TEXAS ARCHITECTS' KNOWLEDGE AND ATTITUDE REGARDING AN ANSI STANDARD FOR CLASSROOM ACOUSTICS

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ABSTRACT

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Acoustical barriers to communication are disruptive to the learning process, affecting speech perception, student behavior, and educational outcomes for students. Acoustical barriers in classrooms include excessive background noise and reverberation. When measured these barriers often exceed criteria established by the American National Standards Institute (ANSI) S12.60, 2002, Acoustical Performance Criteria, Design Requirements and Guidelines for Schools. The United States (U.S.) Access Board, which enforces the Americans with Disabilities Act Accessibility Guidelines (ADAAG, 2004), cannot require school architects and designers to comply with the national standard for classroom acoustics because acoustical performance criteria are not specified in the Architectural Barriers Act (U.S. Access Board, 2005). Regardless, this voluntary standard has been adopted into building code by some states and school districts. Texas, however, has not taken any action in this area. To understand why, 64 architects were surveyed by telephone about their knowledge of acoustical performance criteria for the classroom, practices to address acoustics in design and renovation phases, and attitudes regarding ANSI S12.60, 2002 as a possible enforceable code for schools. Findings revealed that more than half of the architects surveyed were aware of the acoustical standard, but only

20% reported applying the criteria. Most architects did not feel classroom acoustics was a priority, yet were not opposed to the standard becoming an enforceable code. Additional feedback revealed why classroom acoustics was not a priority, and suggests how we might use our energy and resources to change perceptions and ultimately practices.

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CHAPTER I

INTRODUCTION

Acoustical barriers to communication are disruptive to the learning process, affecting speech perception, student behavior, and educational outcomes for students. Acoustical barriers in classrooms include excessive background noise and reverberation. These barriers can be measured and they often exceed criteria published in the American National Standards Institute (ANSI) S12.60, 2002, Acoustical Performance Criteria, Design Requirements and Guidelines for Schools. Acoustical barriers affect every person's auditory perception ability, but most significantly young children (Anderson, 2004), persons with communication or learning disabilities (Bess, 2001; Boothroyd, 2004; Smaldino & Crandell 2001), and those with English as a second language (Crandell, 1996; Crandell & Smaldino, 1996).

The U.S. Access Board, which enforces the Americans with Disabilities Act Accessibility Guidelines (ADAAG), cannot require school architects and designers to comply with the national standard for classroom acoustics because acoustical performance criteria are not specified in the Architectural Barriers Act (U.S. Access Board, 2005). Children spend around 45% of classroom time listening to instruction from their teacher and yet, there is no assurance that the teacher's voice is adequately heard (Berg, 1987). This voluntary standard has been adopted into building code by some states and school districts. Texas has not taken any action in this area.

For the purposes of this capstone project, Texas architects, responsible for school design, were surveyed about their knowledge of acoustical performance criteria for the classroom, practices employed to address acoustics in the design and renovation phases, and their attitudes regarding ANSI S12.60, 2002. This project was approved by Central Michigan University's Institutional Review Board (IRB) through IRBNet.org. The project number at IRBNet.org is 130135-2.

CHAPTER II

REVIEW OF LITERATURE

Excessive background noise or reverberation in a classroom decreases auditory perception, resulting in a loss of transference of the teacher's spoken message (Crandell & Smaldino, 1995, 2000; Finitzo-Hieber &Tillman, 1978; Nelson, Soli & Seltz, 2002). Auditory perception is essential to learning language, language comprehension, and academic achievement (Bronzaft, 1981; Evans & Maxwell, 1997; Maxwell & Evans, 2000). Poor acoustical performance in the classroom presents a barrier to communication and to educational access.

Evidence and Reasoning for Why We Need Good Classroom Acoustics

The effects of poor acoustics are often not noticed by mature listeners with proficient language skills (Anderson, 2004; Boothroyd, 2004). Adults are often unaware of the auditory effects of a poor acoustic environment on young listeners still developing language and learning to use language properly (Crandell & Smaldino, 2000). Auditory skills develop progressively in childhood (Erber, 1982). Johnson (2000) reported that in a condition of excessive noise *or* excessive reverberation, children are unable to detect or understand speech with adult-like skill, until the age of 14 years. With both noise *and* reverberation present, young teens do not perceive speech like adults. However, these abilities will develop in later teenage years.

Comprehension will suffer if auditory perception of phonemes, specifically consonants, is poor (Flexer, 2004). The classroom listening environment has long been acknowledged as a particular problem for children with hearing disorders (American

Speech-Language-Hearing Association, 2005; Crandell & Smaldino, 2000); learning, communication and attention deficit disorders (Boothroyd, 2004). English as a second language (ESL) students are among those performing poorly in classrooms with inappropriate acoustics (Crandell & Smaldino, 1996).

Speech Perception

Researchers reported the effect of poor acoustical conditions in classrooms on academic outcomes for children (Darai, 2000; Flexer, 2004; Shield & Dockrell, 2003). Phoneme recognition and perception are essential components of speech and reading development (Flexer, 2004). Reading skills suffer, for any child, when spoken language is poorly received (Nelson & Soli, 2000). Reading deficits have been observed in children whose classrooms had excessive noise due to traffic outside of their classrooms (Evans & Maxwell, 1997; Maxwell & Evans, 2000).

In 1997, state legislatures in 8 of 15 states representing the Southern Regional Education Board (1997) acted to improve reading achievement in early elementary grades. Influencing them was research revealing that children not reading at grade level after the third grade were likely to experience continued failure. Other research influencing legislation indicated that children who need remedial reading instruction reached required performance levels more quickly when training included phonological awareness (Iverson and Tunmer, 1993). Therefore, the states emphasized the need for instruction in phonics.

Children listen to a teacher's instruction for about 45% of their time spent in the classroom (Gertel, McCarty & Schoff, 2004; Palmer, 1997). A teacher's voice must be available to all the students in the room. A signal-to-noise ratio (SNR) of at least +15 dB SPL is recommended in the classroom for most normal listeners and essential for all children with disabilities (American Speech Language Hearing Association [ASHA], 2005; Boothroyd, 2004).

The typical speech level of a teacher in a quiet classroom averages around 60-65 dB SPL at 1m (Bess, 2001; Nelson et al., 2002). The speech level decreases by 6 dB, each time the distance doubles from the speaker. Thus the signal decreases by about 12 dB at 13 feet (4m) from the speaker and by 15 dB at 20 feet (6m). The signal can be reduced to about 45-50 dB at the back of a quiet room. This level may just meet the optimal +15 dB SNR if the room meets the criteria of 35 dBA for background noise.

Background noise measurements in typical classrooms range from 40-58 dBA (Crandell & Smaldino, 1995) to 65.9 dBA (Knecht, Nelson, & Whitelaw, 2002). Increasing noise reduces the SNR of the teacher's voice. When this occurs, more listening effort is required, attention wanes and children add to the noise from shifting about or talking. Behavior may also become an issue causing the teacher to pause and redirect attention (Anderson, 2004; Gertal, McCarty & Schoff, 2004). Anderson and Goldstein (2004) reported that children wearing hearing aids have a particular problem in background noise, as both the noise and the teacher's voice will be amplified as they listen.

The affect of seating arrangement on speech perception was investigated in normal hearing children ages 5-7 years (K-1^{at} grade). The teacher's voice had a SNR of

+6 dB and reverberation time was less than .6 seconds. Normal hearing children correctly perceived sentences 89% of the time from a presenter at a 6ft distance. Scores decreased to 55% correct at 12 feet and 36% correct at 24 feet (Crandell & Bess, 1986).

Crandell and Smaldino (1996) found that Spanish-speaking children, who acquired English as a second language (ESL) around the age of 2 years, had a harder time perceiving speech when the SNR declined. The investigators observed speech perception ability in children ages 8-10 years and found perception of speech in quiet for ESL children was similar to their native English-speaking peers; however, perception ability decreased for ESL listeners as the SNR declined from +3 to -6 dB. Listening effort for ESL children was comparable to children with a mild to moderate sensorineural hearing impairment; therefore, they suggested acoustic recommendations for both groups should be similar.

Speech perception will also be affected by the health and hearing ability of children. Otitis media (OM) afflicts many young children and often goes unnoticed. According to Schappert (1992), half of all 2-5 year old children visiting a physician in 1990 were diagnosed with OM and about 18% of 6-10 year old children had OM. Visits to physicians since 1975 increased by 129% and 78% for these age groups respectively. Nelson and Soli (2000) reported of the 70 cases of OM per year in any randomly chosen group of 100 children under the age of 5 years, only half of the children with OM were clear of middle ear fluid within one month regardless of whether they received medical treatment. As a result of the fluid, hearing thresholds can fluctuate from 0-40 dB (normal hearing to mild hearing loss). Nelson and Soli (2000) reported that two-thirds of first grade children had a case of OM lasting 3 to 4 weeks in one year. Holmes et al. (1997) reported 4.7% of adolescents aged 10-20 years failed tympanometry and 8.5% failed otoscopy during a hearing screening of 342 middle and high school students.

Nisker et al. (1998) identified 15% of school-aged children had minimal sensorineural hearing loss. Bess, Dodd-Murphy, and Parker (1998) reported that these children have a significantly higher chance to repeat a grade than normal hearing children.

Crandell and Smaldino (1995) reported that data obtained from several studies indicated that children with minimal (mild or fluctuating), unidentified or unamplified losses (unilateral and high frequency) are challenged to hear in a reverberant classroom. Children with hearing loss have significantly poorer speech recognition scores than normal hearing children as reverberation increases (Wetherill, 2002). A summary of several studies investigating acoustic characteristics of classrooms revealed reverberation times to be .4-1.2 seconds (Crandell & Smaldino, 2001).

Even with an optimal SNR throughout the classroom, children with any hearing loss need to be within the critical distance for listening and reverberation time should be .4s or less (Anderson & Goldstein, 2004).

Speech Delivery

A poor acoustical environment is not just a problem for listening in the classroom. Occupations requiring the use of voice, like teachers, are at risk for vocal injury. The National Center for Voice and Speech (n.d.) report statistics gathered from the U.S. Bureau of Labor and other professional groups. They reported that teachers, at 4.2% of the workforce in the U.S., comprise 20% of clients receiving treatment from voice clinics. Teachers raise their voices, straining to be heard across the distance of a noisy classroom, resulting in half of teachers incurring a voice disorder sometime during their career; well above a very low 5% risk for the rest of the population. A strained voice has a narrow frequency range which degrades the speech signal. Vowels get emphasized and consonants get masked (Anderson, 2004).

Classroom Amplification and Classroom Acoustics

Classroom amplifiers are marketed heavily and some believe it is a better solution than building a classroom to the criteria of the ANSI standard for classroom acoustics. Amplifiers are not without their problems and it is important to bring this issue to the attention of facility planners (Acoustical Society of America, 2006; Lubman & Sutherland, 2001). Classroom amplification systems must be properly installed (Gertal, McCarty & Schoff, 2004). Boothroyd (2004) advises that improper installation or installation in a room with excessive reverberation can have negative consequences. Excessive reverberation and amplified speech can increase the level of late reverberations in the room. The resulting SNR would not be beneficial and sound levels in the classroom could become worse, a situation that could be detrimental to a child wearing hearing aids. A speaker arrangement on a desktop or physically closer to the child with hearing loss can increase the ratio of direct sound to reverberant sound, therefore increasing the likelihood that the system will be useful.

Classroom amplification used in a noisy classroom can increase the total classroom sound level if the teacher raises the volume of the amplifier to be heard over the classroom noise. This sound could travel into an adjacent learning space interfering with learning elsewhere. The Acoustical Society of America (2006) warns against the use of amplification to overcome excessive noise in a loud active classroom. It is not a good substitute for poor acoustics and should not be used routinely in classrooms.

Only when classroom amplification is properly utilized can it provide benefit for all students. Benefit of classroom amplification to all students has been compared to the concept of universal design (Flexer, 2002). Universal design is applied in education to reduce extraneous effort in learning and decrease the need for remedial education (Bremer, Clapper, Hitchcock, Hall, & Kachgal, 2002).

Some positive aspects of classroom amplification include that speech delivery can be improved when the system is properly installed in a classroom with good acoustic characteristics (Boothroyd, 2004). Classroom amplification delivers the teacher's voice uniformly throughout the classroom via loudspeakers placed in the ceiling or on the walls of the room. The teacher's voice can be boosted by 8-10 dB and the cost of a system is a few dollars per student over the lifespan of the device (Crandell & Smaldino, 2001).

Classroom amplification has received much praise for improving auditory perception (ASHA, 2005; Flexer, 2004; Heeney, 2004; Larsen, Vega & Ribera, 2008; Rubin, Aquino-Russell, & Flagg-Williams, 2007; Smaldino, 2008) and increasing student awareness of the teacher's voice (Flexer, 2004). First grade students in classrooms with whole room amplification in Florida demonstrated improved reading literacy compared to controls (Darai, 2000). New Zealand students receiving classroom amplification in grades 1-6 had improved phonemic awareness, listening, reading, and math scores compared to controls (Heeney, 2004). Classroom amplification significantly improved perception for ESL students who at first performed poorly when compared to native English speaking students in inappropriate noise and reverberant conditions for classrooms (Crandell, 1996). In fact, most studies report increased teacher and student satisfaction with the devices, less need to repeat directions, decreased outside distractions, better time management in classrooms, increased student input with an accessory classroom microphone, and less vocal strain on the teacher. Students even reminded the teacher to put the transmitter on when it was forgotten (Rubin, et. al, 2007).

Children wearing hearing aids might receive benefit from classroom amplification. However, student performance must be assessed before concluding benefit is being received (Smaldino, 2008). Hearing aid microphones amplify all sounds and do not improve the SNR necessary in the classroom. Different classroom amplification systems can vary in performance. Anderson and Goldstein (2004) report infrared ceiling mounted systems were not helpful to students wearing hearing aids, but personal FM systems or desktop systems worked very well. Personal FM systems, however, should be used selectively in primary or secondary grades, so that social learning is not deterred in the classroom (Boothroyd, 2004).

Teachers must also learn to control undesirable noises while wearing the microphone. Knocking the microphone, coughing or sneezing into the microphone, and feedback are sources of noise potentially produced by the teacher (Rubin et. al, 2007).

Disability and Acoustical Barriers Defined by Law

Federal civil rights laws ensure equal opportunities for persons with disabilities. The ADA Guide to Disability Rights Laws (ADA Act of 1990, 2005) summarizes the following laws that affect children with disabilities in schools.

Section 504 of The Rehabilitation Act (U.S. Department of Education, 2004d) prohibits discrimination of disabled persons by any federal agency or any program receiving federal funding. Depending on their developmental or educational performance, children with mild hearing loss might be covered by this law, but might not be eligible for special education programs and services. They especially need a good listening environment with a favorable SNR. These children might eventually receive additional benefits after they have failed in the public school general education system.

The Individuals with Disabilities Education Act (IDEA) (U.S. Department of Ed., 2004b) recognizes that a student's disability can adversely affect educational performance and special education services will be provided to eligible children as indicated on the Individualized Education Plan (IEP) developed through the child's school. IDEA requires that schools must provide a free and appropriate public education in the least restrictive environment that is appropriate for the child's needs.

The Americans with Disabilities Act (ADA Act of 1990, 2009) protects citizens from discrimination due to disability. All schools must abide by ADA laws and disabled citizens are protected by the ADA in most public places. The Architectural Barriers Act of the ADA (U.S. Access Board, 2005) requires any buildings designed, constructed or altered with federal funds, must follow federal standards for physical accessibility.

The U.S. Access Board enforces the ADA. Any public facility receiving federal funds (i.e., schools) must follow the ADA Accessibility Guidelines (ADAAG) for new construction or alterations. The current proposed ADA standards for accessible design, as of August 2008, do not address acoustical barriers (ADA Act of 1990, 2008).

According to ADA Title II General Effective Communication Requirements (ADA Act of 1990, 2007b), state and federal governments must provide persons with communication disabilities “effective communication” that is equal to persons without disabilities unless it places undue burdens on government. Effective communication requires communication to be as understandable to persons with disabilities as to those without them. All modes of communication must be made available to meet the needs of persons with disabilities.

Generally, children with mild communication problems who are not eligible for special education do not have the same opportunity for effective communication when classroom acoustics are poor (Sorkin, 2000). In order for these children to have equal access to communication and instruction they require an adequate SNR in the classroom.

The ADA toolkit (ADA Act of 1990, 2007a) states that “despite good intentions, many communities did not have the knowledge or skills needed to identify barriers to access in their programs, activities, services, and facilities. They did not know how to survey buildings to identify physical barriers.” The knowledge and ability to identify acoustic barriers exists, and a standard for building acoustically-appropriate schools exists. A law that requires and enforces the standard is needed. Applying the design requirements of the standard and proper supervision during the building process could avert unanticipated noise problems. The last important point the toolkit makes is to plan ahead so that problems do not have to be addressed retroactively at a greater cost.

According to the ADA Title III Technical Assistance Manual (ADA Act of 1990, 1993), structural architectural and communication barriers must be removed from public accommodations when this can be readily achieved (easily accomplished and without much expense). Structural architectural barriers create physical impediments to access. For those with hearing loss, a structural communication barrier is a lack of communicative devices, such as signs, visual alerts, Telecommunications Device for the Deaf (TDD) or audible alerts for visual impairment. Barriers to communication can also include physical partitions impeding the passage of sound waves during communication, and "the absence of adequate sound buffers in noisy areas that would reduce the extraneous noise that interferes with communication with people who have limited hearing", (ADA Act of 1990, 1993). Although the Act states that excessive noise in a reverberant area should be reduced, there are no criteria for an excessive noise level or reverberation time in the manual.

Both permanent and temporary facilities must remove communication barriers. School districts often use temporary modular units to house classrooms while waiting to build new, or expand existing, buildings. Modular classrooms are subject to the barrier removal requirements.

Barrier removal compliance might not be "readily achieved" as stated by ADA regulations (ADA of 1990, 1993). Removal measures might be taken, but full compliance might not be met. The ADAAG allows this practice as long as there is no significant risk to the health or safety of individuals with or without disabilities. What needs to be determined is whether acoustical barriers result in grade retention or an increase in the need for remedial services. If so, then the resulting grade retention and remedial services could pose significant psychosocial health risks (Jimerson & Kaufman, 2003).

Public Action against Acoustical Barriers in the Classroom

In 1997, one parent brought the issue of acoustical barriers in the classroom to the attention of the U.S. Access Board (The HEAR to Learn Center, 2002). Her son was allowed access to assistive listening devices as stated in the ADAAG (2004). However, access to a classroom with appropriate acoustical characteristics was not assured. As a result, the Access Board requested the creation of a national standard for acoustical performance criteria and design guidelines for building classrooms (The HEAR to Learn Center, 2002). Advocates of the resulting national standard American National Standards Institute (ANSI) S12.60, 2002, Acoustical Performance Criteria, Design Requirements and Guidelines for Schools, want to see it become an enforceable building code. Those attempting to get Leadership in Energy and Environmental Design (LEED) certification in high performance schools object, claiming the criteria are too stringent, too costly to meet and even too difficult to interpret (Kurtz, Bruck, Salter & Lubman, 2009). The standard has been adopted by some states and municipalities as a building code for schools (U.S. Access Board, 2009). The classroom acoustical performance standard has still not been adopted into the Architectural Barriers Act of the ADA. If it were, all entities receiving federal money would have to follow the standard that becomes law.

States and municipalities that have adopted ANSI S12.60 (U.S. Access Board, 2009) include:

- New Hampshire State Board of Education
- New Jersey School Construction Board
- State of Connecticut
- Ohio School Facility Commission
- New York City Public Schools
- Arlington County (VA) Public Schools

Other classroom acoustics standards/directives that are in use are:

- New York State Department of Education
- Los Angeles Unified School District
- State of Minnesota
- Minneapolis Public Schools
- Washington State Board of Health
- Washington DC Public Schools
- California Collaborative for High-Performance Schools (CHPS)
- Northeast Collaborative for High-Performing Schools
- Seattle School District
- Redmond WA School District
- Portland OR School District
- Clark County NV School District
- Maryland State Department of Education (cites ANSI/ASA S12.60-2002)
- University of Minnesota
- School District of Philadelphia
- Poudre District Schools, Fort Collins, CO (cites ANSI/ASA S12.60-2002)

The national classroom acoustical standard, ANSI S12.60, 2002, Acoustical Performance Criteria, Design Requirements and Guidelines for Schools was developed by the Accredited Standards Committee S12, Noise. The Acoustical Society of America provides the Secretariat for the committee. Representatives of the committee include members of technical, consumer, and general-interest groups as well as government agencies.

Summary of ANSI S12.60, 2002

The scope of the standard is to provide acoustical performance criteria and design requirements for classrooms and other spaces of learning in new and remodeled school buildings.

The standard is intended to help planners design classrooms with acoustical qualities needed for good speech communication, without the need for sound amplification systems. Criteria and allowable tolerances are specified for two significant problems affecting auditory perception: background noise and reverberation. Criteria for Sound Transmission Class (STC) ratings of building materials used to separate spaces and provide noise isolation are also specified.

Background Noise

Background noise criteria are specified for core learning areas (enclosed classrooms) and ancillary learning spaces (areas of informal or social communication). Ancillary spaces include corridors, cafeterias, gyms, and indoor swimming pools.

Background noise in unoccupied furnished core learning spaces with areas less than 20,000 ft^3 are limited to 35 dBA. Core learning areas greater than 20,000 ft^3 or ancillary spaces are limited to 40 dBA. Special purpose or special education rooms should meet the standard, but may also be more stringent.

Sound levels represent the measured frequency-weighted sound pressure level of an airborne sound. A-weighting represents how the human ear hears different frequency components of speech at typical listening levels. Low-frequency content of the sound is attenuated. C-weighting does not significantly attenuate low-frequency content of the sound (ANSI S1.4 1983, R2006). It can be used if C-weighted criteria from the standard are met.

Sound measurements are taken in unoccupied rooms during the noisiest one-hour period when children would typically be present. Building services and utilities operate at maximum levels during testing, but classroom instructional equipment would not be operational.

Sound measurements can be categorized as steady or unsteady. Steady noise is fairly constant over time. Unsteady noise varies over time and may come from indoor or outdoor sources. Heating Ventilation and Air-Conditioning (HVAC) units or transportation sources are unsteady noises. The tolerances in the standard allow for a small increase in background noise for a limited time for unsteady noise.

Traffic noise can travel into the classroom from outside the building envelope. Location planning must consider environmental noises or future developments in that location before building. Noise isolation design measures help attenuate intruding environmental sounds.

Sounds from within the school that travel into the classroom come from building services (HVAC), utilities (plumbing and electrical) and occupants in adjacent spaces. These sounds can travel through wall assemblies, ceilings, ventilation and other openings leading into the classroom area. The design requirements in the standard help builders abate these sounds.

Sound Transmission Class Rating

Minimum ratings for sound transmission class (STC) and impact isolation class (IIC) for single or composite wall; floor-ceiling and roof-ceiling assemblies are specified. An STC or IIC rating is a single number rating that designates the ability of building materials to attenuate or isolate airborne or structure-borne sounds. STC and IIC ratings are published by manufacturers after testing materials in a lab. However, not all manufacturers provide these ratings. Installation of materials, if not completed to the manufacturers specifications, can affect ratings.

Noise Isolation Class (NIC) or Field Impact Isolation Class (FIIC) ratings result from field tests that measure airborne or structure borne noise attenuation after the building is completed. The standard's criteria specify ratings ranging from 45-60, depending on the amount of attenuation required or recommended for various school spaces. Specific class ratings are required for noise isolation between core learning and adjacent spaces, and recommended between ancillary and adjacent spaces.

Background noise criteria are easier to meet if planners follow the design guidelines of the standard in the design phase and during the installation of building services and utilities. Regular maintenance of the building structure and its systems will also help control noise.

Reverberation Time

Reverberation time is a measure of the time it takes a signal (presented in an enclosed room) to decay by 60 dB. The time varies depending on room configuration and the frequency of the test signal.

Reverberation occurs in enclosed rooms and is affected by room shape, room size and sound-absorbing material. Reverberating or persisting sound repeatedly reflects off surfaces in the room. The reflecting sound waves cancel out important speech cues. This can make speech unintelligible for normal hearing listeners and difficult for persons with communication or learning disorders. Conversely, too much absorption can reduce beneficial early sound reflections and reduce auditory perception (Boothroyd, 2004).

Sounds will either be absorbed or reflected by materials in the room. A sound absorption coefficient is a measure indicating the ability of a material to absorb sound. Builders can use coefficients and the Sabine formula ($A \geq kV/T_{60}$) to determine the amount of absorbent material needed to attain a certain reverberation time within a given area.

Reverberation times are specified by ANSI S12.60 for core learning spaces only. Maximum reverberation times for unoccupied furnished rooms are .6 seconds for a classroom less than 10,000 ft^3 and .7 seconds for rooms greater than 10,000 ft^3 and less than 20,000 ft^3. There are no criteria for rooms larger than 20,000 ft^3. Recommended guidelines for acoustical performance in larger classrooms and lecture rooms are provided in an annex of the standard.

When a room meets the ANSI criteria for background noise and reverberation, it will likely create an environment supporting a favorable SNR. The standard does not specify criteria for SNR. Some authors mistakenly report SNR as criteria in the standard. One author reported a measurement of the sound level of a computer while it was turned on. The measurement was taken directly next to the computer and then at the ear level of the observer. The two measures were 45 and 35 dB respectively (Baker, 2003). While technical equipment would not be operational during noise measurements, this information can be helpful. The author's measurement taken at ear level passed the criteria of the standard. The reporter still criticized the difficulty to attain proper sound levels in the room.

The Annexes

Seven Annexes of the standard provide information on criteria rational, design for noise isolation and reverberation control and verification of conformance to the standard.

- Annex A includes rational for the standards criteria based on evidence from studies of speech perception in classrooms and the affect on academic achievement, especially for those with language, learning and communication disorders.
- Annexes B, C, and D are for facility planners and designers of schools. They include recommendations for controlling noise from building services, utilities, and instructional equipment; controlling reverberation and isolation of noise.
- Annex E covers verifying conformance to the standard.
- Annex F addresses indoor air quality and multiple chemical sensitivity issues when considering materials for sound reduction.
- Annex G addresses different noise descriptors. A-weighted sound levels are different than commonly used Noise Criteria (NC), Balanced Noise Criteria (NCB) and Room Criteria (RC) ratings. These later ratings are obtained by frequency specific analysis measures. Criteria based on A-weighted measures can

differ by 2-24 dB from these other ratings. It would be inaccurate to use NC, NCB or RC ratings for verification to the criteria specified in the standard.

Cost of Education and the Cost of Acoustic Modifications

Cost is often discussed when people debate whether the ANSI standard should be a national building code. Approximately 50 million children attend public schools. The average cost to educate a student in the United States during the 2005-2006 school year was $10,615 (US Department of Education, 2008a). The cost per child is greater when a child is retained in a grade. Six percent of 6-11 year olds have repeated one grade. Eleven percent of 12-17 year olds repeated one grade (U.S. Census Bureau, 2009).

Remedial coursework increases the cost of education. Reading scale scores for eighth grade students in 2007 revealed 27% of students were below a basic score level (US Dept of Ed., 2008c). Thirty-four percent of fourth graders were below basic that year (U.S. Dept. of Ed., 2008b). Remedial coursework in reading was needed by 11% of students entering 2 year colleges in the year 2000 (U.S. Dept. of Ed., 2004a). Students taking remediation courses are less likely to earn a degree and remedial reading needs create great difficulty to obtaining a degree (U.S. Dept. of Ed., 2004c). Poor reading achievement presents a high cost to individuals and to society.

The United States lags behind other developed nations in school achievements in reading, math and science (Organisation for Economic Co-operation and Development, 2005). The U.S. Access Board (2009) lists nine countries that have taken action on classroom acoustics, including Germany, Italy and the United Kingdom. Further research could investigate if there is a link between countries following these standards and academic achievement.

The House of Representatives recently passed a bill that would allow federal funds to be used for acoustic improvements. H.R. 2187, the 21st Century Green High-Performing Public School Facilities Act, would make $46.4 billion in grants available for modernizing, renovating or repair. The bill includes provisions for school districts to address classroom acoustics. The bill still has yet to go through the Senate (ASHA, 2009). When money is spent on improving classroom acoustics, researchers should investigate the efficacy of these improvements on student achievement.

The cost of acoustic modifications to classrooms is not available in some case studies (The HEAR to Learn Center, n.d.). Some studies do report the cost of modifications (Teel, 2005). When reported, actual costs were generally much lower than suggested by the Heating, Ventilation and Air-Conditioning (HVAC) industry. For example, the Air-Conditioning & Refrigeration Institute (ARI, 2005) estimated the cost of renovating old or retrofitting new classrooms to meet the ANSI criteria. An architectural and engineering firm studied 48 classrooms and estimated material, labor and professional costs. Increased school construction costs were projected to range between 4 and 19%.

The greatest amount of classroom noise is generally from HVAC systems. Wall mounted air-conditioning units create the most noise in the classroom. The ARI opposed the standard and claimed schools could not budget sufficiently for the changes to meet the ANSI criteria (Lubman & Sutherland, 2004; Teel, 2005). The ARI reported noise reduction would be impossible without major restructuring of a building. Concerns were expressed that law suits and finger pointing between the various professions would follow if standards were not met.

The state of Connecticut found an average 1.5% increase in costs to meet acoustic criteria of the standard (The School Noise/Quiet Classrooms, 2003). The Maryland State Department of Education (2006) estimated an increase of .5 to 5% based on the age of the classroom. The Collaborative for High Performance Schools (n.d.) reported a jump in cost of $5.70/ft^2 representing a 3% increase.

The Maryland State Department of Education (2006) also reported that positive impacts on classroom acoustics have come from new building codes, improved fire protection materials, and LEED criteria that improve indoor air quality or energy conservation.

Schools budgets typically allot 10% to facility design and construction on a building serving thousands of students with a lifespan of thirty or more years. Cost can be averaged over the building's useful life years and the number of students enrolled. On this basis, new construction was estimated at $7.50 per student each year for 20 years.

Renovations to classrooms over time and the cost of remedial coursework for students can increase the cost per classroom to $1500-$4500; or to $224 per student over the 20 years (The School Noise/Quiet Classrooms, 2003). For immediate renovations, excessive reverberation costs the least to fix and can have a significant effect on acoustical outcome (The School Noise/Quiet Classrooms, 2003).

Professionals installing HVAC units agree that lack of consideration for noise can become an expensive and difficult problem to correct once installation is complete

(Guckelberger & Harshaw, 2009; Simmons, 2007). The building team, including the owner, engineer, architect, equipment manufacturer and contractor, must make a concerted effort to achieve good acoustical performance (Guckelberger & Harshaw, 2009).

Efficacy of Improving Classroom Acoustics

Efficacy measures are needed from classrooms that have been modified to improve acoustical performance (Crandell, Kreisman, Smaldino & Kreisman, 2004; Lubman & Sutherland, 2001; Smaldino 2008). Measures of background noise and reverberation should be made before and after modifications. Objective behavioral speech perception tests, subjective functional measures, and educational achievement should all be observed (Smaldino, 2008; Crandell et.al, 2004). Effects on remedial intervention rates and reading achievement should be investigated longitudinally (Sutherland & Lubman, 2001).

Teacher absenteeism due to vocal injury should be documented when possible. Lubman and Sutherland (2001) reported 2.9 million teachers missed an average 2 days of work due to vocal strain in the year 2000. The resulting cost for substitutes, at up to $220/day, was estimated at $638 million U.S. dollars each year.

Texas School Facility Planning

The Texas Administrative Code (2008) Chapter 61 School Districts, Subchapter CC Commissioner's Rules Concerning School Facilities designates standards for schools built before January 1st 2004, and for those built after January 1st 2004. Both standards state that school districts will comply with provisions of Titles I and II of the

ADA, 1990. Several provisions were added for buildings constructed after 2004. These include standards for technology, indoor air quality, sustainable design and the Texas Accessibility Standards (Texas Department of Licensing and Regulation, 1994).

The Texas Accessibility Standards (TAS) is administered by the Texas Department of Licensing and Regulation. While TAS is not the same as the ADA Accessibility Guidelines, they are certified by the U.S. Department of Justice in a similar manner. Each state has the option to propose its own guidelines for approval by the U.S. Department of Justice (Texas Department of Licensing and Regulation, n.d.). The Texas Department of Licensing and Regulation states the TAS are as stringent, or more stringent, than federal accessibility guidelines. Buildings can receive a certificate that verifies their compliance to TAS. TAS requires visual and audible communication modes in buildings. In likeness to the ADAAG, they do not address acoustical performance of a room.

The Texas Comptroller's Office (2000) reported that school facilities are the most expensive investment for a school district and planning is sometimes not well thought out or not thought out at all. In a study to control costs and improve services in schools, The Texas Comptroller's Office produced a list of the Top 10 issues facing public schools with suggestions on how to solve them. Number 4 on the Top 10 list was "Plan before you build", (Texas Comptroller of Accounts, 2000). The state recommended a specially hired employee to monitor construction on a daily basis and to assure that quality workmanship and components are applied and cost overruns are minimized.

The aim of the following investigation was to identify the knowledge level of Texas architects designing public schools regarding ANSI S12.60, 2002. Specifically, their awareness level of the relationship between classroom acoustics and speech perception, whether they apply the standard to their plans or use other criteria, their opinion of the standard becoming a code, and the current assessment used to determine that children in classrooms are perceiving speech accurately and without unnecessary effort.

CHAPTER III

METHODOLOGY

This project was approved by Central Michigan University's Institutional Review Board (IRB) through IRBNet.org. The project number at IRBNet.org is 130135-2.

Participants

One hundred architects specializing in the design of educational buildings were recruited for this study. A multi-stage approach to reach the architects was employed.

The first stage was to identify the architects through the Intermediate School Districts (I.S.D.s) of Texas. A list of all Texas Public School I.S.D.s (not including charter schools) was obtained from the Texas Education Agency (TEA). This list included 1034 I.S.D.s. All school districts were stratified into their Educational Region (ER). The number of I.S.D.s in each ER varied from 12-96. Twenty percent of all I.S.D.s were randomly selected from each ER. The total number of I.S.D.s randomly selected was 215.

I.S.D. administrations were contacted by phone to request architect contact information. Those I.S.D.s that had not designed or built schools since 2003, the year following the publication of the ANSI standard for classroom acoustics, were eliminated from the study. Overall 25% of the I.S.Ds selected had not built since 2003 and were eliminated. If the I.S.D. used a structural engineer, but no architect, it was eliminated from the study. The remaining 160 I.S.D.s reported the names of 100 architects or firms. Some architects or firms served several I.S.D.s.

The second stage of the study was to contact the architect. Thirty six of the architects did not respond to 3 solicitations to participate in the survey and were eliminated from the study. The remaining 64 architects represented 129 I.S.D.s from all of the 20 educational regions of Texas.

Tools

Pilot Survey

A pilot survey was conducted on a small group of five easily accessed architects who design schools. The pilot survey was used to determine content validity only. Data collected were not included in the survey results. All of the 5 architects included in the pilot survey were interviewed by telephone after giving consent. The architects responded that they understood what was being asked of them in the survey and they were able to answer all the questions. They willingly gave opinions to questions that solicited their response. A few changes were made to the pilot questionnaire which included rearrangement of the questions, combining two questions that seemed redundant and rewording of questions to make interviewing easier.

Survey

The twelve questions of the pilot study were rearranged and revised for the final survey. The questions were developed to obtain architect demographic information and to gain insight into the architects' knowledge and design practices for classroom acoustics. Commentary was solicited in response to architectural practices and beliefs. Commentary was also solicited to questions regarding possible use of federal money and public policy. The survey is located in Appendix A.

Procedures

A telephone survey was conducted as opposed to an internet or mailed survey to limit any opportunity for an architect to do research before giving responses to questions. A telephone survey also allowed for clarification of questions and responses. The phone survey was intended to take a minimum of 10 minutes, but could take as long as the architect desired to offer commentary. A consent form was read to the architect and permission was received before completing the interview.

Survey responses were combined and reported for the group of architects that completed the study. Responses were then clustered into the education regions where the architects design school buildings.

Demographic information for students was collected for both statewide and the sampled populations. This demographic information included number of districts according to size, based on student enrollment, and percent minority population, percent of English as a Second Language population and percent of Limited English Proficient population.

CHAPTER IV

RESULTS

Architects' Responses to Survey Questions

Of the 100 architects recruited, 64 architects responded to the survey questions, yielding a response rate of 64%. All Texas Education Regions were represented in the responses. Reponses to each of the 12 questions are reported in the following series of charts. Solicited opinions from all 64 of the architects were grouped into commonly expressed statements. The number of comments reported per question varies depending on the variety of opinions expressed.

Questions #1 and #2 dealt with demographic variables. Question #1 asked the architects how many years they had been designing schools. The architects reported 2-44 years of experience. The mean years of experience were 21.61 and the mode was 20. Question #2 asked the architects if they built for more than one I.S.D. or region. All but one architect responded that they did (98%). Most of the architects had contracts with several school districts and some in multiple educational regions.

Question #3 asked the architects whether they knew if classroom acoustics could affect a child's perception of speech, language development or reading ability. Figure 1 illustrates that most of the architects (92%) were aware of this possibility. Five (8%) of the architects indicated that they were not aware or not really sure there was evidence to support this. Comments included:

"No. I have not heard that."

"I'm not sure about that."

Can classroom acoustics affect a child's language development and learning?

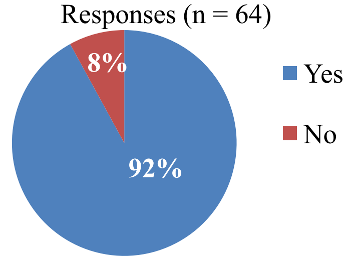


Figure 1. Response to Survey Question #3

Question #4 asked the architects if they believed that a normal hearing adult could judge whether classroom acoustics were appropriate for a child developing speech. Several architects asked for clarification as to who would be the judge. The interviewer clarified the judge might be a normal hearing adult architect, school staff or school administrator. Figure 2 illustrates the responses to Question #4.

Can an adult judge classroom acoustic performance with their own hearing ability?

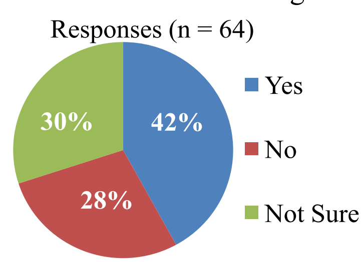


Figure 2. Response to Survey Question #4

Question #5 asked architects if they were familiar with the ANSI standard for classroom acoustics. Thirty nine of the architects knew of the standard. Eighteen were aware of it, but not its' criteria. Many asked for the reference to be repeated so they could write it down. Figure 3 illustrates the responses to Question #5.

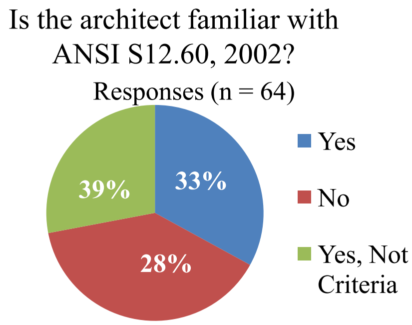


Figure 3. Response to Survey Question #5

The first part of Question #6 asked the architect if they used the ANSI criteria for designing classrooms. Figure 4 illustrates the response to Question # 6.

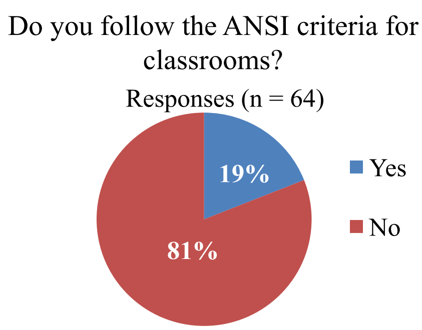


Figure 4. Response to Survey Question #6

The 52 architects who did not follow ANSI criteria for classroom acoustics were further asked Question #6a, if there were other criteria that they use. Seven of the architects referred to other published criteria on classroom acoustics. Five architects in the group relied on LEED criteria. One relied on criteria published by the American Society of Testing and Materials (ASTM). Another used a sound level meter and technical manuals from MDC Vacuum Products and U.S. Gypsum Board. Forty of the architects not using other criteria relied on acoustic consultants to assist in design of the largest areas of the school, including cafeterias, gymnasiums and performance areas. The most commonly reported reason to involve an acoustical consultant was for performance areas of buildings, such as auditoriums. Half of the architects said that they relied on the many years of experience they had in building schools. One third relied on in-service presentations from manufacturers of building products and acoustical materials. All registered architects are required to obtain continuing education. Two of the architects commented that they choose topics on building acoustics. Figure 5 illustrates the response to Question #6a.

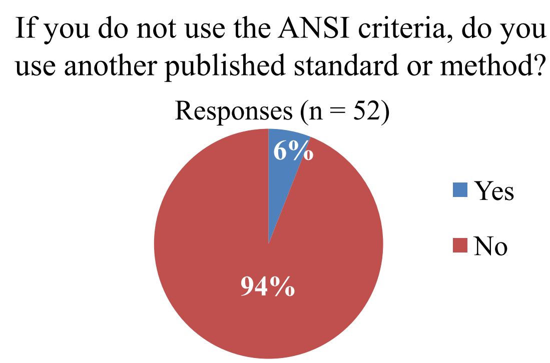


Figure 5. Response to Survey Question 6a

Question #7 asked how often STC ratings of building materials are considered in the design process. Comments about STC ratings included:

> “We only check them for special rooms because design practices used now are based on experience.”
>
> “Products don’t change much, that’s why we’re not looking at STCs all the time.”
>
> “The materials were working so well that the students in the classrooms didn’t hear the fire alarm.”

"You can't rely on STC ratings to stay the same after you built with them."

Figure 6 illustrates the response to Question #7.

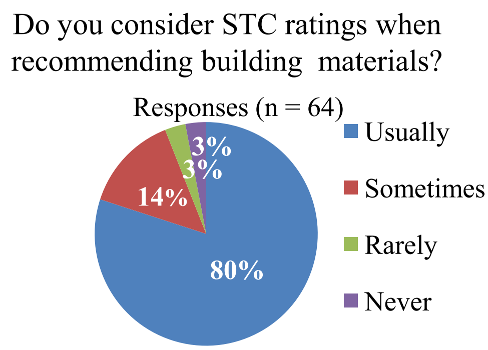


Figure 6. Response to Survey Question #7

Question #8 asked if I.S.D.s ever report unwanted noise or an undesirable acoustical response within the school building and ask for it to be fixed. Comments on noise issues and how they were addressed included:

> "Reverberation is irritating; students in bad acoustics get noisy and carry loud behavior back to class with them."

> "An open air return (plenum) is very typical and causes noise. You need ducting."

> "Sound travels into the room from walls not built up to the deck, improper insulation and single pane windows"

> "The I.S.D. doesn't want to spend money up front. Materials get omitted to keep cost down. Then you go back and remedy problems when they're unhappy."

> "After Hurricane Ike, renovating 30+ year old buildings, you may not get the sound quality you want and it's hard to bring things (HVAC) up to code."

> "I hate vinyl flooring tile. I love anti-microbial carpet to reduce noise. But it depends on the I.S.D.s maintenance philosophy."

> "Engineers are responsible for mechanical operations and follow their own standards. They are responsible to make sure noise is isolated."

"Teachers are most critical of noise. They walk around the class to be heard. Many just live with noise problems."

"We use "reinforcement" without construction. Sound speakers (soundfield) around the room."

Figure 7 illustrates the response to Question #8.

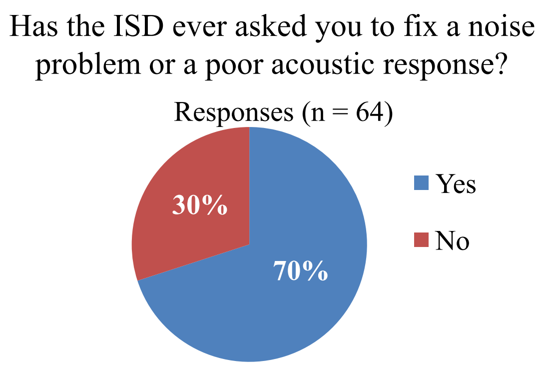


Figure 7. Response to Survey Question #8

Question #9 asked the architects if they ever requested measurements of background noise or reverberation in the classroom or other school areas. Comments about taking measurements included:

"We only do this for a performance area, where it is more critical."

"We are not getting any feedback about whether the teachers think this would help."

"…not required to verify for LEED certification. We just sign off on using the required materials and building design."

"I once saw a band teacher clap his hands in the room to check reverberation. I never saw that before."

Figure 8 illustrates the responses to Question #9.

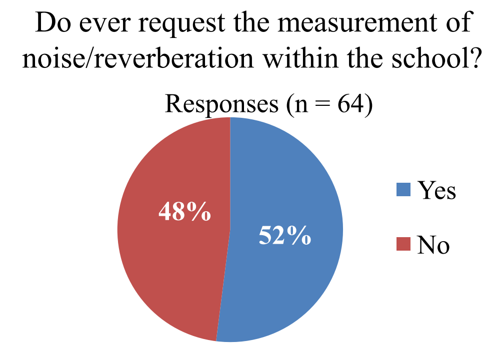


Figure 8. Response to Survey Question #9

Upon further consideration, Question 9a asked the 33 architects who reported instruments were used to measure noise and reverberation if measurements were taken in classrooms. Only 4 of the architects reported measurements taken in the classroom. Figure 9, illustrates the responses to question #9a.

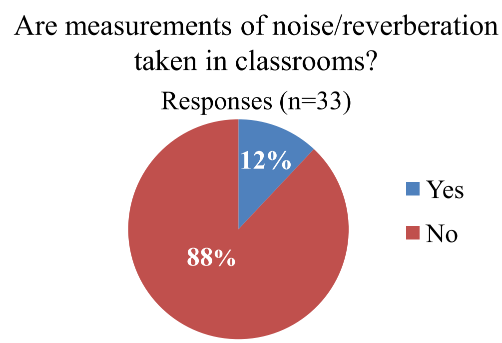


Figure 9. Response to Survey Question #9a

Question #10 asked the architects if they felt that a child could hear adequately in the classroom regardless of the child's seating location; while listening to a teacher speaking at an average level; the teachers voice being neither a soft voice or at a raised speaking volume. Comments about hearing and location included:

"Depends on the flooring philosophy.

"Kids struggle at the back."

"They can't hear at back. Also, now they are sitting kids in groups and some of them, their back is facing the teacher and they are looking at another student."

"They should be able to."

"Teachers don't report on this."

Figure 10 illustrates the responses to Question #10.

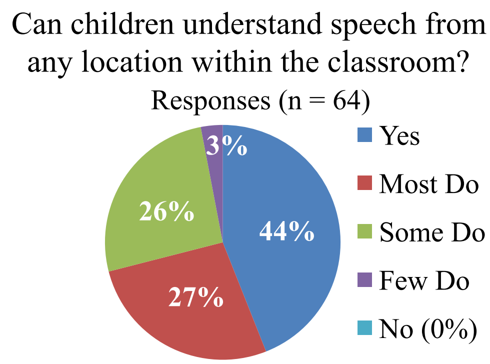


Figure 10. Response to Survey Question #10

Question #11 asked architects whether they believe it is appropriate to use federal stimulus money for verifying acoustic performance in the classroom or to fix rooms with issues of unwanted noise or poor acoustic performance. Comments about accepting stimulus money for classroom acoustics included:

Architects who supported use of stimulus money for acoustics:

"It's important to be sure they can hear the teacher (supporting verification)"

"Money goes to ADA and special needs, maybe this issue belongs there."

"I suspect regionally, classrooms need to be checked. Maybe school administration should verify rooms and let you know if there is a problem."

"Yes, if it is regulated, the language allows it. Money tends to be tied to energy."

> "I don't have an opinion on that because it is totally up to the discretion of the I.S.D. on how to use the money.
>
> "It's not a priority; Texas won't take the stimulus money anyway."
>
> "Yes, we would welcome money to come in so we could do the work, it's good for business."

Architects who opposed the use of stimulus funds for classroom acoustics:

> "We just need to hire qualified architects and hold them accountable. Make them fix it themselves!"
>
> "We have too many other priorities. Classrooms don't have issues and it doesn't cost much to fix those that do."
>
> "I would like to see you show me the need for that."
>
> "That's a waste of time and money. The I.S.D.s should take care of their own issues."

Figure 11 illustrates the response to Question #11.

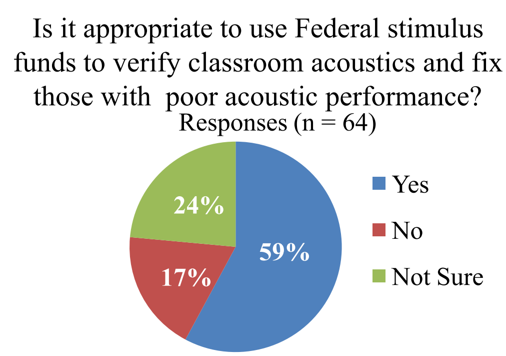


Figure 11. Response to Survey Question #11

Upon further consideration of Question #11, the 45 architects who responded "yes" or "not sure" had different opinions for Question #11a, whether money should be spent on both verification and fixing problems. Figure 12 illustrates the response to Question #11a

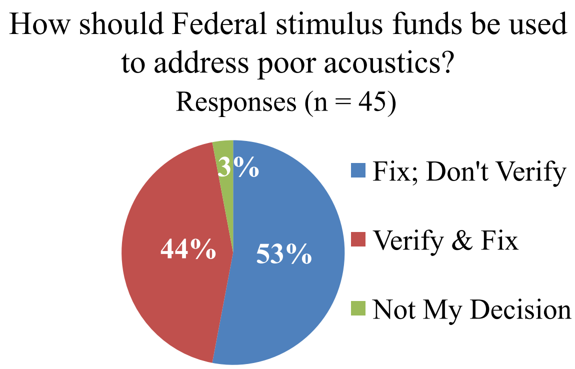


Figure 12. Response to Survey Question #11a

Question #12 asked the architects about their opinion regarding the ANSI criteria (or other acoustical criteria) as an enforceable code for schools. Several architects replied that it would “just be another code to follow.” However, 15 of the 48 who responded “yes” that would be ok, thought it was a good idea. Comments on enforcement of acoustical criteria included:

Architects who supported a code for acoustics:

> “Texas will become more stringent on these standards now that the CHPS manual for Texas came out.”
>
> “Architects are responsible to sell the point of good acoustics. It’s a constant “budget battle.”
>
> “No hearing means no learning. The students are our future. We want to have an appropriate acoustic space.”
>
> “I may still need to have an acoustic consultant. An architect needs to be a generalist and look to a specialist. We don’t have time to learn everything.”
>
> “We must show a need for this. 99.9% of schools aren’t thinking of acoustics.”
>
> “We need to show how kids perform with better acoustics. People will only follow it if TEA (Texas Education Agency) makes it a standard. If it’s only a guideline, you can’t hold anyone to it.”

"It's ghastly how many millions are spent on sports, but blank stares are received when we suggest how to make rooms better for education."

"I wouldn't like it, but would do it. I don't believe lighting is an issue either."

"People will balk at first, but eventually accept it. We follow plenty of ADA rules."

"I'm ok with it, but it will add to expense. The legislation will be no good if there are still bad designers."

"Poorer regions can't afford it; you'll have to have public money for this."

Architects who objected to an enforceable code for classroom acoustics:

"You should get design right in the first place."

"Why do we have to bring classrooms up to performance condition?"

"We have too many codes from the "green" people and handicapped people."

"Our standards exceed those. ANSI keeps trying to "one up" the previous code."

"Good acoustics=high maintenance."

"If there was a problem, clients would complain. Acoustics is not an exact science."

'Codes conflict with each other. Now they want you to sprinkle a room for fire. This means lowering walls and leaving doors open. That's terrible for acoustics!"

"This is not a hazard to health, safety and welfare."

"People in rooms decrease reverberation, especially when they wear heavy coats in winter."

"I'm tired of government thinking we need a rule to fix everything. Better to promulgate good design standards. There was a push to build rooms with less noisy lights for special needs kids. In rural areas when the expensive quiet bulbs burnt out, they just went to Home Depot to get a regular bulb to replace it."

> "How will you enforce it? A building official will go to every room of a new building and test it?"

Figure 13 illustrates the response to Question #12.

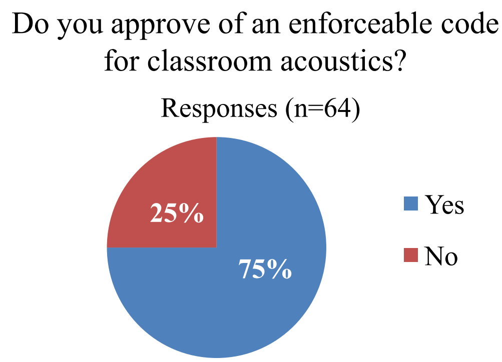


Figure 13. Response to Survey Question #12

Architects' Responses to Survey Questions by Region

Architects responses were sorted into regions where they contract to see if there was any variation between the regional responses. Regional demographic information were also considered for the regions when looking at these responses. Statistics could not be applied to the regional responses for the architects. Some of the architects were only entered into a single region while others were reported for multiple regions. The data were simply checked to see if any differences in the averaged responses could be observed for the regions. There was only a slight difference in 2 regions on awareness of the effect of classroom acoustics on language development. This difference occurs for regions with higher ESL and LEP status populations. Otherwise the responses were too variable regionally to be compared to demographics.

Comparison of State Demographics to Survey Demographics

District Size

Texas school district sizes are based on student enrollment. The percentage of all Texas I.S.D.s that are small (<1000) is 58%, medium (1000-9999) is 34% and large ≥10,000) is 8%. Represented in this survey are 53% small, 36% medium and 11% large I.S.D.s. The proportions of small, medium and large I.S.D.s in this survey are very similar to the statewide proportions.

Ethnicity

Texas is a majority minority state as far as student population is concerned. Student ethnic group size for the 4,383,871 students is 45% Hispanic, 38% White, 14% African American, 2.5% Asian/Pacific Islander and .3% Native American. In this study, ethnic groups included 43.5% Hispanic; 34.3% White; 17% African American; 5% Asian/Pacific Islander; 0.35% Native American.

ESL Status

ESL students in Texas represent 15.5% of the total student population. The population of ESL students per district varies greatly across the state from 0-67.7%. This study included districts with ESL populations that ranged from 0% to 42%.

LEP Status

LEP students in Texas represent 16.7% of the total student population. The population of LEP students per district varies across the state from 0-55.7%. This study included districts with LEP populations ranging from 0-48%.

CHAPTER V

DISCUSSION

The survey results reported in this study illustrate what a group of 64 Texas architects, specializing in school design, know, practice and believe regarding classroom acoustics. The architects' comments and opinions revealed that, on average, they are concerned with acoustics in their buildings. These architects reported that they learned how to address noise and reverberation through experience, continuing education, acoustical consultants and building product representatives. Several had heard about the ANSI standard, but many were unaware of acoustical criteria for the classroom.

Many of the architects stated that it is not complicated to design and build a classroom with adequate acoustics. The majority of the architects surveyed regularly utilize STC ratings and building practices to isolate classrooms from noise and limit reverberation. While they felt that they were accomplishing this, almost none of the architects surveyed ever verified that their conclusions were correct.

Poor classroom acoustics, the architects said, result from cutting corners and poor design. The architects hold school districts accountable for what they are able to accomplish in planning and design based on the district's budget and the choices made by the district for environmental maintenance. The architects stated they also have to work in conjunction with other professions to address noise traveling to classrooms from mechanical systems or other building services. The architects in this survey expressed that most concerns regarding noise and reverberation, or acoustic performance, came from large challenging spaces like performance areas, cafeterias and gymnasiums; not classrooms. Performance and large challenging areas received attention from an acoustical consultant when it was allowed in the budget. Repeatedly, the architects commented that classrooms do not need verification with instruments.

Many Texas schools are trying to stretch bond dollars while others do not have them. Some school districts have already used stimulus money received from the ARRA for school construction. This money is welcomed by schools that might need to fix a roof, get a building in compliance with building codes or even become ADA compliant. It may be impossible to convince schools with many priorities that stimulus or other public money should be spent on classroom acoustics when they do not think it is an issue.

Most architects responded that they were willing to "follow another code" if classroom acoustics were enforceable. School districts would have to address classroom acoustics if it is a part of the ADA accessibility guidelines, included in the Texas Accessibility Standards, and ultimately required by the Texas Education Agency. Verification would have to be addressed.

Based on responses from the architects, we can assume that most are not verifying and there is no evidence that K-12 classrooms in Texas are acoustically appropriate for speech perception. Architects that report they rely on LEED criteria for classroom acoustics are not meeting the criteria of the ANSI standard for background noise. LEED criteria (U.S. Green Building Council, 2009) recommend a minimum background noise level in unoccupied classrooms of 45dBA which is 10dBA above the ANSI criteria. LEED reverberation criteria are similar to ANSI criteria, 0.6sec for classroom of 10,000 square feet or less. The ANSI standard is referenced in the LEED manual for schools.

The recently published Texas Collaborative for High Performing Schools Assessment Tool (CHPS, 2009) references the Acoustical Society of America and the ANSI standard for classroom acoustics. The Texas CHPS manual however, differs from the ANSI criteria for background noise. Texas has two criteria for background noise that distinguish between providing classrooms with adequate acoustic performance (at 45 dBA) and superior acoustic performance (at 40 dBA). Superior acoustic performance is recommended for classrooms with "young children", Limited English Proficient, and children with hearing or language impairment. The superior performance recommendation, however, does not specify what age or grade would be included in the "young children" descriptor and does not refer to English as a Second Language either. The Texas CHPS manual does follow the ANSI criteria for reverberation. The Collaborative for High Performing Schools movement originated in California and the 2006 Basic Assessment Manual does follow the ANSI classroom acoustic criteria (CHPS, 2006). CHPS also published a Verification Program User Guide (CHSPS, 2007) for schools in California. This verification program if followed by California schools is an incentive to become eligible for grant money from the state. Texas architects that choose to follow the Texas CHPS guidelines may need more information regarding the importance of meeting ANSI criteria rather than the less stringent Texas criteria, which are also less specific as to who exactly should have "adequate" or "superior" classroom acoustics. Texas architects following CHPS criteria could be an important resource with whom Texas audiologists could collaborate in gathering evidence to document classroom acoustic conditions. Evidence that could be gathered would include which criteria the architects are following, verification measurements for new building or renovation, objective measures of student auditory perception, and subjective behavioral observations by the teacher. Academic outcome could be reported if acoustical performance is the only variable of change for the student in the classroom. As Smaldino, Doggett and Thunder (2004) suggested, it is important for audiologists to be engaged in gathering evidence in the classroom as we've been trained to make acoustic measurements with instruments and we already collaborate with teachers regarding hearing performance in the classroom.

Evidence should include cost efficacy and teacher feedback. Important places to begin are older schools and districts with large ESL and LEP populations. A suggestion from one architect was to train a school administrative employee to take simple sound level measurements in their own districts. Simple screening without the need to call in a consultant might help identify acoustical problems in a less costly and efficient manner.

CHAPTER VI

CONCLUSIONS

There is no accountability in Texas for classroom acoustic performance. It is often assumed that classrooms are adequately isolating noise and absorbing reverberant sound. Adult ears cannot make physical scientific measurements of background noise levels and reverberation times for children with or without communication disorders; learning disorders; and ESL or LEP status. Unless a school district voluntarily measures classroom acoustics and records noise and reverberation data, there is no evidence that classrooms meet the ANSI criteria demonstrated to be necessary for children to perceive speech.

There were some limitations of this study. One limitation was that a rural area near the New Mexico border had a large percentage of ISDs that were not building and therefore fewer architects from this area were included in the study. It would be interesting to know if those architects are contracting work in New Mexico and meeting LEED criteria required there, which addresses classroom acoustics.

This study reveals that regardless of what the architect knew and what their opinions were on classroom acoustics, it is the I.S.D. and public policy that ultimately influence how a school building will be built and whether classrooms will be verified to check if they meet published acoustic criteria. The architect can influence construction based on knowledge and experience. This influence will not extend to verifying classroom acoustics unless the I.S.D. agrees it is necessary. I.S.D. administrators should be surveyed to determine what, if any, importance classroom acoustics has for them and to see if evidence can convince them that it should be a priority.

Educational architects and school administrators do not want designers cutting corners that result in poor acoustics that require costly remedies later. School administrators, architects and the public should be able to examine evidence that classrooms are appropriate listening environments for children. Perhaps in initiating a program for local districts to screen their own classrooms for noise and reverberation levels, there will be interest garnered in an area that has not received sufficient attention.

APPENDICES

APPENDIX A

SURVEY FOR TEXAS ARCHITECTS

1. Can you tell me how many years you have been designing schools? ___yrs.

2. Have you designed for more than one I.S.D. or Region? ___yes ___no

3. Do you know if classroom acoustics can affect speech perception, language development, reading ability for children? ___yes ___no

4. Do you know if an adult with normal hearing could judge if a classroom provides an appropriate acoustic environment for school-aged children?

   ___yes ___not sure ___no

5. Are you familiar with ANSI Standard S12.60 titled; Acoustical Performance Criteria, Design Requirements and Guidelines for Schools?

   ___yes ___yes, but not its' criteria ___no

6. <u>If Yes to #5:</u> Do you design classrooms to meet the ANSI criteria?

   ___yes ___no

   6a. Do you follow any other criteria or published specifications for classroom acoustics? ___yes ___no (record verbatim other criteria)

7. When you are designing or renovating classrooms, would you say that you:

   ___usually ___sometimes ___rarely ___never;

   consider sound transmission class ratings for construction materials?

8. Has anyone from an I.S.D. asked if you could eliminate an unwanted noise or change an undesirable acoustic response in the school building? ___yes ___no.

   8a. What caused the noise/problem and what was done? (record verbatim)

9. Have you ever requested that any classrooms or school areas used for speaking/teaching be tested for reverberation; or background noise levels either in quiet or with building services fully operational? ___yes ___no

9a. Where are those measurements taken?(record verbatim)

10. Please think about classrooms you have designed. Would you say that the rooms have appropriate noise isolation and reverberation qualities that allow students to hear their teacher adequately regardless of where they are seated in the classroom?

___yes ___most do ___ some do ___ most do not ___no

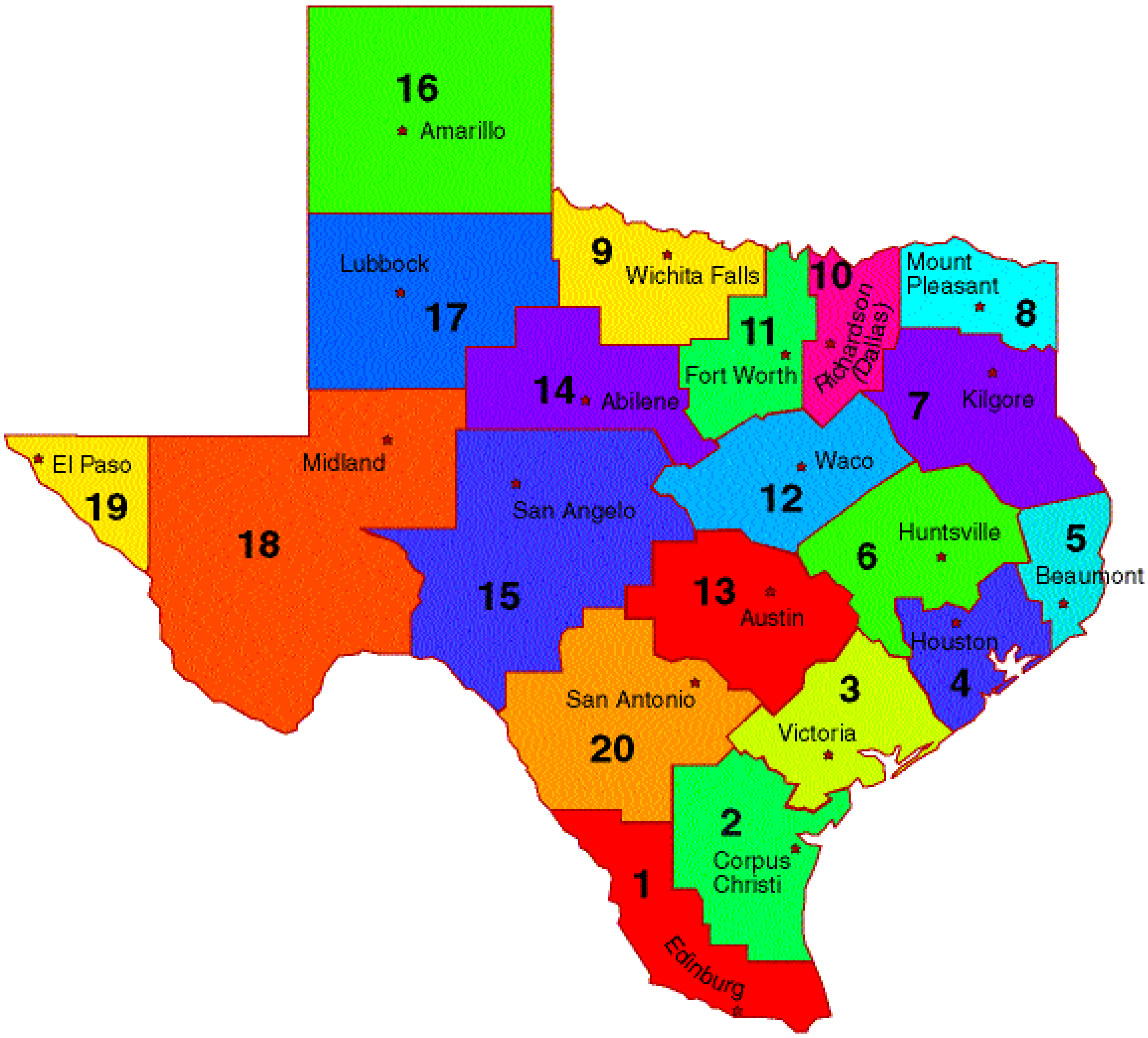
11. If any Federal funds from the American Recovery and Reinvestment Act are received in Texas for school construction or remodeling, should some of the money be applied to verifying classroom acoustical performance and renovation of classrooms with poor performance? ___yes ___ not sure ___no; Comments:(record verbatim)

11a. Should we ___fix ___verify or ___do both?

12. Several states or school districts have adopted ANSI S12.60 as a building code or regulation. If Texas were to adopt the ANSI standard for classroom acoustics as a building code for schools, would you approve of that action? ___Yes ___No Comments:(record verbatim)

APPENDIX B

EDUCATIONAL REGIONS MAP OF TEXAS



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