton, Rolfe & Siraj-Blatchford, 2010). For example in a large-scale mixed methods study of student perceptions of personalised learning in open-plan schools, Prain et al. (2014) accounted for a number of interrelated elements using a mixed methods model. The methodology highlights the significant impact of several moderators, being pedagogy, teacher training and use of space. These factors acted concurrently to influence student perceptions of personalised learning (Prain et al., 2014). Such studies provide opportunity to advance the understanding of a workable model, which explains the nature of the interaction between factors determined by qualitative and quantitative data collection methods.

**Multiple case study**

A case study is defined as an empirical inquiry that investigates a phenomenon within its real-life context (Yin, 2003). Multiple-case study designs provide opportunity to develop theoretical formulations. The generated theories are refined on the basis of a comparative analysis of student cases (Willig, 2008). The student cases and their ‘voice’ regarding inclusion in the learning environment take centre stage as the affordances of the NGLE are interrogated in this study.

Multiple-case studies are instrumental in nature as emerging theories are modified in order to account for all instances associated with the phenomena under investigation (Willig, 2008; Yin, 1984 ). Bromely (1986) draws attention to the fact that cases always exist within a context and to be useful, the research has to be sharply focused. Within the construct of this study, the focus is on the child with suboptimal hearing abilities and their lived experiences in the NGLE.

**Sampling**

Creswell and Plano Clark (2011) state that there is no widely accepted typology of mixed methods sampling strategies; however, cases should provide rich and detailed insight into the problem under investigation.
Selection of the school site

St Helens Primary School (pseudonym) was selected via purposeful sampling (Yin, 1984). It is a two-year–old newly designed and built Catholic primary school. It encapsulated all the essential elements of a new generation learning environment; that is, technology rich, spatially open with flexible furnishings and based on a social constructivist pedagogy. The school had approximately 400 students at the time of data collection.

Dovey and Fisher (2014) identified six main learning space typologies and examined how these had been assembled to support pedagogy in NGLEs. Dovey asserts that considering how an environment has been assembled is a useful way of rethinking theories of ‘place’ in terms of process, identity formation, and what we become. It is important to note that the typology of St Helens Primary School is not representative of all NGLEs; it has a great sense of uniformity in its openness and few typologies.

Figure 6 depicts the floor plan of a learning community with two typologies of space; that is, six breakout pods separated by one collaborative shared area. A common teaching activity are children in pairs or groups of 4-6 working on tasks together. The teacher acts as a facilitator scaffolding and extending learning activities as they drifting between groups. Intermittently large groups of children meet in various spaces for direct instruction before dispersing for individual or group activities. This cycle occurs throughout the school day.
A learning community at St Helens is made up of a shared collaborative area with a series of adjacent open-plan breakout pods, akin to regular-sized classrooms, leading off the main space. There are no solid barriers between any of the typologies of space. A typical learning community houses 150–160 students with 6–7 teachers. Daily organisational structures and further information are outlined in Appendix 1.
Figure 7 is a photograph depicting a typical learning community at St Helens Primary School. The breakout pods commence where the ceiling height drops down to the left of view. There are three breakout pods either side of the central shared collaborative area. The collaborative area links to the next learning community, doubling as a transition space.

Selection of student cases and participants

The student cases were selected via purposeful stratified sampling after the school site was confirmed (Teddlie & Yu, 2007). There is no widely accepted typology of mixed methods sampling strategies; however, researchers should continually ask whether their data will provide answers to the research questions and consider this when choosing specific cases (Creswell & Plano Clark, 2011).

Following institutional protocols, three case study students with hearing difficulties were identified by the deputy principal and with parental permission, the students selected/identified agreed to participate in the study.
The criteria for selection of cases were as follows:

(1) The students have a diagnosed hearing difficulty confirmed by an allied health professional, audiologist, school nurse or school advisor.

(ii) The student participated fully in the curriculum within the learning environment.

(iii) The student’s primary mode of communication is oral language.

(iv) The student’s teacher agreed to fully participate in the study.

(v) Parental permission is granted.

(vi) The student is an informed and willing participant.

Purposeful and strategic selection of information-rich cases that manifest the phenomena intensely, but not extremely, are supported by prior case studies (Stake, 1995).

It is widely recognised that multiple methods and instruments used in mixed methods studies place hefty time demands upon the researcher in terms of collection, organisation and analysis of the volume of data (J. Creswell & Plano Clark, 2011). Therefore, three cases are justified for this Masters level thesis.

Case study student 1: ‘Lucy’

Lucy (pseudonym) is aged nine and in Grade 3. She has auditory processing disorder (ADP). Her abilities to detect and localise, discriminate and process speech in noise is impeded. Lucy experiences difficulties remembering verbal instructions, particularly when several steps are given at once. Lucy’s functional hearing test was reported within normal range. An educational assessment administered by a trained department school advisor indicated that Lucy did not have significant cognitive delay or intellectual impairment. Identification of an auditory processing disorder followed, after completing the Rowe, Pollard and Rowe Royal Children Hospital Melbourne Auditory Processing Assessment. Lucy describes listening in noise as ‘making her feel dizzy’, particularly when background noise escalates and nearby voices are clearly audible.

When it is noisy for prolonged periods, greater than 30 minutes, Lucy’s teacher reports that Lucy becomes restless, appears frustrated, anxious and tires easily, particularly during tasks that involve listening and responding verbally.
**Case study student 2: ‘Ben’**

Ben (pseudonym) is aged eight and in Grade 2. He has a moderate sensorineural hearing loss; he wears bluetooth-enabled hearing aids. Without hearing aids, Ben would not hear 40–60% of what is said in a quiet environment. Ben intermittently uses assistive listening devices such as a personal bluetooth streamer and a personal frequency modulation system (FM system). Ben’s teachers use a Soundfield system fitted in three of the Grade 2/3 breakout pods. This system is funded through a program for students with disability. An audiogram representing Ben’s hearing loss is depicted in Figure 8.

*Figure 8. Ben’s audiogram*
Case study student 3: ‘Sammy’

Sammy is aged six and in Grade 1. She has a mild low-frequency sensorineural hearing loss and is currently unaided. Her loss is akin to lightly cupping your hands over your ears. Sammy was recently diagnosed prior to the commencement of this study and her audiogram is depicted in Figure 9.

![Sammy's audiogram](image)

Fig 9. Sammy’s audiogram

At the time of data collection, Sammy remained unaided by any type of assistive listening device.

At all stages of data collection, student voice was privileged and student perceptions guided and informed the next steps in the study. The importance of ‘student voice’ research is
highlighted by the perspective of children as citizens and competent participants in research (Mac Naughton et al., 2010).

**Participant teachers and leaders**

The other participants in the study depicted in Table 2 include the school leaders and teachers, pseudonym names Karen, Lucy’s teacher; Tait, Ben’s teacher; Carol, Sammy’s teacher; Deputy Principal Tim; and Principal Beth. These participants provided data regarding the enactment of pedagogy, the culture of St Helens Primary School and daily organisational structures.

*Table 2. Summary of Participant Information*

<table>
<thead>
<tr>
<th>Name</th>
<th>Role / Description</th>
<th>Grade level at school</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lucy</td>
<td>Student with an auditory processing disorder</td>
<td>Grade 4 aged 9 years</td>
</tr>
<tr>
<td>Ben</td>
<td>Bilateral moderate hearing loss</td>
<td>Grade 3 aged 8 years</td>
</tr>
<tr>
<td>Sammy</td>
<td>Bilateral mild hearing loss</td>
<td>Grade 1 aged 6 years</td>
</tr>
<tr>
<td>Karen</td>
<td>Teacher of Lucy</td>
<td>Grade 2/3 teacher</td>
</tr>
<tr>
<td>Tait</td>
<td>Teacher of Ben</td>
<td>Grade 2/3</td>
</tr>
<tr>
<td>Carol</td>
<td>Teacher of Sammy</td>
<td>Grade 1</td>
</tr>
<tr>
<td>Tim</td>
<td>Deputy Principal</td>
<td>Leadership</td>
</tr>
<tr>
<td>Beth</td>
<td>Principal</td>
<td>Leadership</td>
</tr>
</tbody>
</table>

*Karen*

Karen is case study student Lucy’s home-base teacher. Karen is a graduate teacher and states that her biggest challenges include constantly grappling with an overwhelming sense of responsibility for the children and their learning outcomes. Karen said, ‘nothing prepared me for the shock and reality of teaching for the first time in the open plan flexible learning environment.’
Karen describes how she received a folder of information at the beginning of the year outlining the personal details of each of her students. Lucy’s educational assessment was in the folder; however, she did not understand how to interpret all the tests and skipped directly to the recommendation section. Karen set about implementing suggested strategies that predominantly focused on literacy development. Karen said the noise in the learning communities gave her headaches shortly after she started teaching; however, she said she eventually ‘got used to it and the headaches stopped’.

**Tait**

Tait is case study student Ben’s Grade 2 teacher. Prior to her appointment at St Helens, Tait had taught for several years in both a traditional school setting and semi-open-plan setting. Tait said that teaching in an open environment forces you to consider others, but most of all you need to consider that the child is at the centre of the learning; teamwork and collaboration are a continual work in progress. Tait notes that trial and error, measured risk taking and supportive colleagues is what is required to begin to understand teaching in such open spaces. Furthermore, Tait says data collection, observation, as well as formative and summative assessments guide the decisions we make regarding our teaching and learning practices.

Tait has taught in cellular classrooms and states that she would prefer not to go back to that style of teaching, which can be quite isolating. Tait completed one hour of additional training conducted by a Visiting Teacher of the Deaf prior to commencing the year as Ben’s Grade 2 teacher. The professional learning session focused on the use of Ben’s assistive listening devices and personalised learning strategies, such as always making sure Ben could see her face when she was talking.

**Carol**

Carol is case study student Sammy’s Grade 1 teacher. Carol is an experienced early learning centre educator who recently retrained to be a primary school teacher. St Helens is Carol’s first appointment as a mature-age graduate. Carol taught case study student Ben when he was in Grade 1. Consequently, Carol is familiar with assistive listening technologies. At the end of her first year of teaching, Carol was allocated another Grade 1 class, Sammy’s class. The learning community of Prep/Grade 1 relocated to another learning space to enable Ben to remain
where the assistive listening technology was located, in particular where the inbuilt zoned Soundfield system had been fitted.

Carol detected Sammy’s hearing loss through observations. This led to Sammy’s diagnosis. Carol advocated for a Soundfield system for Sammy’s learning environment; however, the funding pathways for additional support had closed for the year. Carol had concerns about Sammy’s ability to hear and engage in learning activities and said that noise control in the Prep/Grade 1 learning community was problematic.

Carol believes that all children benefit from the open learning environment as the spaces facilitate personalised learning approaches that build relationships, trust and self-regulation. Carol feels the pedagogy of the learning community enabled her to get to know Sammy on a more personal level, leading to the detection of her hearing loss.

*Principal Beth*

Principal Beth and Deputy Principal Tim share a common understanding of instructional leadership and a clear vision that states that the child is at the centre of the learning process where student achievement data drives the decisions we make regarding our teaching and learning practices.

Principal Beth says that instructional leaders have an awareness of the direct impact that being involved in learning and teaching makes. She explained that not catching every child in the net has led to talking about what makes the difference in our leadership. Beth says practices that empower students to develop the skill of self-regulation and a passion for learning are best implemented in flexible open-plan environments where teachers can collaborate and coordinate personalised learning activities.

*Deputy Principal Tim*

Deputy Principal Tim describes the value of the NGLE and his perspectives on inclusion at St Helens Primary School: ‘Big open space isn’t the big deal — it’s the learning that the big open space allows to happen, that’s the key part... the open spaces are freeing for kids to work in.’ Furthermore, Deputy Principal Tim states that he has worked in behavioural schools where kids have been excluded. Both principals are steadfast that teachers at St Helens demonstrate ‘a strong passion that every child counts’.
Qualitative and Quantitative Methods Overview

The research design set about allowing for effective communication with the participants, whilst being sensitive to their daily activities at school. The research design invited the case study students to participate in avenues that could potentially lead to social change processes as advocated by Creswell, Plano and Clark (2011). The methods are multidisciplinary, as quantitative building acoustic measures, the study domain of acoustical engineers are used to corroborate ‘student voice’ and participant responses regarding inclusion in communicative experiences.

Qualitative methods included:

(i) photo elicitation (Moss, 2011; Christiansen & James, 2011)

(ii) structured and unstructured observations (Christensen & James, 2012)

(iii) semi-structured interviews (Mac Naughton, et al., 2010)

(iv) focus groups (Farrell, 2005; Cohen et al., 2011).

Table 3 gives an overview of the qualitative methods, aims, objectives and outcomes.
<table>
<thead>
<tr>
<th>Data collection Methods</th>
<th>Aims</th>
<th>Objectives</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Formal Observations</strong></td>
<td>Record • Teacher actions / student response to events occurring on a typical day</td>
<td><strong>Understand</strong> • Student and teacher directed occurrences • Modes of communication • Response of the environment to noise generation</td>
<td><strong>Define</strong> • Personalised and differentiated teaching and learning practices • Modalities of communication</td>
</tr>
<tr>
<td><strong>Informal observations</strong></td>
<td>Record • Pedagogical enactments • Student level of independence • Movement patterns • Engagement with technology tools and furnishings</td>
<td><strong>Understand</strong> • Planning processes • Placement of activities • Use of furniture and technology tools • Opportunity for independent decision-making • Teacher-student, peer-to-peer interactions</td>
<td><strong>Establish</strong> • The level of congruency between rhetoric and actions</td>
</tr>
<tr>
<td><strong>Photo elicitation</strong></td>
<td>Visually record • Occurrences and events • Organisational structures and furniture arrangements • Students and teachers in situ during various activities</td>
<td><strong>Understand</strong> • Pedagogy and space • Space and communicative experiences • Pedagogy and communicative experiences • Use of technology and communicative experiences</td>
<td><strong>Identify</strong> • Links and interrelationships between various elements acting upon the child in the learning environment</td>
</tr>
<tr>
<td><strong>Semi-structured interviews</strong></td>
<td>Record • Student perceptions of experiences in the learning environment • Teacher interpretations of elements within the learning environment</td>
<td><strong>Understand</strong> • What constitutes a quality communicative experience for a child with a hearing difficulty • Teachers’ perceptions of hearing difficulties, personalised and differentiated teaching and learning practices • Participants perspectives on learning in a social context</td>
<td><strong>Identify</strong> • Meaningful communicative experiences • The elements that enhance access to opportunity to engage in communicative experiences • The child’s perceived level of inclusion</td>
</tr>
<tr>
<td><strong>Focus groups</strong></td>
<td>Record • Students’ shared interpretations of their collective experience • Delve into the congruency between teacher rhetoric and actions</td>
<td><strong>Clarify</strong> • Participants and researchers interpretation of perceptions and events • Share synthesis of results of semi-structured interviews, photo elicitations and observations • Discuss meaning of the acoustic measures in relation to access to communicative experiences</td>
<td><strong>Enhance</strong> • Validity and reliability of evidence • Prompt transformative actions • Heighten awareness of perceptions of inclusion</td>
</tr>
</tbody>
</table>
Quantitative methods included an audit of technology and collecting building acoustic measurements using standard industry protocols based on the recommendations of the American National Standards Institute (ANSI) (2010) and the Association of Australian Acoustical Consultants (AAAC) (2010) guidelines for educational facilities. An outline of the acoustic measurement method aims and objectives is given in Table 4. Acoustic measurement methods include:

(i) Reverberation Time RT(s) (Canning & James, 2012)

(ii) ambient noise levels, unoccupied room (dBA) (Canning & James, 2012)

(iii) occupied room noise levels, activity noise logged over time, equivalent average Leq (dBA) (Canning & James, 2012)

(iv) clarity of sound C50 (ms) in various positions (Bradley, 2010).

The acoustic properties of spaces are determined by the design of the building. In order to achieve suitable internal noise levels, noise control or attenuation of noise is considered during the design phase.

Acousticians determine the internal ambient noise levels by accounting for several factors such as:

(i) building services: air conditioners, toilets, lighting, and computer systems

(ii) external noise intrusion: road, rail, air traffic, nearby industry and sporting activities

(iii) internal noise transmission: between rooms and spaces generated by the activities of the occupants).

Achieving suitable noise levels requires testing procedures and assessments using acoustic methodology and instruments, with the building being constructed of materials that reduce, to defined limits, the intrusion of noise from external sources and internal transmissions (Canning & James, 2012).

Attention to acoustical design factors has led to the development of noise attenuation techniques such as:

(i) floor impact isolation: reducing noise arising from walking, chair-scrapping
(ii) internal sound insulation: control of the level of difference or transmission loss between walls and ceilings

(iii) room reverberation standards: creating rooms that are fit for purpose; for example, classrooms that support clear speech, and concert halls that support symphonic music.

A review of research carried out in the past 40 years into various aspects of noise in open-plan classrooms revealed evidence of the negative effects of noise on children’s attention and cognition (Shield & Dockrell, 2003; Smaldino & Flexer, 2012). Much of the research focuses on noise levels in open-plan versus enclosed classrooms citing open-plan as generally problematic in terms of noise control (Shield et al., 2010).

I was unable to locate in the literature any studies that have elaborated on the collective impacts of pedagogy, learning technologies, acoustic design elements and teacher planned use of space as contributing determinants of noise levels in a learning environment.

The main purpose of collecting building acoustical measurements was to develop baseline statements regarding the acoustic value of the learning environment and to triangulate the results with ‘student voice’ and other qualitative data. Table 4 gives an overview of the aims and objectives of the acoustic method.
Table 4. Quantitative Acoustic Data Collection Methods, Aims, Objectives and Outcomes

<table>
<thead>
<tr>
<th>Data collection methods</th>
<th>Aims</th>
<th>Objectives</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building acoustic measures</td>
<td>Measure: Room noise levels over a 7-day period recorded using a noise logger measured in decibels (dB)</td>
<td>Understand: Variation in noise in the learning communities throughout a school day</td>
<td>Define and establish: Create a visual representation of sound by graphically plotting clarity from various sources to receiver locations in the learning environment</td>
</tr>
<tr>
<td></td>
<td>Reverberation times in various spaces measured in seconds</td>
<td>The clarity within a 50ms time frame at different positions in the learning environment</td>
<td>Share this information with participants in the focus group to elaborate their perceptions of noise control mechanisms and actions</td>
</tr>
<tr>
<td></td>
<td>Clarity C50, ratio of energy received at a given receiver position from a given source location</td>
<td>Noise levels in relation to student hearing acuity</td>
<td>Elaborate upon positions offering ‘best access’ to clear speech reception in the learning environment</td>
</tr>
<tr>
<td></td>
<td>Sound strength G, the total energy received at a given receiver position from a given source location measured in dB</td>
<td>The expected level of accessibility to speaking and listening activities at various positions in the built environment determined by position, clarity and noise present</td>
<td>Broadly explore interrelationships between student perceptions about communicative experiences, spatial elements and building acoustics</td>
</tr>
</tbody>
</table>

Methods Timeline

I negotiated open-access to site, in which I nominated days, but not times, when I would be visiting. This enabled me to discretely enter the learning environment and commence unstructured observations. I introduced myself to Lucy, Ben and Sammy and they were given assurance that they could approach me directly or indirectly at any time throughout the study.

During unstructured observations, I noted furniture arrangements, placement of windows/doors, flow of foot traffic, and movement patterns of students and teachers.
After three site visits, acoustic measurements were taken. I then met the students individually on-site. Together, we took photographs of their favourite spaces using an iPad. At this time, we chatted generally about space, place and technology in age-appropriate language. I recorded comments/notes in my research diary.

After synthesis of my initial notes, photographs were thematically coded noting similarities in spaces and student preferences for place. In accordance with the themes of pedagogy, space and technology, selected photographs were then used during the student semi-structured interviews.

The teacher interviews followed and lines of inquiry were pursued based upon ‘student voice’. Transcripts of all of the interviews were coded using the NVivo software tool. After further synthesis, I formally observed each student for a school day.

I next ran a focus group for students as advocated by Creswell and Plano Clark (2011), where interpretation of data is cross-checked as a measure of enhancing reliability, validity as well as mitigating researcher bias. Finally, a teacher focus group was conducted following the same protocols. Figure 10 depicts a time line of data collection demonstrating the intertwining of methods. A total of 60 hours were spent on-site.

**Figure 10.** Methods time line

**Qualitative Methods and Instruments**

The following sections explain, in detail, the methods and instruments used to collect the qualitative data used in this study.

**Photo elicitation**

Wagener (1979) suggests photographs are factual data, a recording of the research. Others believe photographs are tainted, subjective and secondary evidence (Bogdan & Knopp
Photo elicitation is the use of photographs to elicit, prompt, clarify, or spark a conversation or comment in an effort to explore participants’ thoughts, understanding or feelings regarding a situation under investigation (Moss, 2008). Those who use the visual reflexively have a belief in the transformative potential for modern thought, culture and society, self-identity, and memory and social science itself (Pink, 2001). Informed by prior research projects, selected photographs were thematically coded, with similarities and differences in spaces identified. Synthesised findings from acoustical data, interviews, focus groups, and observation notes were triangulated alongside the photographed spaces (Bourke, Grosvenor, & Norlin, 2014; Loughlin, 2013; Moss, 2008). Pictorial representations in research can be used to cross-check interpretations and provide a multi-lens approach to viewing the situation under investigation (Loughlin, 2013; Moss, 2008). Christensen & James, 2012 found less structured methods of interviewing children are most appropriate, and for children under the age of 11, visual prompts act as aids to memory and assist children with conveying thoughts and feelings. The case study students were asked to show me their favourite spaces within the learning environment. While touring, I prompted students to show me the following:

- A space they liked to be when chatting to the teacher.
- A space they liked to be when chatting to peers.
- A space they liked to be when working on an individual task.
- A space they liked to be when working in a group.

During these times I was able to familiarise myself with the environment from the child’s perspective whilst developing a rapport with the students. As researcher-participant, I chose to take the photographs to remove the distraction of students having to perform a skill while I prompted them for clues. This also allowed students to look clearly at my face as I spoke, enhancing their access to verbal communication. The photographs were taken with an iPad in order to spark impromptu conversations regarding student perceptions of technology in the environment. Students were asked:

- Do you have an iPad?
- What do you do with iPads?
- When can you use them at school?
Figure 11 depicts an excerpt from my research diary demonstrating the recording of photographic evidence alongside other mixed methods data.

**Site Visit 12/11/2014**

**Photo 1. Grade 2/3 Shared Open Collaborative Space**

- Highest Reverberation time 1.1 seconds at 1000Hz.
- Does not have perforated acoustic plasterboard ceiling
- No additional acoustic treatment post occupancy
- Grade 2/3 teachers avoid this space, few students choose to work here. Lucy says 'too distracting'
- Furniture arrangements vary from visit to visit. 2/3 collaborative area is generally more sparsely furnished than all other spaces. Carol says -open sparsely furnished spaces invite students to run! Teachers often say 'walking feet please'. Today this space is simply a transition space. The lack of furniture makes it sound more echo like. Sammy does not like to be in this space, Ben takes his hearing aids out here!

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**Figure 11. Excerpt from mixed methods research diary**

**Formal and informal observations**

Open-access to the school site was an initiative intended to reduce the ‘observer effect’, which is the phenomena of people behaving atypically when they are being observed (Gay, Mills & Airasian, 2006). As a consequence of the initial observations, further lines of inquiry...
developed. All data collected during observations were recorded and stored in a research diary that was kept under lock and key to protect the anonymity of participants (J. Creswell, 2012). Electronic data were stored in a password-protected file.

In order to document observations, I developed an observational protocol, which is a tool for organising a description of events and processes observed, as well as descriptive notes about emerging codes, themes and concerns that arose during the observations (Creswell & Plano Clark, 2011). Table 5 depicts the tool. I considered the technique of photo elicitation and how participants articulate events prompted by an image. The development of the tool enabled the articulation of an image in a moment in time, the physical learning space. I then added categories to capture other qualitative and quantitative data collected that could be coded and analysed.

Table 5. Example of an Observation Protocol Recording

<table>
<thead>
<tr>
<th>Date:</th>
<th>Learning environment comments</th>
<th>Who is directing movement</th>
<th>General comments</th>
<th>Movement patterns</th>
<th>Location changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.40</td>
<td>Students are in pairs scattered between the breakout pod and collaborative area, 3 doing work sheets/writing using iPads. Lots of chatter, bursts of noise but a general hum</td>
<td>Students are self-monitoring Self-directed, Karen is roaming Students directed out of nooks guided to desks</td>
<td>Lucy is sitting alone against desk facing outside window Task focused writing, intermittently using iPad. Student on single desk nearby occasionally shows Lucy her iPad work. Lucy acknowledges, smiles, shows iPad to student</td>
<td>Lucy remained in a seated position for entire activity until prompted by Karen Minimal student movement around Lucy</td>
<td>Lucy = 0 Karen= 6 Other students mostly stayed seated. Nooks not used, because of Karen’s direction</td>
</tr>
</tbody>
</table>

**Semi-structured interviews**

The importance of ‘student voice’ research is highlighted by the perspective of children as citizens and competent participants in research (Mac Naughton et al., 2010). Dialogue and interaction with children enables researchers to co-construct knowledge, reflect and monitor how one learns, and become attuned to the conditions that are conducive to learning (Mac
Naughton et al., 2010). Each participant was formally interviewed once for 30 minutes, answering a series of semi-structured questions (Kvale, 1996).

The purpose of the semi-structured interviews was to engage in dialogue in particular contexts. When children act and express themselves in a particular activity in an interactive context, mutual constituent of data generation is supported (Hedegaard & Fleer, 2008). The semi-structured open-ended questions were recorded as researcher narratives (Riessman, 2008). An overview of semi-structured questions is given in Appendix 2.

Drawing on research from cognitive psychology it was found that less structured methods of interviewing children are most appropriate, and for children under 11 years of age, visual stimuli are especially useful in the questioning process because pictures make the issues far more concrete than verbal representation alone (Christensen & James, 2012; Moss, 2008). These aids to memory assist children in conveying thoughts and feelings. Facial gestures and emotive reactions were also noted in order to gain greater insights when the child’s language skill presented difficulties in conveying articulate responses (Christensen & James, 2012; Moss, 2008).

**Focus group**

Participatory research often goes further than simply the inclusion of children’s participation; children are included in the design, execution and interpretation phases (Farrell, 2005). The children’s focus group is an inherent process that facilitates the checking of data (Cohen et al., 2011). It is a forum for sharing thoughts and problem-solving issues of inequity from a position of power. During the teacher focus group, prompts formulated during the synthesis of student perceptions are presented to the teachers. Through elaboration of personal perceptions amongst those with differences who represent a minority culture, individuals are given agency to the possibility of change (Biesta & Safstrom, 2011; Freire, 1970; Hart, 1990; Slobodzian, 2011). Clarification of prior comments made by teachers and congruency between rhetoric and action are elaborated. This procedure is a way of deliberately seeking alternative perspectives on a situation in order to disrupt thinking (Farrell, 2005). This decision is in line with the transformative design of the study.
Quantitative Methods and Instruments

The following headings set out, in detail, the methods and instruments used to collect qualitative data for this study.

Technology audit

An audit of technology devices in the learning environment was undertaken in order to account for visual and auditory support tools that enable multimodal communication. Table 6 depicts the instrument developed to complete the technology audit. The tool was developed to enable a description of the enactment of pedagogy simultaneously with the use of technology. It was designed to account for the context in which technology is deployed in the learning environment (Abbott, 2007; Moyle, 2010). The observation categories in the tool account for qualitative and quantitative responses to the use of technology in a moment in time in the physical learning space.

Table 6. Example of Technology Audit Instrument

<table>
<thead>
<tr>
<th>Place</th>
<th>Technology device and application</th>
<th>Access</th>
<th>Pedagogy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prep/Grade 1 Area</td>
<td>Netbooks x 28. Various activities, word processing, Google websites</td>
<td>Shared resource 28 laptops, 147 students, 6 teachers</td>
<td>Teacher directed activity Students must seek permission to access</td>
</tr>
<tr>
<td>Grade 2/3 Area</td>
<td>Inbuilt zoned Soundfield system. Voice enhancement</td>
<td>Teacher-centred use. Student’s use when directed by teacher</td>
<td>Used during explicit instruction and dyadic teaching and presentations. Teacher-centred group work</td>
</tr>
</tbody>
</table>

Acoustic method design

An acoustical engineer was approached to provide expert advice on how best to determine the clarity of speech a student could expect to access when positioned in various places within the open-plan environment. For the purpose of this study, attaining this type of baseline measure is significant because it demonstrates optimal positions teachers may adopt during explicit instruction and informs where students may place themselves during independent activities when they wish to avoid hearing others in order to concentrate (Harvey Clark, 2014).
Following standard industry protocols and recommendations by the American National Standards Institute ANSI S12.6-2002. Acoustical performance criteria, design requirements and guidelines for classrooms. USA, the following acoustical measurements were taken:

(i) Reverberation times (seconds)
(ii) Ambient noise, unoccupied room (decibels)
(iii) Noise present, occupied room (decibels)
(iv) Clarity C50 (milliseconds)

The intentions of the selected measurements were to explore responses to the environment in various positions within the space, and more specifically, account for the lived experience of individuals. It was decided that comparison of reverberation times and average noise levels would not define the optimal positioning for the student, teacher and sound absorption materials in the open-plan learning environment. For this reason, a measurement known as clarity C50 was calculated. Clarity is defined as ratio of energy arriving in the first 50ms to the remaining energy (Bradley, Sato, Picard, 2003). This approach is supported by Bradley (2010) who highlights that some acoustic measures are linear quantities and others are logarithmic, so that simple correlations may not be very revealing.

Within this mixed methods case study design, acoustic data is considered as corroborating evidence when critiquing ‘student voice’ and other participant perceptions regarding communicative experiences.

**Acoustic instruments and procedures**

Acoustic data collection methods were implemented following ANSI (2002) industry standards and protocols, and co-administered by an acoustical engineer and me. The protocols are explained in ANSI S12.6-2002. Acoustical performance criteria, design requirements and guidelines for classrooms. Table 7 outlines the acoustic measurement parameter, instruments and procedures.
Table 7. Acoustic Measurement Instruments and Procedures

<table>
<thead>
<tr>
<th>Measures</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reverberation times and clarity C50</strong></td>
<td>The reverberation time and clarity were measured in octave bands across the range 50–5000 Hz. A sound source signal was generated from a dodecahedron (non-directional) speaker at a designated location. A receiver, which is a triaxial microphone, which records sound from any direction, was placed at various positions from the sound source (Harvey Clark, 2014). The results are downloaded in the Iris™ software program for analysis. The results were recorded and presented as 3-D graphical representation of the measures</td>
</tr>
<tr>
<td><strong>Noise levels</strong></td>
<td>Noise was logged using an instrument referred to as a noise logger. The logger captures all sound sources in the room such as ‘class noise’ generated from students and furniture movement; ambient noise from external and internal sources, eg., air conditioners and road noise and speech noise (Canning &amp; James, 2012). Recordings were logged every 15 minutes over a 7-day period. The software program in the noise logger records the results, which are downloaded to excel for analysis. The results are then graphically represented as time weighted averages in recorded in decibels.</td>
</tr>
</tbody>
</table>

Analysis Techniques

The following sections explain in detail the analysis techniques used in this study.

**Qualitative analysis**

The qualitative evidence was analysed using thematic narrative analysis (Riessman, 2008). Similarly, with a focus on content, that is ‘what is said, written or visually shown’, Riessman (2008, p. 53) suggests that thematic narrative analysis can support researchers to develop theories based on the stories that are gathered. The process remains iterative. Data were triangulated and cross-checked in cycles as new theories evolved and the hypothesis tested. A within case, followed by cross-case analysis teases out similarities and differences, and correlations in situations (Denzin & Lincon, 2005; Yin, 1984). While a grounded theory building approach was considered, it was decided that thematic narrative analysis (Riessman, 2008) and using theory to explain phenomena were more suited to this emergent cross-disciplinary methodology.
To guide the analysis process a matrix was created to assist with keeping a coherent line of logic between themes, lines of inquiry and questioning. See Appendix 3 Matrix of Thematic Questioning.

The mixed methods data of semi-structured interviews, observation notes, building acoustic measures, technology audit notes, and annotated photographs were uploaded to the NVivo™ software tool and organised into themes. As patterns emerged, data were reorganised into subthemes.

Open coding followed by axial and selected coding followed (Strauss & Corbin, 1998). Through cycles of testing generated theories and sharpening the focus, patterns of affordances in the environment emerge. Slobodzian (2011) in a study of deaf students in a mainstream school, demonstrated that critical to this process is an understanding of student perceptions (Creswell & Plano Clark, 2011; Slobodzian, 2011).

During synthesis of the data, account is given to the impact of interrelated factors on the perceptions of the child, rather than considering such factors in isolation (Radcliffe, 2008, Prain et al., 2014). Once a set of circumstances is identified, further probing leads to deeper meaning, edging closer to understanding relationships and elements in the environment that impact access to quality communicative experiences and inclusion.

An example of a research diary narrative thematically coded is given in Figure 12. Social constructivist theory posed by Vygotsky (1989) and critical theory (Habermas, 1987) are used to develop meaning from participant perceptions in order to empirically map the affordances for inclusion in the NGLE.
Site visit 17/10/2015: Research Diary Narrative ‘Observing Ben 12.10 pm’

...he looks down at his opened exercise book at his writing attempts, appropriately answering verbal questions posed to him by the co-educator. This indicates a level of speech intelligibility is being accessed in spite of the constant presence of background noise. There is a lot of structures and routine surrounding Ben. He constantly returns to the same seat, along with his co-educator, who uses the ipad app with picture-word correspondences, this prompt’s Ben’s imagination. Words appear to take on meaning; digital pictures, a connection to literacy development, a communicative experience?? He completes tasks and shows her. Tait passes-by and occasionally checks in with Ben. She goes to him, not he to her. The team-teachers follow set routines in terms of timetable structures that have been agreed upon in planning. Predictability seems to mediate confusion arising from not hearing everything. Calm and order reigns, many students near-by work independently or quietly with one other, chatting, in quiet voices. The children are doing a task call ‘Waiting for’.... Note photograph (19) Ben undertaking this task, he sits in his favourite spot in his breakout pod, the Soundfield system is used to call all students together at the end of the task. Ben responds enthusiastically wanting to share......

Communicative Experience

Pedagogy

Technology

Self-regulation

Spatial affordance

Figure 12. Example of thematic narrative analysis (Riessman, 2008)

At different stages of data collection, demonstrating rigor in analysing qualitative ‘student voice’ research required the study to be grounded in the subjective meaning of human action (Cohen et al., 2011). At times, quantitative data were considered corroborating evidence for the purpose of validating the students’ perceived level of inclusion. This served to mitigate researcher bias and perspectives (Creswell & Plano Clark, 2011). Fereday and Muir-Cochrane (2006) advocate for three essential processes to be followed when analysing data:

1. The researcher must establish the highest degree of clarity of the conceptual framework and method applied, and these must follow the principles of formal logic.

2. The model must be grounded in the subjective meaning the action had for the ‘actor’.

3. There must be consistency between the researcher’s constructs and typifications and those found in common-sense experience; this model must be recognisable and
understood between the ‘actors’ in everyday life (Fereday & Muir-Cochrane, 2006; Schutz, 1973).

Whilst evaluating the NGLE under investigation, this study attempted to demonstrate rigor at all stages through transparency and multiple accountabilities in reporting the perceptions of inclusion of the child.

**Quantitative analysis**

Acoustic data were analysed using standard industry protocols (AAAC, 2010; Bradley, 2012; Canning & James, 2010). The data were used for two main purposes:

(i) to triangulate with the qualitative data and corroborate ‘student voice’

(ii) to develop baseline statements regarding the acoustic value of the breakout pods and collaborative area.

**Clarity**

The measurement and analysis system for recording reverberation times, ambient noise and clarity is referred to as the Iris™ system. The system is specifically designed to capture and analyse room impulse responses and report results using 3D graphical representations. Reflected signals are measured in time (milliseconds) and strength (decibels). When the reflected ray strength is considered along with signal direction, it provides an indication of the ratio of early to late sound arriving at the receiver position. The higher the ratio, the better the clarity. This is because the most important parts of speech are contained in the first 30–50 milliseconds in the octave bands across the range 50–5000 Hz. Figure 13 depicts this concept in a speech frequency chart that graphically represents sound frequencies.
Figure 13. Speech frequency chart: Normal, Mild, Moderate, Severe, Profound refer to levels of hearing loss.

Typically, vowel sounds are louder and appear in the mid-frequency range, whilst consonants are less audible appearing in a higher frequency band (Flexer et al., 2005; Smaldino & Flexer, 2012). Often, children with good hearing abilities find it difficult to differentiate high frequency sounds in noisy environments as they are easily masked by unwanted sound.

**Occupied room noise levels**

Logging noise over time enables researchers to look at patterns and track noise generation and noise control mechanisms more accurately (Canning & James, 2012; Shield et al., 2010). Once noise levels are logged, a number of calculations can be applied to extract information about how a space is acoustically responding to the activities of the occupants. Table 8 outlines a number of occupied room noise level descriptors. The equivalent continuous (time-averaged) A-weighted sound level was considered the most appropriate descriptor for this study. This is commonly referred to as the ‘average’ noise level.
<table>
<thead>
<tr>
<th>Noise level descriptors</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_{A90}$</td>
<td>The noise level exceeded for 90% of the measurement period, measured in dBA. This is commonly referred to as the background noise level.</td>
</tr>
<tr>
<td>$L_{A_{\text{max}}}$</td>
<td>The A-weighted maximum noise level. The highest noise level which occurs during the measurement period. (In the context of a school, this could be a loud squeal near the microphone, or someone dropping something – it is unlikely to be teacher voice.)</td>
</tr>
</tbody>
</table>
| $L_{A_{\text{eq}}(t)}$ | The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the ‘average’ noise level.  
  The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.  
  Sound varies over time. The $L_{A_{\text{eq}}}$ is effectively defined as a notional steady sound level, which over a stated period of time, would contain the same amount of acoustical energy as the actual, fluctuating sound measured over that period (in our case 15 mins). |

An example of A-weighted sound level time histories are given in Figure 14, which demonstrates the various ways the logged noise parameters can be interpreted.
Figure 2-15. Example A-weighted Sound Level Time Histories

Figure 14. Example A-weighted sound level time histories (Bradley, 2010)
Strengths and Weaknesses of Design

We can come to an understanding of the particular and as such, comprehend a little more about the general (Stake & Usinger, 2010). This research project is situated in a specific context, a new generation learning environment. The student cases have hearing abilities that are not equal to that of their peers. In each individual context, the child’s hearing abilities present similar and different challenges.

The research aims to understand a particular situation rather than explain situations in general. The methods were specifically chosen to add to a collective body of knowledge, a close-up look versus trying to draw generalisations to many contexts.

A strength of this approach is the ability to develop emerging methodologies in order to respond to the rapidly changing landscapes for learning. Learning environment evaluation approaches that encapsulate pedagogy, space and technology are not reported in research on students with learning differences. Whole-school program approaches are also not widely reported in the literature on students with hearing difficulties. The research methodology for this study enables the sensitive elaboration of equity issues experienced by minority cultures, while alerting the majority culture to the possibility that transformational change is required for education to be truly emancipatory (Biesta & Safstrom, 2011; Freire, 1970; Hart, 1990).

Comparisons between the three cases were made, however this was not a strength of the research.

Comparison is a close companion to description and an essential aid to interpretation—but it is not the strongest base for coming to understand how a thing works (pp. 27 Stake and Usinger, 2010).

A deeper exploration of uniqueness and context are better suited to complex situations. For this reason, the strength of the mixed methods approach was the ability to deliver rich descriptions with corroborating evidence.

A weakness of the design is the replicable nature of the research method in its current format. As a participant observer, a significant amount of time was consumed at the research site checking, cross-checking and observing. Validity and reliability were strengthened by the cross-checking of synthesis by experienced research supervisors (Glaser & Strauss, 1967).
Interpretation was challenging due to the variety and number of data sources; however, experienced research supervisors strengthen reliability.
Chapter 4: Findings

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).

Chapter Overview

This chapter reports the findings of the acoustic measurements and qualitative data collection. The chapter begins by presenting the results of the acoustical measurements, highlighting the variance in the way particular spaces were able to mediate noise generated by the occupants of the learning environment. Next, the qualitative data findings are presented. A cross-case thematic narrative analysis highlighted similarities and differences in the way the participant students accessed communicative experiences. Student perceptions of inclusion in the NGLE were formed as personal communicative experiences occurred via multimodal pathways.

Acoustic Findings

The following sections detail the data collected with respect to noise/acoustics within the NGLE. Definitions and descriptions of acoustic parameters and target values are given in Appendix 4.

Noise logger data

The ambient noise level in the collaborative area and breakout pods was recorded at 25 decibels; this is considered a good room response and is below the average current industry recommended standard of 35 decibels in an unoccupied classroom. Ambient noise is generated from building services such as air conditioning systems and lighting, and accounts for external noise sources intruding into the space, such as passing road traffic.

Occupied room noise accounts for the noise generated by the activities of the teachers and students. An average of 73 decibels was recorded in the collaborative area during the school day. This is considered very noisy, akin to running a hair blow dryer 20 cm from your ear.

Industry standards suggest that for speech to be intelligible it must be heard 15 decibels over background noise (Flexer, 2012). Teachers standing 2–3 meters from a student would effectively have to yell to be heard clearly over 73 decibels of background noise.
How to read the noise logger graph

The noise logger results are presented in Figure 15. Each ‘dot’ represents the Leq (average noise level) over a 15-minute period. Each coloured line represents a day. Sound was recorded over a seven-day period.

Figure 15. Noise logger data recorded in the Grade 2/3 collaborative area

Reverberation

Room reverberation in the breakout pods was measured at 0.4 seconds, which is within general industry standards of between 0.3–0.6 second reverberation time for learning spaces (see Table 10).

In contrast, room reverberation of 1.1 second was recorded in the Grade 2/3 collaborative area, far exceeding industry standards for learning spaces (see Tables 9). The prep / grade 1 area recorded 0.7 second reverberation time. Although this was still above the recommended 0.3 seconds, it was lower than the grade 2/3 collaborative areas. Post occupancy the prep teachers complained of excessive noise generated during play-based activities. As such additional acoustic panels were installed thus accounting for the difference in reverberation times between the spaces.
As a result of long reverberation times, the collaborative area echoed and noise generated from student activities quickly escalated and flowed back into the breakout pods.

While the breakout pods had good reverberation times, occupant noise escalated rapidly when noise intruded from activities being conducted in the adjacent reverberant collaborative area.

Table 9. Collaborative Area Reverberation Times

<table>
<thead>
<tr>
<th>Space</th>
<th>Reverberation time (sec)</th>
<th>ACCC 2010 recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 2/3</td>
<td>1.1</td>
<td>&lt;0.6 secondary school</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;0.3 primary school</td>
</tr>
<tr>
<td>Collaborative area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prep/Grade 1</td>
<td>0.7</td>
<td>&lt;0.6 secondary school</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;0.3 primary school</td>
</tr>
</tbody>
</table>

Table 10. Breakout Pod Reverberation Times

<table>
<thead>
<tr>
<th>Space</th>
<th>Reverberation time (sec)</th>
<th>ACCC 2010 recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakout pods Grade 2/3</td>
<td>0.4</td>
<td>&lt;0.6 secondary school</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;0.3 primary school</td>
</tr>
<tr>
<td>Breakout pods Prep/Grade 1</td>
<td>0.4</td>
<td>&lt;0.6 secondary school</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;0.3 primary school</td>
</tr>
</tbody>
</table>

**Reading the findings**

The findings are presented by first depicting an image of the learning space, followed by an image of the floor plan. Next appears a table of acoustic measurement results followed by an Iris plot which is a graphical representation of the acoustic measurement results.
**How to read the graph depicting clarity**

*The* Marshall Day Acoustics Iris System™ is a recent innovation in capturing and presenting the clarity of sound in a space. For the purpose of this study, information is presented in the following format:

1. First appears a photograph of the learning space under investigation. Next appears a floor plan of the learning environment. On the floor plan ‘S’ depicts the location of the sound source, for example, the place a teacher stands whilst speaking. ‘R’ depicts the location of the receiver, for example, the position of the student listening. The measurements recorded by the Iris system appear next in table format, followed by the corresponding Iris graph. The graph depicts sound movement and strength. Sound rays arriving at the measurement position are represented as a series of easy to identify coloured spikes. It is interpreted as follows:

   - The spike direction tells where the ray has come from.
   - The spike length tells the strength of the ray.
   - The spike colour tells when the reflected sound arrived at the microphone.

2. The red is the fastest, strongest, most direct signal associated with the highest degree of audible clarity in this instance. The light blue is the weaker, slower signals. These represent late energy arriving at the receiver. More light blue lines in the plot appearing from multiple directions indicate less clarity. This is because lots of sound coming back late, after 80ms, causes the important content in speech to be lost.

   The plot can be used to relate sound rays to physical features of the room, observe the directional distribution of early and late sound energy, as well as identify surfaces causing problematic reflections.
Figure 16. Collaborative Grade 2/3 learning space
Figure 17. Floor plan Grade 2/3 learning environment with source and receiver positions

<table>
<thead>
<tr>
<th>Key</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td><img src="source_icon" alt="Source" /></td>
</tr>
<tr>
<td>Receiver</td>
<td><img src="receiver_icon" alt="Receiver" /></td>
</tr>
</tbody>
</table>

The following data collected using the Iris™ system outline reverberation times, clarity and ambient noise findings in the collaborative area.
**Table 11. Grade 2/3 Shared Collaborative Area Receiver 3m from Source**

<table>
<thead>
<tr>
<th>Room Number:</th>
<th>Room Description:</th>
<th>Collaborative area</th>
</tr>
</thead>
</table>

| Area: **146m²** | Volume: **730m³** |

**Finishes**

<table>
<thead>
<tr>
<th>Ceiling</th>
<th>Plasterboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor</td>
<td>Carpet tile</td>
</tr>
<tr>
<td>Walls</td>
<td>Glazing / plasterboard / pinboard (echopanel)</td>
</tr>
</tbody>
</table>

**Acoustic test results summary**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Receiver 1 (approx 3m from source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{mf}$, s</td>
<td>1.1s</td>
</tr>
<tr>
<td>$L_{A90}$, dB (unoccupied)</td>
<td>25dB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Octave Band Centre Frequency (Hz)</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1k</th>
<th>2k</th>
<th>4k</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{20}$ [s]:</td>
<td>0.8</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>$T_{30}$ [s]:</td>
<td>0.9</td>
<td>1.2</td>
<td>1.3</td>
<td>1.1</td>
<td>1.1</td>
<td>0.9</td>
<td>-</td>
</tr>
<tr>
<td>$C_{50}$ [dB]:</td>
<td>3.1</td>
<td>1.5</td>
<td>2.5</td>
<td>3.4</td>
<td>2.1</td>
<td>5.2</td>
<td>8.1</td>
</tr>
<tr>
<td>$D_{50}$ [-]:</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>0.6</td>
<td>0.8</td>
<td>0.9</td>
</tr>
</tbody>
</table>
Figure 18. Iris plot of Grade 2/3 collaborative area 3m from source to receiver representing poor clarity

The Figure 18 Iris plot shows lots of late sound reflections bouncing back from many different directions. These mask the clarity of the strongest most direct signal depicted by the red spike. The reflections can be related to the solid plasterboard walls, ceilings and celestial windows. The absence of soft furnishings in the space exacerbate the reflective nature of sound, as obstacles like fabric-covered couches, curtains and acoustic panels absorb sound reflections.
The following data collected using the Iris™ system outline reverberation times, clarity and ambient noise findings in the breakout pod.
Table 12. Grade 2/3 Breakout Pods Receiver 2.5m from Source

<table>
<thead>
<tr>
<th>Room Number: Learning Area 4</th>
<th>Room Description: Breakout Pod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area: <strong>69m²</strong></td>
<td>Volume: <strong>186m³</strong></td>
</tr>
<tr>
<td>Finishes</td>
<td></td>
</tr>
<tr>
<td>Ceiling</td>
<td><strong>Perforated plasterboard</strong></td>
</tr>
<tr>
<td>Floor</td>
<td>Carpet tile</td>
</tr>
<tr>
<td>Walls</td>
<td>Glazing / plasterboard / pinboard (echopanel)</td>
</tr>
</tbody>
</table>

Acoustic test results summary

<table>
<thead>
<tr>
<th>Receiver 1 (approx 2.5m from source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>T\text{mf}, s</td>
</tr>
<tr>
<td>\text{L}_{A90}, \text{dB (unoccupied)}</td>
</tr>
<tr>
<td>Octave Band Centre Frequency (Hz)</td>
</tr>
<tr>
<td>T20 [s]:</td>
</tr>
<tr>
<td>T30 [s]:</td>
</tr>
<tr>
<td>C50 [dB]:</td>
</tr>
<tr>
<td>D50 [-]:</td>
</tr>
</tbody>
</table>
Figure 21. Iris plot Grade 2/3 breakout pod receiver position 2.5m from source representing good clarity

The strongest most direct signal is depicted by the red spike. It has minimal interference from later sound reflections. Lower ceiling heights with perforated plasterboard, soft furnishings, blinds on the windows, and acoustic panels on the walls contribute to enhancing greater sound clarity. Appendix 5 reports further acoustic measurements from a variety of positions within the learning environment. When a room supports clarity of sound the speech signal is more intelligible as it is less prone to distortion caused by reverberation and unwanted late sound reflections (Bradley & Sato 2008; Canning & James 2012).

Clarity

Clarity of sound varied significantly between spaces with high reverberation times compared to spaces with low reverberation times. The lower reverberant breakout pods supported significantly greater clarity of sound, whilst the highly reverberant collaborative areas did not support clarity of sound, which in turn impacted the capacity of students to access clear speech signal.
Levels of clarity also varied within lower reverberation spaces, with particular positions within the breakout pods presenting slightly greater clarity than others. Figure 18 and 21 depict the differences in clarity between the break out pod and the Grade 2/3 collaborative area.

**Noise control in the collaborative area and breakout pods**

Controlling noise in open-plan environments can be problematic if the acoustic conditions and design of the space are not conducive to controlling unwanted sound reflections and reverberation. For example in the collaborative area high ceilings created a greater volume of space, in addition the area was sparsely furnished. Sound reflections bounced off hard plaster walls where sound attenuation panels or acoustic panelling were not fitted. This made the space echo to a greater extent than adjacent areas.

Because of high reverberation times, noise was hard to control. Compounding this problem was the ‘Lombard effect’. This occurs when entering a noisy space, people tend to talk louder and noise quickly escalates. The opposite is the ‘Library effect’; that is, when entering a quiet space people tend to talk more quietly.

Teachers routinely sent students to the collaborative spaces for noisy activities such as group work and play-based activities, openly stating that they avoid teaching in the collaborative area as it is ‘too noisy’, preferring to remain inside the breakout pods.

In the breakout pods noise was slightly easier to control. The volume of space was less due to lower ceilings, which had acoustic rated perforated plasterboard that broke up sound reflections. Additional acoustic panelling lining the walls dampened echo. The windows, which contained highly reflective surfaces that contribute to reverberation were slimline and not to the floor. They also had perforated blinds fitted and these factors contributed to reducing echo and enhancing clarity.

Whilst the smaller breakout pods had good noise attenuation, occupant noise spilt from the collaborative areas into the pods, as there were no barriers to contain the noise. This remained highly problematic. The noise logger demonstrated that an average of 73 decibels regularly intruded into the pods. This noise interfered with the ability of all occupants to engage in clear intelligible speech reception; those with hearing difficulties were excluded from activities that involved listening when specific attention was not paid to intermittently ceasing adjacent noisy activities whilst verbal instructions were delivered.
Qualitative Findings in the NGLE

During analysis the findings were thematically code and recoded within the themes of pedagogy, space and technology. As patterns of evidence emerged in the learning environment, the connectedness and interrelationships of teacher pedagogical approach, spatial design and technology became apparent. The qualitative findings shed light on the personal experiences of the acoustic value of the learning environment by demonstrating particular ways the occupants experience activities in the space.

Pedagogy

Pedagogy is defined as practices, strategies or styles of instruction engaged by teachers and students (Cleveland, 2011). In addition to building acoustics, organisational structures and the enactment of pedagogy both enhanced and precluded access to communicative experiences for the case study students. At times, teachers taught independently in the pods only meters away from each other, often speaking over the top of each other. The unrelated teaching and learning activities interfered with the students’ abilities to listen and cognitively process intelligible speech. This situation provided a greater barrier to the students’ already challenged hearing abilities and auditory processing pathways.

Conversely, teachers who taught synergistically as a team by coordinating speaking and listening activities increased opportunity for the case study students to access communicative experiences, as this organisational procedure reduced the incidences where voices competed. For example in case study student Ben’s breakout pods the teachers taught synergistically viewing two classes of 26 students as effectively one class of 52. When explicit instruction was given all students stopped and the Soundfield system was used which distributed the teacher’s voice throughout the space.

Noise dropped significantly when teachers in adjacent spaces cooperatively planned a silent activity during short stints of explicit teaching, however it was found that this approach in the Prep / Grade One area was rarely adopted. This is because the Prep teachers tended to operate separately from the grade one teachers. There were no apparent pedagogical strategies for implementing day-to-day collaborations regarding the placement of activities in particular spaces. The result was that at times the preps occupied the play-based collaborative area while the grade one’s attempted to learn teacher directed mathematical concepts on a
nearby interactive white board. Play-based student noise escalated dramatically during the activity making it difficult for the Grade 1 students to hear teacher explicit instructions.

**Space**

In the context of this paper the term space is not considered fixed or absolute, but as socially produced, it is a social construct that has values and power relations that make their way through structures (Armstrong, 2012). Space produces particular forms of activity and sets of relations by configuring the identities and understandings of people who occupy it (Lupton, 2009). The personal experiences of space are reported in the following findings.

The case study students preferred spaces within the breakout pods that were found to have lower reverberation times, less foot traffic and reduced visual stimulus. These spaces can be described as a ‘nook’ or space that is generally found in a tucked-away place. According to the online Merriam Webster Dictionary, a nook is a quiet place that is sheltered by a tree, rock, etc: a part of a room (such as a corner) that is used for a specific purpose.

When given a preference, the case study students retreated to nooks, which were found to be acoustically sound spaces that offered sensory reduction experiences. These spaces were frequently occupied during individual tasks or pair-shared activities. Figure 22 depicts Lucy’s favourite learning space.
Lucy’s favourite space was a nook against an acoustic wall in the breakout area; Lucy said she felt comfortable because there were fewer distractions making it easier for her to concentrate and complete tasks. Lucy was often observed communicating with a peer or her teacher here; sound clarity was good. She said in these moments she felt included.

Sammy’s preferred space was in the far corner of the breakout pod where sound clarity was also supported, as depicted in Figure 23. The couch elevated students, giving them a clear visual to the teacher’s face. In this position, the teacher was less than two meters away from the back row of students. When the adjacent collaborative area was unoccupied, background noise levels dropped significantly. Sammy was observed looking intently at the teacher’s face and answered questions appropriately here.
Ben liked to sit against an acoustic panelled wall in the corner of the breakout pod, as depicted in Figure 24. This was popular with many students who worked together to secure this position during snack-time. As informal conversations flourished, Ben was observed contributing on a regular basis.
The term technology is used to emphasize the wide range of tools and resources that students and teachers might access both inside and outside the learning environment. Technologies maybe hardware-based such as computers, mobile devices, Soundfield systems; or they maybe software-based such as web applications, social networking spaces, blog sites. The term also covers virtual reality, integrated learning systems and multimedia (Abbott, 2007). More recently the term ‘e-inclusion practices’ has emerged to describe the interaction between digital tools, contexts and people, and focuses attention on the activity of the use of technologies by or with people with learning differences (Abbott, 2007). The following findings report on the practices of engaging with technology in the learning space.

During observations, on three separate occasions explicit instruction stopped abruptly in case study student Sammy’s breakout pod as noise suddenly escalated when the Prep teachers sent groups of students to the shared collaborative play-based area. When this occurred, technology was often deployed as a tool for learning. Alternatively, independent or pair/shared activities that involved some degree of self-regulation were set up.
Technology provided a bridge into many learning activities. Banks of laptop computers and iPads were shared amongst the grades at a ratio of one device to three students. At times, the case study students requested to use a device; however, accessibility was often restricted as they were in high demand.

Ben had his own iPad funded through a program for students with disability; however, the teacher controlled access to the iPad, which had not become an embedded tool in Ben’s learning. Ben also had a funded inbuilt Soundfield system in his breakout pods. The teachers said the gentle amplification and distribution of their voices helped all children to hear more clearly over background noise. Ben’s teachers said it was a most valuable tool for him, as he began to refuse to use his other personal assistive listening devices, preferring just his hearing aids and the Soundfield system.

*Figure 25. Technology visual support tools; Interactive White Board*

Sammy highlighted the importance of visual support tools that enable her to understand activities more clearly; she described how her teacher Carol directed her to the interactive white board when she was uncertain about the next steps in a task. This was a
strategy that made Sammy feel independent and capable. At times, she was unable to hear Carol’s instructions yet could understand the simple picture-word correspondences on the board. Other times, Sammy was observed guiding other non hearing-impaired students towards the board.

**The interrelationships of pedagogy-space-technology**

Ben’s favourite learning space was all of his breakout pods; he liked all of it. He enthusiastically told me, “it has microphones and I like technology like iPads and computers”. Two classes occupied this space, but as they worked together in synergy, they appeared more like one class of 50 students.

In contrast, Lucy’s Grade 2/3 breakout area, although identical in design, housed three classes with 78 students in total. At times, the teachers set up independently and competed against each other, conducting activities as they would if they were in three separate classrooms.

![Figure 26. Lucy’s teachers teaching simultaneously next to each other.](image-url)
When Lucy was shown Figure 26, she described that when her teachers talked at the same time at the separate IWBs it made her “feel dizzy, anxious and frustrated”.

**Student perceptions of inclusion**

The case study students perceived, to different degrees, that they were included in many and varied communicative experiences in their learning environment throughout the school day.

Ben found it difficult to think of a time he didn’t feel included, only highlighting one time in the playground when someone said he couldn’t join in.

Lucy said she felt “OK” about being included but highlighted that she was frustrated and distracted by noise during explicit instruction time when Karen, her teacher, “talked too much too long”. She said she “did not feel that included then”.

Sammy pointed out her favourite learning space was the outside playground; this is when she felt most included as she could hear better in the outdoor environment. When Sammy was asked to try to choose a space inside that she liked she took me to the ‘nooks’ found in tucked-away places towards the edges of the breakout pods. Noisy spaces precluded Sammy from engaging in conversations with her peers and teachers. She was observed accessing instructions using technology or working closely with a trusted other who demonstrated the tasks. Sammy appeared to be self-regulating and was content to watch and then participate as a means of working out what to do next.

Sammy’s teacher Carol was very diligent in tracking the progress of all her students; she had developed deep familiarity with the students as she circulated throughout the learning environment, regularly checking in on an individual basis as students worked independently or in small groups. This is how Carol detected Sammy’s hearing loss. Sammy felt included by Carol and her peers. She seemed to be unaware of her own hearing loss, simply exploring her environment and finding places and spaces that innately suited her learning and communication needs. The pedagogy of the space in Sammy’s breakout pods enabled these opportunities to unfold.
Chapter 5: Discussion

Chapter Overview

This chapter elaborates upon the communication modalities of the case study students and draws upon the emancipatory lens of Friere (1970) who stated:

To surmount a situation of oppression, people must first critically recognize its causes, so that through transforming action they can create a new situation, one which makes possible the pursuit of a fuller humanity (pp. 28).

This chapter discusses the four subsidiary research questions that emanated from the literature review, and subsequently addresses the key research question: ‘What affordances are required for inclusion of students with hearing difficulties in new generation learning environments?’ The subsidiary questions are:

1. What level of noise is present in the case study students’ learning environment and how is this mediated?

2. How are teachers planning the use of the space?

3. How is communication facilitated for, and by, the case study students?

4. What elements in the open-plan learning environment facilitate opportunity for case study students’ participation in speaking, listening and communication?

The central themes of the study are used as a framework to address the questions. This approach is supported by Istance (2011) who contends that learning in the 21st century is not a private matter associated first and foremost with the individual, but an accomplishment with and through others in a learning environment. Such a perspective sits at odds with the traditional nature of educational institutions and formalised schooling structures that are based upon individualistic thinking. Istance further asserts that in seeking ‘what works’ in education, collective holistic solutions are required that take into account what happens at macro, meso and micro levels. As the questions in this chapter are addressed, the interrelationships between elements within the construct of the study are elaborated.
Hearing Abilities — Student Self-regulation and Self-advocacy

Question 1: What level of noise is present in the case study students’ learning environment and how is this mediated?

When the case study students were afforded the opportunity to access a diversity of experiences, inclusion was perceived by the students. Feelings of frustration, however, were reported when teachers’ explicit instruction was lengthy, particularly when background activity noise levels were high. Diminished opportunity to self-advocate and self-regulate during these times presented a hurdle for the case study students, as they were unable to mediate their own hearing abilities in these situations.

Both Lucy and Ben reported feelings of anxiousness when they were unable to process auditory information and subsequently did not understand the task at hand. This frustrated both the students and the teacher. Thompson (2013) asserts that within an inclusive paradigm, failure to succeed on the part of the student is attributed to a mismatch between the needs of the student and the variables in his or her instructional and social environment. The opposite to an inclusive paradigm is the deficit perspective, which has individualistic theoretical underpinnings framing all problems as the individual’s problem; this perspective tends to examine the child apart from his or her social context (Thomson, 2013).

The school actively sought to implement an inclusive model of intervention for students with learning differences. The leadership team explicitly raised awareness of student learning differences with the teaching staff. This escalated conversations amongst teachers that aimed to address inequities experienced by minority culture students.

Principal Beth said “…we have looked at several of the practises that are leading to not every child being able to access and engage to their capacity, and it’s about what do we do around those practises, so it’s certainly on the agenda…”

In was apparent that the leadership team critically recognised that students like Ben with hearing difficulties had different learning needs to students without hearing deficits. As such provision was made to install a Soundfield system in Ben’s breakout pods and affordances made to ensure the technology was used appropriately to enhance inclusion in learning activities.
Deputy principal Tim said... “I worked in behavioural schools where kids have been excluded, I have a strong passion that every child counts. Every child needs to be supported. Every child needs to have the exact same opportunities for their learning, for their spiritual growth, for their social growth as anybody else, whether they present with behavioural issues – we work with that; they present with physiological issues – we work with that; they present with learning difficulties – we work with that.”

The case study students reported feeling included when they were empowered by choice, for example, when they selected a position in the space and were allowed to freely access technology tools. As a result, Ben and Lucy reported greater access to communicative experiences and a heightened sense of independence during learning activities. This led to a positive self-image as an equal amongst their peers in terms of contributing to the community of learners. During these times, the hearing abilities of the students were mediated by self-advocacy and self-regulatory mechanisms specific to their own needs. This included positioning themselves closer to the person speaking, watching others and interpreting their actions, lip reading, and using technology such as personal listening devices and shared iPads that were used collaboratively in some activities.

*Question 2: How are teachers planning the use of space?*

The teachers reported feelings of frustration in relation to collaboratively planning the use of the vastly open space and placement of activities. Whilst teams of teachers within year levels planned together, there was little communication and collaboration between the year level groupings. This resulted in clashes of activities in adjacent spaces. Teachers became increasingly annoyed and frustrated at the noise escalations; this led to blaming one another for a perceived lack of consideration of each other’s teaching and learning needs in the learning environment. In turn, the leadership team raised issues of noise control and suggested pedagogical enactment was to be addressed to rectify the situation. A lack of physical barriers to negate noise, however, remained problematic.

*Dovey and Fisher (2014)* discussed the school as a socio-spatial assemblage using an analytic framework of assemblage theory to examine situations of pedagogical and spatial alignments. At St Helens, the use of space, its order of assemblage, and subsequent occupation resulted in problems with noise control, collaborative teacher practices, and inclusion of students with hearing difficulties. *Dovey and Fisher* suggested that the most open of school plans are not the most agile or fluid. The lack of spatial typologies in the overall design meant
that teachers did not have alternative spaces to retreat to when conducting noisy activities, or quiet, explicit instructions.

An intricately designed timetable of activities assigned to particular spaces was considered as a noise control mechanism. However, teachers grappled with the potential restriction of fluidity and flexibility in delivering a personalised learning experience for students, saying that such a structure was against the school vision of being responsive to the needs of students who may wish to pursue an activity through alternative modalities other than those timetabled. Concerns were also raised that students would be ‘locked into class groupings’ rather than iteratively moving amongst interest and skill-based groups should such a timetable be imposed. As such, noise continued to be problematic, with 73 decibels consistently present in the collaborative area. It was increasingly evident that the assembling of space, its lack of typologies and the inability of the teachers to manipulate the design led to issues of noise control. In turn, noise was a barrier to inclusion of the case study students during explicit listening activities.

**Habitation — Organisational Structures and Culture**

**Question 2: How are teachers planning the use of space?**

Very poor acoustic standards in the Grade 2/3 collaborative space rendered it practically useless as a teaching and learning space. Ben’s teacher described a time that he once took out his hearing aids and threw them on the desk, as he could no longer tolerate the noise level. When asked if she taught in this space, the teacher replied, “no I find it too noisy”. She preferred to stay in the breakout pods. The collaborative area had a high reverberation time, well above the learning space recommendations made by the ACCC (2010) and ANSI (2010). Only silent activities were suited to this space in terms of usefulness and noise mediation. This seemed at odds with intent of the space articulated by teachers and students as “the shared collaborative area”. The Merriam Webster Dictionary defines collaboration as the act of working jointly with others or together, especially in an intellectual endeavour. The space had become little more than a transition hallway, a thoroughfare to the rest of the school. It was difficult to speak and listen to one another as noise intruding from the breakout pods reverberated due to lack of acoustic affordances. This part of the building was excluding students and teachers with hearing difficulties from accessing speaking and listening activities.
The subsequent impact of not utilising the noisy collaborative area meant that students and teachers were inadvertently forced back into the breakout pods in order to avoid the unpleasantness of the area. This in turn created congestion in the breakout pods and additional noise. As such, teachers tended to limit group discussions and pair-share activities in order to mediate the persistent noise. Alternatively, some teachers would occasionally take their classes outside to work, which was Sammy’s favourite learning environment.

Imms (in press) found spaces afforded certain practices, excluded certain practices and elicited certain practices. While teachers spoke of a pedagogical approach that privileged personalised and differentiated teaching and learning practices, they struggled to find appropriate settings within the learning environment that enabled this to unfold. Lippman (2013) suggests that collaborative activity settings must be purposefully designed —structured to support the learner, the learning, and the things to be learned. All three case study students reported difficulty accessing learning opportunities involving periods of intent listening in the collaborative shared areas.

Emergent NGLE research has found links between different learning spaces and student perceptions related to their learning, and in particular, that teachers were able to alter their pedagogies in different spatial layouts (Bayers, Imms & Hartnell-Young, 2014). However, while particular spaces within the learning environment were supportive of active pedagogical practices and collaborative learning modalities, the agent of change was the teacher and that the success of the learning spaces movement lies in their hands.

It was found that the acoustic spatial characteristics at St Helens, however, played a role in influencing teacher decision-making with regard to pedagogical initiatives and use of space. If it was too noisy, the teacher changed practices or spatial location, often avoiding collaborative practices.

The enactment of inclusive education policies such as the Disability Standards for Education (2005) and the Disability Discrimination Act (1992) call for multiple accountabilities and transparencies in provisioning equitable access to learning opportunities for all students at school. Classrooms with poor acoustics are non-inclusive environments (Anderson 2001). Acoustic standards for learning spaces are not mandated in Australia. Oversights such as high reverberation times have resulted in the development of inequitable learning spaces, hence compromising opportunities for inclusion of students with suboptimal hearing abilities. Lippman (2015) asserts that it is less about the building and more about understanding what
activities are intended to occur in the space when designing effective teaching and learning environments. Furthermore it is about recognising that activities lead to transactions, which transform the learner so they can develop skills that can be transferred across settings. Exclusion happens when a student is prevented from entering into such transactions. Wegner (1998) says spaces must be purposefully planned as integrated learning systems, where the learners must be valued and understood as an apprentice who will learn the shared practices within the learning environment. This highlights the importance of building spaces that are fit for purpose and provision equitable access for all. Teachers must be afforded the opportunity to construct learning experiences in spaces that are malleable, responsive to the needs of the learner and include everyone, particularly in speaking and listening activities.

**Question 3: How is communication facilitated for and by the case study students?**

There were few sensory reduction zones and constant noise in Lucy’s Grade 2/3 breakout pods, which housed three classes totalling 75 students. Constant noise and chatter bothered Lucy who said “it makes me feel dizzy”. Klatte, Bergstroem and Lachmann (2013) found that when a child is required to process verbal auditory information, more cognitive effort is required when intelligible speech can be heard in the background, as compared to unintelligible babble. Students with hearing difficulties are most at risk of not being able to access verbal information unless a level of quiet is sustained for the period in which direct teaching occurs (Smaldino and Flexer 2012). Momentary drops in noise levels were intermittently observed in the breakout pods. These times inconsistently coordinated with planned explicit instruction times. With no acoustic barriers between the breakout pods and the collaborative areas noise was a constant hurdle for the case study students. Ben however was afforded additional support via a Soundfield system which overcame the distance to noise ratio in his breakout pods, he said “the speakers and microphones” gave him a greater sense of inclusion during explicit teaching times.

Lucy and Sammy did not find their learning environment always pleasant and inviting. Sammy preferred outside and Lucy preferred to retreat to a favourite nook on the edge of the breakout pods. It was here that they found it easier to communicate with peers as there were fewer distractions and they could concentrate more intently on the person talking.

Ben’s Grade 2/3 breakout pods had two classes totalling 50 students, who were strategically spread throughout the pods. Two teachers worked cohesively and collaboratively, mindful of the timing of activities, and cognisant never to speak over the top of each other.
Ben’s hearing aids were a constant visual reminder to attend to the auditory environment. A Soundfield system purchased for Ben provided auditory access to the interactive white board and facilitated access to spoken instructions. Twenty-five fewer students contributed to a less cluttered, less noisy environment. Ben found his breakout pods pleasant and reported a sense of inclusion and connectedness to the learning community. Ben disliked the highly reverberant collaborative area. Self-advocacy enabled him to self-regulate his response to the environment; feeling stressed, he refused to work in the collaborative area and placed himself in his favourite position in the breakout pods, an action supported by the teachers.

For all three case study students communication was regularly facilitated through multimodal pathways including the use of assistive listening devices, iPads and interactive white boards, which reinforced information sharing via visual prompts.

**The New Generation Learning Environment**

*Question 4: What elements in the open-plan learning environment facilitate opportunity for case study students’ participation in speaking, listening and communication?*

Sammy’s and Lucy’s teachers said they had little control over the learning environment beyond their breakout pods and felt limited in their capacity to change the situation for their students. They cited the ‘noise’ as a reason students may feel excluded at times. The teachers had not considered that assembling spaces in particular ways enabled or disabled their ability to control noise and inclusion. Pedagogical and spatial alignments made Lucy feel anxious, confused and tired in situations such as when the interactive white boards were lined up close together, yet used independently. Rowe, Pollard and Rowe (2004) and Flexer and Smaldino (2012) describe how some students working in noisy environments experience noise-induced cognitive overload, with auditory processing disorder students most at risk. This was the case for Lucy who said “I cant block other teachers speaking, they sound fuzzy together... it’s frustrating and makes me angry”.

Organisational structures adopted by Prep/Grade 1 teachers also precluded Sammy from accessing oral language development during play-based activities. She couldn’t hear her friends, so simply avoided the indoor play-based area. While on the surface it would appear that Sammy had equitable access to play-based learning, the reality was that she was excluded from engaging in conversations with her peers because of her hearing deficit and the noisy environment, as a consequence she missed oral language learning opportunities.
Sammy had become accustomed to her hearing loss and had developed strategies to enable access to verbal communication, these included waiting for momentary drops in background noise before asking questions, writing or drawing prompts for her friends, working with peers in nooks and lip reading. Sammy’s favourite learning space was the outdoor play areas, she was able to find places where there were no competing activities nearby, places where she could hear her friends speak. While inside it appeared that teacher timetabling of the use of space was problematic, yet not insurmountable. When scenarios were raised in focus group discussions involving alternative strategies developed by students, all the teachers agreed that better coordination of activities in particular spaces at particular times was worthy of further investigation as a noise control mechanism. This included relocating the indoor play-based area to an undercover outdoor area.

**Affordances for Inclusion**

Returning to the key research question, several affordances or qualities of the environment facilitated inclusion of the case study students. The emergence of particular elements acting in synergy rather than isolation led to the identification of what was working for the case study students in this interactive noisy place. The elements included the trusted other, student agency, nooks-sensory reduction zones, technology and policy and governance. These are discussed in detail below.

**The trusted other**

A pivotal moment in the study surfaced when I simply stopped trying to understand why Ben, Lucy and Sammy felt included in this poor auditory environment and just started focusing on what they were actually doing.

Regular access to working with a ‘trusted other’ or learning buddy enhanced perceptions of inclusion for Ben, Lucy and Sammy. The trusted other is a person that a student considers a ‘good choice for their learning’. Engagement with a trusted other often facilitated a sense of connectedness and social inclusion whilst bridging the case study students into learning activities.

I asked the students, “Do peers help you learn?” Ben said, “I help them to learn too”. Lucy said, “We motivate each other by encouraging each other to stay on task”. Sammy said, “I look and I learn”. Many times, she was observed picking up on visual prompts from her
peers. Freely accessing a trusted other for learning provided a heightened sense of inclusion for all three case study students.

**Student agency**

The trusted other emerged within the theme of habitation as a consequence of organisational structures and the culture of the environment. Student agency is the power to act (Van Leir, 2008), as students moved freely about the space they were able to seek, receive and act upon the support of others in places that they deemed appropriate for them. Teachers frequently underestimate their students’ ability to be perceptive about what works and does not work for them (Thiessen & Cook-Sather, 2007). Student agency, however, led students to choose spaces and places that suited their learning needs, strategically increasing access to learning opportunities and activities.

Tanner’s (2015) meta-analysis of the effects of architectural designs on students’ accomplishments highlighted how the school’s physical environment compliments human behaviour and cognition, drawing on Maslow’s hierarchy of needs to demonstrate the connections. For example humans experience their world through sight, touch, smell, hearing and taste. Maslow’s hierarchy of needs commences with physiological needs. When the case study students found some of their needs were not met they were afforded the opportunity to act, to change their experience based upon their own perceptions of what might be a better choice for their learning. This involved changing locations within the learning environment if they could not see, seeking a quieter position in the space if they could not concentrate, approaching a teacher for permission to use resources such as technology that may help overcome a hurdle in a learning activity. Paulo Freire sort to uncover effects of external social realities and structures on peoples lives and help them develop the tools for countering inequitable conditions, at a micro level this is akin to teachers enabling student agency in the learning environment (Manning, 2010).

The case study students were regularly observed making a good choice about what worked for them in terms of selecting spaces and places that acoustically suited their needs.

**Nooks — sensory reduction zones**

When Ben, Lucy and Sammy wished to communicate with a trusted other, they moved to suitable places with fewer distractions, into ‘nooks’ within the environment. For the purpose of this study nooks are defined as a series of diverse sensory reduction zones strategically
found in low reverberation spaces. They are another type of space assembled within the environment offering less visual and auditory distractions, they are usually found in a corner or on the peripheral of a room.

Students, when given the freedom to place furniture, often created nooks. These types of spaces were popular with all students and frequently occupied. Teachers noted student preferences for such places and began to align furniture strategically, purposefully creating more nooks to accommodate their growing popularity. The case study students said they could freely chose to retreat to nooks. It was here that communication was more easily accessed; they were closer to the person talking, making it easier to hear. Nooks provided a sense of intimacy and connectedness that led to feelings of inclusion in communicative experiences.

Inclusion in speaking and listening activities at school is a basic requirement for all teachers and students. It therefore follows that school infrastructure accommodate people with a diverse range of hearing abilities and sensory needs. 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 specialised design (Millet, 2009., Universal Design Principles, 2015). The principle is that changes made to accommodate persons with disability will benefit everyone; given that a core component of learning at school is speaking and listening, well-designed learning spaces with good listening properties are not simply an issue of equity, budget or design, but a fundamental requirement for everyone, not just a design affordance for those with suboptimal hearing abilities.

Further research is needed in order to identify universal design principles for developing acoustic nooks-sensory reduction spaces within a learning environment. For example it is not known if the popularity of nooks identified in this study is attributed to a sense of safety and cosiness, or because they offer a different acoustic experience, or whether the nook enhances opportunity for verbal communication, or enables independent learning.

**Technology**

All of the case study students reported a sense of inclusion when communicating with and through technology modalities. At times the devices triggered peer discussions about the learning. Other times, the case study students engaged with picture prompts, apps, and listened with headphones to video clips.
Lucy highlighted her satisfaction at being able to use a laptop with spell check and apps that assisted with literacy tasks and enabled her to work independently. Ben expressed dissatisfaction at not being able to use classroom technology at will, such as his iPad.

The case study student responses highlighted that universal access to basic technology devices added great value to their ability to engage in communicative and learning experiences in what might otherwise be described as an impossible environment to access information by auditory means alone. This highlights that learning happens in many different ways and for the pedagogue, it is important to know the path one should lead the child. For the architects, it is particularly important to know the affordances required for the creation of inclusive NGLEs; and for teachers it is important to know how to manipulate the affordances of a learning environment such as leveraging the available technology to enhance accessibility to learning opportunities.

Policy and Governance and the Impact on Individuals

Amendments to existing parliamentary acts and new legislation have heightened awareness of situations of inequity. For example, the Australian Education Bill 2012 intends to ensure that all children can equitably access the high quality education to which they are entitled. Informed by legislated requirements in the Disability Discrimination Act 1992 (DDA), key initiatives have included developing and implementing a national plan for school improvement and needs-based funding arrangements.

*Transparency and Accountability* and *Meeting Student Need* are key reform areas that can play a vital role in addressing the quality of accessibility in the physical learning environment (Hooge, Burns, & Wilkoszewski, 2012).

Building compliance, quality assurance and adherence to legislated regulations are effective mechanisms for ensuring that student needs are met. For example, implementing the mandatory requirements of the Building Code of Australia *Design for Access and Mobility: Communication for People who are Deaf or Hearing Impaired*. There is yet to be a system-wide approach to evaluation and a certification process to ensure implementation of hearing accessibility legislative requirements in Australian schools, in spite of the rhetoric found in inclusive education policy. Figure 27 depicts Australian legislative initiatives towards creating equitable spaces and the need for implementation issues to be resolved. Figure 27 highlights
the Commonwealth Government of Australia’s response to provisioning additional support for people with hearing difficulties in public meeting places.

Ministry of Education policy documents define and categorise student’s with learning differences (disability) and map out the ways in which schools determine which supports are to be applied to which learners (Cobb, 2015). On one level students maybe given an individual learning plan, however these can be time consuming to create and there is no guarantee that they will be implemented or the desired outcomes achieved. On another level, in a supportive learning environment students have access to a rich array of resources and infrastructure that ensure greater access to inclusion in multiple learning opportunities. While many students with learning differences are identified, the phenomena of non-identification exists where many students go undetected and remain unsupported in their particular learning environments (Cobb, 2015). For example Lucy and Sammy’s hearing difficulties were undetected for a significant time. Effectively Sammy and Lucy were ‘designed-out’ of opportunities for inclusion in their built learning environment as the spaces were acoustically poor, reverberant and unlike Ben, they did not have access to a Soundfield system. This highlights the importance of universal design strategies for ensuring hearing accessibility in learning environments and adherence to government legislation that aim to ‘design-in’ affordances for inclusion at school, including providing the contingency for the development of inclusive building infrastructure.
Figure 27. Australian legislated initiatives towards creating equitable spaces for people with hearing difficulties and implementation issues.
Chapter 6: Conclusion

What Affordances Enable the Inclusion of Students with Suboptimal Hearing Abilities in new generation learning environments?

In the research school, the fluidity and openness of the learning spaces, coupled with the culture of the environment, enabled the case study students the opportunity to develop strategic decision-making skills, a valuable tool in today’s society. The learning environment was structured well enough to provide a sense of safety, yet fluid enough to allow for a sense of freedom, self-discovery and self-regulation. Student agency, defined by Van Lier (2008) as the power to act, was directly observed.

Communicative experiences unfolded in spaces that the children innately found worked for them, without the pedagogical structures that enabled students the latitude to explore the environment this may be a different situation.

All three case study students perceived they were included in communicative experiences, particularly when they were collectively afforded the opportunity to access technology, engage with trusted others and occupy sensory reduction zones such as nooks.

High reverberation times in the collaborative areas excluded the case study students from listening activities. There are no mandated acoustical standards for learning spaces in Australia and as a result, institutions are not held accountable for oversights such as high reverberation times and lack of adherence to hearing access legislative initiatives, which result in inequitable access to the learning environment for students with hearing difficulties.

An affordance speaks directly to the quality of an experience and goes beyond the rhetoric of current disability discrimination legislation such as the DDA 1992 that speak to ‘reasonable adjustments’ that don’t impinge on the majority culture.

In summary, building on past research and moving forward, this study endeavoured to engage with new approaches to solving issues of equity in mainstream learning environments by employing a multidisciplinary approach and considering factors in synergy rather than isolation.
This is because assembling a space creates an infinite amount of possible experiences for individuals, and for the pedagogue, designers and education systems it is particularly important to know the affordances of a learning environment that enable the enactment of inclusive education policies, so that every child has every opportunity to learn.

Future Research

Future evaluative research is required to develop the metrics for measuring inclusion in a NGLE environment. Figure 28 depicts an inclusion concept model of evaluation. The model depicts the themes within this study, which were explored in order to identify the affordances of the environment — and then maps them along a continuum — suboptimal to optimal opportunities for participation in communicative experiences, for example:

Pedagogy: The type and frequency of pedagogical acts that enabled inclusion as perceived by the student.

Spatial performance standard: Measurement of the acoustic value of the learning environment.

Technology: The number of technology devices and level of student access to appropriate technology tools.

Habitation: The number of organisational structures that typically enable student agency.

Hearing abilities: Student self-advocacy and self-regulation skills.
Empirically recording and evaluating this information may give an evidence-based picture of the level of inclusion one can expect to experience in a new generation learning environment. The tools for this model are yet to be explored.

The concept model aims to broadly and accurately assess a learning environment’s capacity to include students with suboptimal hearing abilities. Justifications for adopting this model are that the study uncovered interrelating factors acting in synergy, rather than isolation, mediated the case study students’ communicative experiences.

Given that a core function of a learning environment is to support speaking and listening, educators must be assured that the environment in which they teach enables the facilitation of the pedagogy and enactment of the principles of inclusive education.
Even though the study found a significant proportion of the learning environment was acoustically poor and excessive noise present throughout the day, the case study students perceived they were included. The study highlighted that considering factors in isolation, such as building acoustics and student hearing acuity alone, does not give a clear picture of the extent and specificity of affordances required for inclusion in a learning environment.

Whist speaking and listening remain the central mode of communication in schools, there is an ongoing imperative to evaluate inclusion of the 7–10% of students with hearing difficulties in mainstream schools in Australia, and an urgent imperative to act upon the evidence-based research findings.

Despite the lack of legislation, future building projects in the education sector need to consider acceptable noise restriction requirements, as noise is an important factor that impinges upon learning and pedagogy.

Hence, this study highlights three levels to be considered: Firstly, at the macro level, in which funding for school building projects explicitly considers noise control and quality acoustic design. Secondly, at a meso level, where school leadership teams develop organisational policies, processes and procedures that are supportive of teachers implementing inclusive education practices, which include noise control mechanisms and the auditory environment. Thirdly, consideration must be given at the micro level where students are given agency to explore the learning environment and allow them choice of technology, spaces and places that optimise learning and foster a sense of inclusion.
Bibliography


Cleveland, B. (2009). Equitable pedagogical spaces: Teaching and learning environments that support personalization of the learning experience. Critical and Creative Thinking 17(2) 59-76.


Rowe, K. J., Rowe, K. S., & Pollard, J. (2004). *Literacy behavior and auditory processing, building fences at the top of the cliff in preference to fences at the bottom*. Paper presented at


Appendix

Appendix 1. St Helens’ daily organisational structures

St Helens Primary School (pseudonym) is situated on the urban fringes of Melbourne in a rapidly expanding growth corridor. The student body is composed of over 50 different nationalities. In the first year of operation, the school catered for approximately 170 students. In the second year, the second stage of the school building was complete, and student numbers rose to 374 students. Data for this research project were gathered at this time.

There is a mix of experienced and graduate teachers. Two of the case study students, Ben (pseudonym) Grade 2 and Lucy (pseudonym) Grade 3, occupy the 2/3 learning community. This community is composed of 5 teachers and approximately 132 students. Sammy (pseudonym), female, Grade 1, is the third case study student, and occupies the Prep/Grade 1 learning community along with 146 students and 6 teachers.

Breakout pods have lower ceiling heights, windows and doors to the outside. The Shared Area has a high vaulted ceiling with celestial windows and forms a large corridor-like space that divides the clusters of breakout pods. Typically, in one learning community there are six breakout pods and one large Shared Area. There is an eclectic mix of furnishings, including ottomans, couches, traditional tables and chairs, cushions, beanbags, dome tents, bookshelves, and bag storage units on casters; some are covered in acoustic soft fabric.

The school day is organised into learning blocks delineated by the timetable depicted in Table A.

Class groupings and teachers are designated to a home-base zone within a learning community. Philosophically, teacher and student placement is fluid, with teams of teachers negotiating the organisational structures within their community. Students are encouraged to make choices about their learning preferences and styles; this includes where they would like to situate themselves during particular activities. The multi-purpose mezzanine room and conference room are the only two locations in the school that require a formalised booking system.
Student choice is mediated by frequent one-to-one conversations focusing on how best to maximise learning potentials and outcomes. These conversations ebb and flow between a teacher and student, student-to-student, and teacher-to-teacher.

*Table A.* Daily Timetable

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.40am</td>
<td>Learning spaces and office open</td>
</tr>
<tr>
<td>08.50am</td>
<td>Preparation for formal learning</td>
</tr>
<tr>
<td>09.00am</td>
<td>Formal sessions begin</td>
</tr>
<tr>
<td>11.00am</td>
<td>Eating time</td>
</tr>
<tr>
<td>11.10am</td>
<td>Recess</td>
</tr>
<tr>
<td>11.30am</td>
<td>Formal sessions continue</td>
</tr>
<tr>
<td>13.30pm</td>
<td>Eating time</td>
</tr>
<tr>
<td>13.40pm</td>
<td>Lunch play</td>
</tr>
<tr>
<td>14.20pm</td>
<td>Formal sessions continue</td>
</tr>
<tr>
<td>15.30pm</td>
<td>Dismissal</td>
</tr>
</tbody>
</table>

Students are required to complete a series of tasks in order to get their weekly passports stamped. On any given day, a series of workshops, focus groups or whole-year level gatherings may occur simultaneously in a learning community. The learning activities are planned in weekly team teacher meetings.

Organisational structures are discussed and negotiated at this time such as student groupings. For example, groups maybe structured as 1 teacher to 25 students, 2 teachers to 65 students, or 1 teacher to 10 students. Groupings are based upon student data, which are collected by various teachers and fed back to the home-base teacher on a regular basis.

Teaching to the point of need drives the collection of selected student data. The student data then form the ‘design specs’ that drive the formulation of learning activities and subsequent organisational structures for the next week. This cycle is continuous and forms part of the fabric of the learning environment.
During explicit and direct teaching, groups are formulated by teachers. However, during semi-structured student-centred activities, students are encouraged to display the attributes of a responsible independent learner, by making choices and decisions that best suit their learning needs. Teachers and students are encouraged to discuss the attributes and expectations in a framework of respect for one another.
Appendix 2. Overview of semi-structured questions

A. Semi-structured interview questions principal, deputy principal, teachers, support staff

*Theme: Pedagogy*

- How best do you describe your schools pedagogical approach?
- What are the underpinning philosophies?
- Can you give an explicit example of what a visitor would see happening in your learning spaces on a typical day?
- Can you describe your staff’s understanding of your pedagogical visions?
- In your experiences, are there any particular challenges with this pedagogy compared to more traditional schooling pedagogies of the past?

*Theme: Learning Spaces*

- How old is your school?
- Can you describe what your learning spaces look like to someone who has not seen them?
- Were you involved in the design concept and building phases?
- What professional learning opportunities did you undertake moving from traditional cellular style classroom environments to open-plan learning environments?
- Are there any identified spaces that are particularly noisy? Why?
- Are there any identified spaces that are particularly quiet? Why?
- What were some of the key considerations in the selection of furniture?
- What do you observe as student-preferred places within the space? (photo elicitation)
- Do your teachers report preferred or non-preferred places to teach in? (photo elicitation)
- Are there any sensory reduction zones within the space that enable students to remain within the environments, however experience less visual and auditory stimulus?
- Have you identified any problematic spaces? Why?
- Do you experience particular spaces that are regularly nosier than others?
- Are there particular behaviours that indicate a student may be experiencing hearing difficulties? Can you describe the frequency, typical behaviours and outcomes of the behaviours?

- Typically, what activities occur when noise escalates, and where are activities situated at this time?

**Theme: Technology**

- Can you describe your technology policies, for example, 1:1 or bring your own device?

- What underpinning philosophies drive your technology policies?

- What are the key considerations and factors in selecting particular technology devices in your learning environments?

- Who selects the devices for purchase?

- What materials and references do you consider before a purchase?

- Can you describe the level of student access to a range of technology devices?

- Can students choose to access devices at will when engaged in independent learning activities?

- Where are fixed and mobile devices kept?

- Do all teachers allow students the same level of access? Why/why not?

- What auditory support technologies do you have access to?

- What visual support technologies do you have access to?

**Theme: Organisational structures**

- How many students attend this school?

- Can you describe your ‘typical’ student cohort?

- How many teachers at this school?

- Can you describe the teaching staff, e.g., young, graduates, older, percentage of males females?
- How do you structure where students and teachers are situated throughout the learning environments?  
- Can students choose to situate themselves freely within designated learning environments?  
- Are students able to choose where they place themselves within the space?  
- Are staff aware of which students experience hearing difficulties?  
- What adjustments are made for students with hearing difficulties?  
- What teaching strategies support students with hearing difficulties?  
- What professional learning opportunities have you participated in, in relation to teaching students with hearing difficulties?  

**B. Semi-structured interview questions student**

**Theme: Pedagogy**

- On an ordinary day, what do you do when you first get to school?  
- What would I see happening in your learning spaces at the beginning of the day?  
- What types of activities do you enjoy?  
- Can you take some photos of where those activities happen?  
- What makes those activities enjoyable?  
- Some activities are just boring; can you describe a boring activity?  
- Are there any particular activities that you find challenging/hard/difficult? Can you take photos of where those activities occur?  
- Why do you think those activities are so challenging/difficult?  

**Theme: Learning spaces**

- How old is your school?  
- How long have you been here?  
- Have you been to any other schools? If so, were they like this one? Which is better? Why?  
- Can you describe what your learning spaces look like to someone who has not seen them?
- What is your favourite space within the school to be in? What do you do there?
- Do you like to be in the big open spaces? Why/why not? What happens there?
- Are there any spaces that are particularly noisy? Why?
- Are there any spaces that are particularly quiet? Why?
- What is your favourite furniture in the space?
- Where do you prefer to work within the space? (photo elicitation)
- Where is your teachers’ favourite space? Why do you think they like to be there?
- Where does the teacher stand when they talk to the whole class? (photo elicitation)
- Can you see their face and hear them clearly, when they are standing there?
- Where do they mainly stand/sit when they just want to talk to you?
- Can you hear and understand what they are saying?
- Where would you like to be sitting when they come over to talk just to you? (photo elicitation)
- Are there any places within your learning environment that are less noisy/less busy?
- Can you choose to go there any time?
- Where do you like to be when you are working with your friends? Which is your favourite space, and why?
- Have you identified any problem spaces that you can’t hear very well in?
- Do you experience particular spaces that are regularly nosier than others?
- What do you do if you are having problems hearing you teacher? Your friends?
- How often does this happen? How do you feel? What would make it better? Where would you like to be in the space?
- What activities are happening when it gets noisy? Where are you? Do you still feel included? Where would you like to be during that activity?

Theme: Technology
- Technology can be things, tools and devices that help you to hear, see, do your work, explore information and organise your work.

- What types of technology do you have in your learning spaces?

- What is your favourite type of technology? What do you do with it? Can you choose when you want to use it?

- What types of activities does your teacher ask you to do with technology?

- What does your teacher do with the different types of technologies? Does your teacher use any technologies that help you to hear and learn?

- Do you feel like you can ask your teacher if it’s ok for them to use technology to help you hear them and understand them better? Why/why not?

- Do you have to ask your teacher if you want to use technology to help get your own work done?

- Where are fixed and mobile devices kept?

- Do all teachers allow students the same level of access? Why/why not?

- Do you feel like you can just help yourself to the technology in your learning spaces? Is this a good thing?

**Theme: Organisational structures**

- Can you choose to sit and work wherever you like?

- How do you feel about the way your day is organised? If you could organise your day what would you do first and last? When would you do the noisiest activities, and why? The quietest activities, and why?

- Are students able to choose where they place themselves within the space?

- Are your teachers aware that you experience hearing difficulties?

- Do your teachers help you in any special way to hear well? If so, how?

- What do teachers do to check that you understand? Where are you and where are they when they check? How often do they check up on you?
- Can you think of a time in your learning space when you have felt really upset and frustrated because of your hearing difficulty? Where were you; what activity was happening then; did your teacher or a friend know about this? What did you do?

- What does your teacher do, that you feel is a good way of helping your hearing difficulty?

- What would you like them to do more of?

- Do other kids know you have a hearing difficulty? Do you find it hard to hear other kids in certain places within your learning environment? What is your favourite place to be with other kids? What activities do you do there?
### Appendix 3. Matrix of thematic questioning

<table>
<thead>
<tr>
<th>Question</th>
<th>Category</th>
<th>Context</th>
<th>Methodology</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the main themes emerging from the data?</td>
<td>Themes</td>
<td>Narrative</td>
<td>Content analysis</td>
<td>Content analysis</td>
</tr>
<tr>
<td>How do these themes relate to the research questions?</td>
<td>Themes</td>
<td>Theory</td>
<td>Content analysis</td>
<td>Content analysis</td>
</tr>
<tr>
<td>What are the implications of these themes for the research findings?</td>
<td>Themes</td>
<td>Implications</td>
<td>Content analysis</td>
<td>Content analysis</td>
</tr>
<tr>
<td>What further research is needed to address these themes?</td>
<td>Themes</td>
<td>Future research</td>
<td>Content analysis</td>
<td>Content analysis</td>
</tr>
</tbody>
</table>

*Note: This table is a simplified example and the actual matrix provided in the document may contain more detailed information and include additional columns.*
### Appendix 4. Definitions and description of acoustic parameters and target values

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>Sound strength</td>
<td>Total energy received at a given receiver position from a given source location</td>
</tr>
<tr>
<td></td>
<td><strong>Target value for school 15dBA</strong></td>
<td>G=\text{L}<em>{\text{p,listener}}-\text{L}</em>{\text{p(dir,10m)}}</td>
</tr>
<tr>
<td>C50</td>
<td>Clarity</td>
<td>Ratio of energy arriving in first 50ms to the remaining energy</td>
</tr>
<tr>
<td></td>
<td><strong>Target value for school 3\text{dBA}</strong></td>
<td></td>
</tr>
<tr>
<td>STI</td>
<td>Speech Transmission Index</td>
<td>Speech Transmission Index. A single number rating system to quantify the intelligibility of speech, or the ease with which speech can be understood. STI is a value between 0.0 and 1.0, where 0.0 is completely unintelligible and 1.0 is perfectly intelligible.</td>
</tr>
<tr>
<td></td>
<td><strong>Target value for school &gt;0.6s</strong></td>
<td></td>
</tr>
<tr>
<td>RT</td>
<td>Reverberation Time</td>
<td>Reverberation time is measured in seconds and is an indication of how quickly sound decays within a space. A low RT 0.2 indicates a quiet or acoustically ‘dead’ space, a high RT 0.9 indicates a more reverberant or acoustically live’ space.</td>
</tr>
<tr>
<td></td>
<td><strong>Target value for primary school 0.3</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Target value for secondary school 0.6</strong></td>
<td></td>
</tr>
<tr>
<td>D50</td>
<td>Definition</td>
<td>A measure that is best thought of as a balance between reverberation and clarity and is described as the early to total sound energy ratio</td>
</tr>
</tbody>
</table>
Appendix 5. Acoustic findings from various positions in the learning environment at St Helens

*Figure A. Collaborative Grade 2/3 learning community*
Figure B. Floor plan – collaborative area with source and receiver positions
Table B. Grade2/3 Collaborative Area (Resource) Measurement Summary

<table>
<thead>
<tr>
<th>Room Number: Resource</th>
<th>Room Description:</th>
<th>Shared learning area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area: 146m²</td>
<td></td>
<td>Volume: 730m³</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Finishes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling</td>
</tr>
<tr>
<td>Floor</td>
</tr>
<tr>
<td>Walls</td>
</tr>
</tbody>
</table>

Acoustic test results summary Receiver 1 (approx 3m from source)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1k</th>
<th>2k</th>
<th>4k</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{mf}$, s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$L_{A90}$, dB (unoccupied)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Octave Band Centre Frequency (Hz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>G %</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{20}$ [s]:</td>
<td>0.8</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>$T_{30}$ [s]:</td>
<td>0.9</td>
<td>1.2</td>
<td>1.3</td>
<td>1.1</td>
<td>1.1</td>
<td>0.9</td>
<td>-</td>
</tr>
<tr>
<td>$C_{50}$ [dB]:</td>
<td>3.1</td>
<td>1.5</td>
<td>2.5</td>
<td>3.4</td>
<td>2.1</td>
<td>5.2</td>
<td>8.1</td>
</tr>
<tr>
<td>$D_{50}$ [-]:</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>0.6</td>
<td>0.8</td>
<td>0.9</td>
</tr>
</tbody>
</table>
**Figure C.** Grade 2/3 Collaborative area receiver 1 (3m from source)

**Table C.** Collaborative Area 2 Receiver 2

<table>
<thead>
<tr>
<th>Acoustic test results</th>
<th>Receiver 2 (Learning area 4/5 approx 7-8m from source) summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_{mf} ), s</td>
<td>1.2s</td>
</tr>
<tr>
<td>( L_{A90} ), dB (unoccupied)</td>
<td>25dB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1k</th>
<th>2k</th>
<th>4k</th>
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<tbody>
<tr>
<td>Octave Band Centre Frequency (Hz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C50 [dB]</td>
<td>4.4</td>
<td>2.9</td>
<td>-0.9</td>
<td>-3.2</td>
<td>-4.2</td>
<td>-2.8</td>
<td>-0.7</td>
</tr>
<tr>
<td>D50 [-]</td>
<td>0.8</td>
<td>0.7</td>
<td>0.4</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Figure D. Grade 2/3 collaborative area receiver 2 (7-8m from source)
Figure E. Learning Area 4 Grade 2/3 breakout pods
Figure F. Floor plan – Learning area 4 with source and receiver positions
Table D. Grade 2/3 Breakout Pods (Learning 4) Receiver 1

<table>
<thead>
<tr>
<th>Room Number: Learning Area 4</th>
<th>Room Description: Dedicated learning area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area: 69m²</td>
<td>Volume: 186m³</td>
</tr>
</tbody>
</table>

**Finishes**

- **Ceiling**: Perforated plasterboard
- **Floor**: Carpet tile
- **Walls**: Glazing / plasterboard / pinboard (echopanel)

**Acoustic test results summary Receiver 1 (approx 2.5m from source)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1k</th>
<th>2k</th>
<th>4k</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{mf}$, s</td>
<td>0.6s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$L_{A90}$, dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>(unoccupied)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G %</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>$T_{20}$ [s]:</td>
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<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>$T_{30}$ [s]:</td>
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<td>0.6</td>
<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>$C_{50}$ [dB]:</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>$D_{50}$ [-]:</td>
<td>6.9</td>
<td>6.9</td>
<td>7.7</td>
<td>9.1</td>
<td>7.4</td>
<td>12.4</td>
<td>14.9</td>
</tr>
</tbody>
</table>
Figure G. Grade 2/3 breakout pods (Learning 4) receiver 1 (2.4m from source)
Table E. Grade 2/3 Breakout Pod (Learning 4) Receiver 2

### Acoustic test results summary Receiver 2 (Learning area 4/5 approx 4-5m from source)

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>250</th>
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<th>1k</th>
<th>2k</th>
<th>4k</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tmf, s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA90, dB (unoccupied)</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Octave Band Centre Frequency (Hz)</td>
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<tr>
<td>Parameter</td>
<td>63</td>
<td>125</td>
<td>250</td>
<td>500</td>
<td>1k</td>
<td>2k</td>
<td>4k</td>
</tr>
<tr>
<td>G %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T20 [s]:</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.5</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>T30 [s]:</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>C50 [dB]:</td>
<td>-</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
</tr>
<tr>
<td>D50 [-]:</td>
<td>4.2</td>
<td>7.1</td>
<td>6.4</td>
<td>3.8</td>
<td>5.1</td>
<td>7.8</td>
<td>8.8</td>
</tr>
</tbody>
</table>

Figure H. Grade 2/3 breakout pods (Learning 4) receiver 2 (4-5m from source)
### Table F. Grade 2/3 Breakout pods (Learning 4) Receiver 3

<table>
<thead>
<tr>
<th>Acoustic test results summary</th>
<th>Receiver 3 (Shared area 2 approx 9m from source)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T\text{mf}, s</strong></td>
<td>1.1s</td>
</tr>
<tr>
<td><strong>L\text{A90}, dB (unoccupied)</strong></td>
<td>25dB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Octave Band Centre Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>G %</td>
</tr>
<tr>
<td>T20 [s]:</td>
</tr>
<tr>
<td>T30 [s]:</td>
</tr>
<tr>
<td>C50 [dB]:</td>
</tr>
<tr>
<td>D50 [-]:</td>
</tr>
</tbody>
</table>

Figure I. Grade 2/3 breakout pod (Learning area 4) receiver 3. 9m from source
Figure J. Prep/Grade1 (special projects 2) collaborative area
Figure K. Prep/Grade 1 floor plan showing source and receiver locations
**Table G. Prep/Grade 1 Collaborative Area (Special Projects 2)**

<table>
<thead>
<tr>
<th>Room Number: Special Projects 2</th>
<th>Room Description: Shared resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area: 138m²</td>
<td>Volume: 690m³</td>
</tr>
</tbody>
</table>

**Finishes**

- **Ceiling**: Perforated plasterboard
- **Floor**: Carpet tile
- **Walls**: Glazing / plasterboard / pinboard (echopanel)

**Acoustic test results summary**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1k</th>
<th>2k</th>
<th>4k</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T\text{mf}, s</strong></td>
<td>0.7s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>L\text{A90}, dB (unoccupied)</strong></td>
<td>30-35dB (fish tank) (estimate – not measured)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Octave Band Centre Frequency (Hz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>G %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>T20 [s]</strong></td>
<td>0.6</td>
<td>0.6</td>
<td>0.5</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>T30 [s]</strong></td>
<td>-</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>C50 [dB]</strong></td>
<td>3.2</td>
<td>4.0</td>
<td>2.7</td>
<td>6.0</td>
<td>4.9</td>
<td>6.3</td>
<td>6.2</td>
</tr>
<tr>
<td><strong>D50 [-]</strong></td>
<td>1.3</td>
<td>0.7</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>
Figure L. Prep/Grade 1 collaborative area (Special projects 2) Receiver 1 (2.5m from source)

Table H. Prep/Grade 1 Collaborative Area Receiver 2 Position

<table>
<thead>
<tr>
<th>Acoustic test results summary</th>
<th>Receiver 2 (approx 7-8m from source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T(_{\text{inf}}), s</td>
<td>0.7s</td>
</tr>
<tr>
<td>L(_{\text{A90}}), dB (unoccupied)</td>
<td>30-35dB (fish tank) (estimate – not measured)</td>
</tr>
</tbody>
</table>

Octave Band Centre Frequency (Hz)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1k</th>
<th>2k</th>
<th>4k</th>
</tr>
</thead>
<tbody>
<tr>
<td>T20 [s]</td>
<td>0.5</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.8</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>T30 [s]</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
</tr>
<tr>
<td>C50 [dB]</td>
<td>-</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>2.0</td>
<td>0.6</td>
</tr>
<tr>
<td>D50 [-]</td>
<td>5.5</td>
<td>1.1</td>
<td>0.5</td>
<td>1.0</td>
<td>1.1</td>
<td>0.1</td>
<td>2.3</td>
</tr>
</tbody>
</table>
Figure M. Prep/Grade1 collaborative area (special projects 2) receiver 2 (7-8m from source)
Figure N. Prep/Grade 1 breakout pods
Figure O. Floor plan showing source and receiver locations Prep/Grade 1 breakout pods
Table I: Prep/Grade 1 Breakout Pods (Learning 13)

<table>
<thead>
<tr>
<th>Room Number:</th>
<th>Learning 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area: 71m²</td>
<td>Volume: 192m³</td>
</tr>
<tr>
<td>Finishes</td>
<td></td>
</tr>
<tr>
<td>Ceiling</td>
<td>Perforated plasterboard</td>
</tr>
<tr>
<td>Floor</td>
<td>Carpet tile</td>
</tr>
<tr>
<td>Walls</td>
<td>Glazing / plasterboard / pinboard (echopanel)</td>
</tr>
</tbody>
</table>

Acoustic test results summary

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Octave Band Centre Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>63</td>
</tr>
<tr>
<td>Tₘᵣ, s</td>
<td>0.5</td>
</tr>
<tr>
<td>Lₛ₀, dB (unoccupied)</td>
<td>30-35dB (fish tank) (estimate – not measured)</td>
</tr>
<tr>
<td>G %</td>
<td></td>
</tr>
<tr>
<td>T20 [s]</td>
<td>0.6</td>
</tr>
<tr>
<td>T30 [s]</td>
<td>-</td>
</tr>
<tr>
<td>C50 [dB]</td>
<td>5.9</td>
</tr>
<tr>
<td>D50 [-]</td>
<td>0.9</td>
</tr>
</tbody>
</table>
Figure P. Prep/Grade 1 breakout pods (Learning 13) (2.5m from source)
Table J. Grade 1 Breakout Pod Receiver 2 Position

<table>
<thead>
<tr>
<th>Acoustic test results summary</th>
<th>Receiver 2 (approx 6-7m from source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_{mf}, \text{s} )</td>
<td>0.5s</td>
</tr>
<tr>
<td>( L_{A90}, \text{dB (unoccupied)} )</td>
<td>30-35dB (fish tank) (estimate – not measured)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Octave Band Centre Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>G %</td>
</tr>
<tr>
<td>( T20 , [s] ):</td>
</tr>
<tr>
<td>( T30 , [s] ):</td>
</tr>
<tr>
<td>( C50 , [dB] ):</td>
</tr>
<tr>
<td>( D50 , [-] ):</td>
</tr>
</tbody>
</table>

Figure Q. Prep/Grade 1 breakout pods (Learning 13) (6-7m from source)
Table K. Grade 1 Breakout Pod Receiver 3 Position

<table>
<thead>
<tr>
<th>Acoustic test results summary</th>
<th>Receiver 3 (approx 9m from source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{mf}$, s</td>
<td>0.8</td>
</tr>
<tr>
<td>$L_{A90}$, dB (unoccupied)</td>
<td>30-35dB (fish tank) (estimate – not measured)</td>
</tr>
<tr>
<td>Octave Band Centre Frequency (Hz)</td>
<td></td>
</tr>
<tr>
<td>Parameter</td>
<td>63</td>
</tr>
<tr>
<td>G %</td>
<td></td>
</tr>
<tr>
<td>$T_{20}$ [s]:</td>
<td>0.4</td>
</tr>
<tr>
<td>$T_{30}$ [s]:</td>
<td>-</td>
</tr>
<tr>
<td>$C_{50}$ [dB]:</td>
<td>1.6</td>
</tr>
<tr>
<td>$D_{50}$ [-]:</td>
<td>2.6</td>
</tr>
</tbody>
</table>
Figure R. Prep/Grade 1 breakout pods (Learning 13) (9m from source)
Author/s: 
Munro, Leanne

Title: 
New generation learning environments: are students with hearing difficulties included

Date: 
2016

Persistent Link: 
http://hdl.handle.net/11343/112438

File Description: 
New Generation Learning Environments: Are Students With Hearing Difficulties Included