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ABSTRACT

A survey of sound levels was taken in several Texas schools to determine the amount of noise and sound present by size of class, type of activity, location of building, and the presence of air conditioning and large amounts of glass. The data indicate that class size and relative amounts of glass have no significant bearing on the production of sound in a classroom, but that air conditioning, the location of the building with accompanying exterior noise levels, and the nature of classroom activity did have significant effects on sound levels, the last factor being the most influential. School planners should pay more attention to the acoustical environment in an attempt to abate noise levels. (RA)

Sound Levels In East Texas Schools

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Sincerely,

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SOUND LEVELS IN EAST TEXAS SCHOOLS

The level of noise that surrounds us has increased dramatically as our society has become more mechanized and urbanized. Numerous articles exhibiting concern about this trend have appeared in the popular press. The term "noise pollution" has been frequently used to describe the problem. We as a society have become so concerned about noise that manufacturers are beginning to capitalize on the quietness of their product.

Certain industries have long had noise problems to the extent of damaging the hearing of workers. Court decisions on suits seeking damages for hearing loss, noise data collected by consulting firms for industry, and U.S. Department of Labor standards for permissible noise levels have all contributed to well-established industrial standards relating to noise levels and their effect on hearing. Much concern about the reduction of unwanted sound is evidenced in noisy industries by attention to acoustical control in the design and installation of machinery, by periodic monitoring of sound levels, and by furnishing ear plugs or other shielding devices to certain employees. An example of industry concern is the wearing of ear guards by service workers in close proximity to screaming engines of jet aircraft.

Temporary threshold shifts in hearing acuity have been experienced by many as a result of being exposed to loud sound for a period of time. This is a common phenomenon among "rock and roll" musicians. Continued exposure to loud noises can cause permanent hearing loss.

Some cities now specify permissible noise levels for air-conditioning units, power mowers, and other sound generators. Unmuffled engines and unnecessary horn-honking have been banned by city ordinances.

A major offender noise-wise may well be the home with its myriad labor-saving devices and modern conveniences. Vacuum cleaners, air-moving devices, garbage grinders, dishwashers, washing machines, power tools, and the clatter of kitchen utensils all contribute to the home being something less than a place of refuge from the noisy outside world.

With the apparent concern expressed by industry, government, and the news media, it would seem school planners would give careful attention to sound control in the design of school buildings. In a 1963 report, *Acoustical Environment of School Buildings*, Fitzroy and Reid made the following observation:

> It might be observed that in few of the schools visited was there any evidence of the use of competent acoustical assistance in planning the classrooms or classroom buildings. In some cases the acoustical materials were in the wrong locations to be effective. In other cases materials intended to be sound absorptive were not substantially so. Other acoustical complications were caused by shape faults.

This also holds true of band, orchestra, and choral rooms. Few gymnasiums or multi-use rooms received competent acoustical attention.

It is our opinion, and it can be substantiated, that careful acoustical planning is mandatory in connection with music rooms, gymnasiums, classrooms and other rooms in the average school plant. Unfortunately, many designers seem unaware of this fact. In a few cases we did find that auditoriums had been given specialized attention, but even these were in the minority.

There has been a dearth of any type of research concerning sound levels in public schools. The above-quoted study gathered data on the extent of noise reduction between classrooms attributable to design characteristics and certain characteristics of the classroom acoustical environment—reverberation time, and two measures termed "speech interference level" and "articulation index."

From a review of the literature, including a DATRIX search of doctoral studies and a survey of Educational Resources Information Center (ERIC) indices, no other major study was noted. Discussions with two professional audiologists, two directors of speech and hearing clinics, and a noted dean of an architectural school confirmed the conclusion that little attention has been devoted to a study of sound levels in the public schools.

Procedures

A study was designed and conducted with the assistance of a faculty research grant from East Texas State University to survey the sound levels in certain public school situations in Northeast Texas. The study sought to determine existing sound levels and to identify factors which might influence sound levels. A sample considered to be representative was selected considering the following factors: location of building by size of city and ambient noise level (typical background sound level) near the building entrance; the extent of glass area in exterior walls; whether facilities were air-conditioned; whether elementary or secondary schools; and to some extent, accessibility due to time and travel requirements. The conclusions of the study are considered to be valid for the school situations surveyed. No attempt is made to generalize to another population. However, the findings hopefully will prove useful to school officials, school planners, and architects in the location and planning of school buildings. Data were gathered by an experienced school administrator trained in the operation of a precision sound level meter (Bruel and Kjaer Model #2203 with #4132 filter set) capable of measuring noise intensity at different octave bands as well as the overall noise or sound level. Noise is defined for purposes of this study as the overall sound level—a composite of sound from all sources. Therefore,

sound level and noise level refer to the same measure and are used interchangeably.

The investigators sought to measure the ambient or exterior noise level of elementary and secondary schools and to determine by statistical procedures (an analysis of variance technique developed by Kruskal and Wallis) whether exterior noise levels appeared to affect interior noise levels in typical first grade and secondary social studies classrooms. Interior sound level measurements utilizing a standard procedure were taken in these school situations: elementary first grade classroom and cafeteria; secondary social studies classroom, band hall, choral room, cafeteria, and shop class. Statistical procedures were employed to examine whether significant differences in interior noise levels existed in relation to class size, type of activity, and whether the building was air-conditioned. The Mann-Whitney U Test was used to compare two groups and the Kruskal-Wallis analysis of variance technique was utilized for comparisons involving three or more groupings.

Analysis of Data

It is recognized that the measurement of sound levels in a field situation is a complex task and that inferences concerning the data are even more challenging due to the many factors that affect the acoustical environment. The investigators standardized measurement procedures and sought to control as many variables as possible in gathering and analyzing the data. In analyzing the data, the findings are presented as briefly and functionally as possible. All usable, comparable data were employed in each comparison.

All sound level measurements are the average sound level over a period of approximately one minute of what was judged to be typical activity, expressed in decibels (using the C scale, slow response, of a standard precision sound level meter). Decibel is defined in this study as a logarithmic unit measure of sound pressure.

TABLE I

Location of Elementary Building
By Population of City

		Under 5000 n=18	5000 - 24,999 n=10	25,000+ n=11
Exterior Noise Level	Low	58	60	61
	Median	62	68	72
	High	74	78	81

Note in Table I the consistent increase in exterior ambient or background noise as the size of the city increases. These differences were found to be significant at the .025 level of confidence.

TABLE II

Location of Secondary Building
By Population of City

		Under 5000 n=20	5000 - 24,999 n=13	25,000+ n=11
Exterior Noise Level	Low	56	62	60
	Median	61.5	70	69
	High	74	78	79

As shown in Table II, differences in exterior noise levels were significant at the .02 level of confidence (that is, the probability is only two in one hundred that the differences were due to chance). The major difference appeared to be in the under 5000 classification with the two larger classifications being very nearly the same.

TABLE III

Exterior Noise Level Related to
First Grade Classroom Noise Level

		Exterior Noise Level		
		62 db or less n=11	63-71 db n=11	72 db or above n=12
1st Grade Classroom	Low	59	58	63
	Median	64	63	71
	High	68	64	75

Table III relates interior noise levels to exterior noise levels. Differences are significant at the .04 level (that is, the probability is only four in one hundred that the differences were due to chance). Among the schools with exterior noise levels of 72 db or above, the interior noise levels were higher. It would seem that as exterior noise levels rise to a point beyond normal interior levels, the interfering sound tends to cause teachers and students to compensate by speaking louder. It should be noted that one school located very near a busy thoroughfare had interior noise levels that varied from 65-82 db as the traffic noise rose and fell. Similarly in two schools near a jet port, interior noise levels varied from 68-82 db in one and 69-78 db in the other. As the noise level reaches 80 db or above, a teacher or student speaking must virtually shout to be heard or wait until the interference ceases. The senior investigator, who has taught in a junior high on a major thoroughfare, recalls waiting many times for a rumbling truck to pass so discussion could continue.

TABLE IV

Exterior Noise Level Related to Secondary Social Studies Class Noise Level

		Exterior Noise Level		
		62 db or less n=14	63-71 db n=14	72 db or above n=7
Secondary Social Studies Classroom	Low	59	55	59
	Median	63	67	66
	High	70	73	76

Interior secondary social studies class noise levels are related to exterior noise levels in Table IV. The differences were not significant though they approached the .05 level, with a probability of less than .20 that the differences were due to chance alone. Again an interior reading was greatly affected by a surge of outside noise. As a jet swooped low over a junior high school the indicator needle zoomed from 69 to 82 decibels. Perhaps the secondary social studies classes were seemingly generally less affected by exterior noise due to secondary buildings tending to be larger and multi-storied Since readings were taken near the front entrance of the buildings, classrooms located farther away from the noise source would tend to receive less outside interference due to the decay rate of sound. Other factors might also have been operative since secondary buildings tended to be newer and of more substantial construction than elementary buildings among those visited.

TABLE V

Extent of Glass in Exterior Wall
Elementary School (Windows closed)
Related to Interior Noise Level — 1st Grade Classes

		50% or less n=8	More than 50% n=12
Interior Noise Level	Low	59	58
	Median	64	63
	High	66	71

Table V indicates that the extent of glass in exterior walls in elementary classrooms with windows closed was not a significant factor in regard to interior noise levels. Since schools with little glass are more likely to be air-conditioned, the extra sound contributed by air-moving equipment might have tended to offset the extra sound transmission allowed by glass as opposed to masonry. Of the eight schools with 50% glass or less, four were air-conditioned, while only two of the twelve schools in the more than 50% glass category were air-conditioned.

TABLE VI

Extent of Glass in Exterior Wall
Secondary School (Windows Closed)
Related to Interior Noise Level in
Secondary Social Studies Classes

		Less than 50% n=15	50% or more n=8
Secondary Social Studies Classroom	Low	59	55
	Median	67	64.5
	High	72	76

According to the data reported in Table VI, no significant differences in interior noise levels in secondary social studies classes were found on the basis of extent of exterior glass with windows closed. Again, the noise due to air-conditioning may have tended to negate the noise transmission allowed by glass. In this case, all but two of the fifteen secondary schools with less than 50% glass in the exterior classroom wall were air-conditioned. However, only two of the eight having 50% or more glass were air-conditioned.

TABLE VII

Interior Noise Levels in Secondary Social Studies Classes
Air-conditioned Compared with Non-Air-conditioned

		Air-conditioned n=14	Non-Air-conditioned n=21
Interior Noise Level	Low	59	55
	Median	68	64
	High	73	76

As shown by Table VII, secondary social studies classes in air-conditioned classrooms had a significantly higher noise level (.025 level of confidence—U test) than their counterpart in non-air-conditioned classrooms. No statistical comparison was made for elementary classrooms due to the small number of air-conditioned buildings in the study. With the increasing length of the school year and a trend toward more summer school programs, air-conditioning is highly desirable. However, care should be exercised in the design and installation of air-conditioning equipment to eliminate excessive noise.

TABLE VIII

Interior Noise Levels in 1st Grade Classrooms by Size of Class

		Less than 25 n=15	25 or more n=19
1st Grade Classrooms	Low	58	59
	Median	64	65
	High	74	74

Table VIII indicates that no significant difference was found in noise levels in first grade classrooms by size of class. It should be noted that class sizes tended to be within a narrow range, clustering around the average size of 25.1 pupils. Only two classes had less than twenty pupils and only two had more than thirty. It is possible that greater divergence in class size might produce greater differences in noise levels.

TABLE IX

Interior Noise Levels in Secondary Social Studies Classrooms by Size of Class

		Less than 25 n=19	25 or more n=15
Secondary Social Studies Classroom	Low	55	59
	Median	66	67
	High	73	76

As in the first grade classrooms, no significant difference due to size of class was found as shown in Table IX. This group was also quite homogeneous, with most classes being near the mean size of 24 pupils.

TABLE X

Interior Noise Levels by Type Activity in Elementary Schools

		1st Grade n=33	Choral Music n=5	Cafeteria n=10
Interior Noise Level	Low	58	72	68
	Median	64	77	76
	High	75	88	79

Table X shows that the differences in noise levels in elementary school by nature of activity are highly significant (.001 level of confidence).

Additionally, one reading of 90 db was taken in an elementary physical education class. It would appear that acoustical requirements vary greatly in reference to the nature of the activity housed.

TABLE XI

Interior Noise Levels by Type of Activity in Secondary Schools

		Social Studies n=35	Band n=9	Shop n=13	P.E. n=10
Interior Noise Level	Low	55	90	60	72
	Median	67	94	79.5	80.5
	High	73	102	90	90

Also in the secondary schools, the type of activity resulted in highly significant differences at the .001 level of confidence (Table XI). It is perhaps logical to expect significant differences among varying activities, but the extent of the differences and the extremely high noise levels found in some activities gives cause for concern. According to the U.S. Department of Labor, noise levels of 85 db or above are capable of producing hearing losses if exposure is sufficiently frequent. According to these data, it would not be surprising to find in a survey of band directors a considerable extent of permanent hearing loss. The possibility of hearing loss from high noise levels is dependent on several factors, including: extent, duration, nature, and frequency of noise exposure. It should be noted that some hearing mechanisms are more susceptible to noise damage than others. It is probable that, among secondary schools studied, some students were in contact with potentially damaging sound levels to the extent to cause permanent hearing damage. Therefore, noise levels are of such intensity in some situations to give cause for concern. Two secondary school activities not measured in this study that can generate very high noise levels are pep rallies and rock and roll concerts or dances. It is perhaps pertinent to report that one rock and roll concert in a college auditorium was measured at a consistent 112 to 120 db with bursts to 130 db—truly a deafening roar. It is inconceivable that a business or industrial employer would permit employees to be exposed to such damaging sound levels as this, unless it was unavoidable and then only with proper protection such as ear plugs or covers. As tort liability laws become more widely applicable to schools, administrators will carefully control sound levels to which students in their care are exposed.

Information was gathered in regard to the extent of acoustical treatment in classrooms. However, virtually all classrooms had ceiling materials with some degree of acoustical treatment. Only one or two had no treatment, only two were regarded to have a medium amount of treatment, and only two had

a large extent of treatment, including carpeting. Because of the small amounts of data in proposed comparison categories, no analysis on the basis of acoustical treatment was attempted. It would seem that careful attention to acoustical treatment in accord with the nature of the activity would be highly desirable in designing school buildings.

Conclusions and Recommendations

1. It is recommended that school planners secure data on present and projected noise levels at each site under consideration. The topography and sub-soil characteristics of a site have long been routinely studied prior to selection of a site and location of the building. Noise levels need also to be carefully studied, for a location with high noise levels would require much more extensive (and expensive) attention to acoustical properties of exterior walls. Sound diminishes as distance from the source increases. Similarly, the topography of the site, including trees, shrubbery, and lawns, significantly affect the acoustical environment. Therefore the location of a building on a particular site may greatly affect exterior noise levels and hence the amount of noise reduction required to minimize interference in classrooms.

2. Among first grade classrooms, the exterior noise levels were significantly related to the interior sound levels. The differences between exterior noise levels and sound levels in secondary social studies classrooms approached significance as noted earlier in Table IV. In certain elementary and secondary classrooms, great variations were found in sound levels that were directly related to exterior traffic flow or the approach of a jet aircraft. Where unusually noisy school sites must be utilized, careful attention needs to be given to acoustical planning in order to provide an acceptable learning environment that is not disrupted by intense surges of noise nor requires teachers and students to raise their voices in order to be heard.

3. The extent of glass in the exterior wall of elementary classrooms with windows closed was not a significant factor affecting interior noise levels. However, as noted in Table V, more of the schools with 50% glass or less were air-conditioned than those with more than 50% glass in the exterior wall—a factor which may have affected the findings.

4. Secondary social studies classes in air-conditioned classrooms had a significantly higher noise level than their counterpart in non-air-conditioned classrooms. Air-conditioning is increasingly being incorporated in school buildings, particularly in warmer climates. Careful attention should be given by the architect and mechanical

engineers to the design and installation of air-conditioning equipment and ductwork to eliminate excessive noise.

5. Class size made no significant difference in sound levels in either 1st grade classrooms or secondary social studies classrooms. It should be noted that little divergence in class size was found with virtually all having between 20 and 30 pupils.

6. The type activity in the classroom made a highly significant difference in the classroom sound level in both the elementary and secondary schools. In the elementary schools, sound levels varied from 58 db in a 1st grade classroom to 90 db in a physical education class. In the secondary schools the sound level varied from 55 db in a social studies class to 102 db in a band rehearsal room. Noise levels above 85 db can produce hearing loss depending upon the length and frequency of exposure and the intensity and nature of the noise. Since readings of 90 db and above were found in all secondary band rooms and in some shop and P.E. classes, it would appear that noise levels are high enough to cause concern as to the possibility of hearing loss for some students. By all means, the design of band rehearsal rooms, choral rehearsal rooms, P.E. facilities, and school shops requires careful attention to sound control.

In summary, this study found that sound levels in schools vary a great deal, being affected by several factors, including: location of the buildings, exterior noise levels, air-conditioning, and by the nature of the activity—the most influential factor. School planners should give careful attention to the above factors in locating and designing school buildings. School administrators should give careful attention to existing noise levels and take corrective action where needed.

The sound levels in schools seem to be of great enough magnitude to affect work efficiency. It is recommended that a study be conducted to determine the effect on teaching-learning efficiency of different sound levels.

Since our children spend a major portion of their "prime time" in school, they deserve an acoustical environment free of potentially hazardous sound levels and one conducive to learning.

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