School Facility Conditions and Student Academic Achievement

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I. INTRODUCTION: SUMMARY OF FINDINGS

Based on my own studies, my review of pertinent research st1udies, and my background and experience in the field, my conclusion is that school facility conditions do affect student academic achievement. In particular, I reach the following conclusions:

a. School building design features and components have been proven to have a measurable influence upon student learning. Among the influential features and components are those impacting temperature, lighting, acoustics and age. Researchers have found a negative impact upon student performance in buildings where deficiencies in any of these features exist. In addition, overcrowded school buildings and classrooms have been found to be a negative influence upon student performance, especially for minority/poverty students. Section III describes studies that used a particular building feature or component such as air conditioning, lighting, or presence of windows to serve as variables with which to compare student achievement.

b. The overall impact a school building has on students can be either positive or negative, depending upon the condition of the building. In cases where students attend school in substandard buildings they are definitely handicapped in their academic achievement. Correlation studies show a strong positive relationship between overall building conditions and student achievement. Researchers have repeatedly found a difference of between 5-17 percentile points difference between achievement of students in poor buildings and those students in standard buildings, when the socioeconomic status of students is controlled. Section IV deals with those studies that used some form of assessment to determine the total condition of the school building and then compared the results with student performance.

c. Ethnographic and perception studies indicate that poor school facilities negatively impact teacher effectiveness and performance, and therefore have a negative impact on student performance. Section V of the report describes ethnographic studies related to the influence the physical environment has upon teacher performance.

d. Recent studies regarding the number of students in schools as compared with its capacity provide ample evidence that overcrowding conditions are a negative influence upon students and teachers. Section VI describes studies dealing with the relationship between overcrowding and student achievement.

All of the studies cited in this report demonstrate a positive relationship between student performance and various factors or components of the built environment. The strength of that relationship varies according to the particular study completed; nevertheless, the weight of evidence supports the premise that a school building has a measurable influence on student achievement.

II. THE STATE OF AMERICA'S SCHOOL BUILDINGS

During this past decade, there have been a number of studies that have demonstrated the deplorable condition of some of the school buildings throughout the country. The U.S. General Accounting Office has identified every state in the union, including California, as having school buildings that are in poor condition (1995). In many school systems, particularly in urban and high-poverty areas, students attend school in buildings that threaten their health, safety, and learning opportunities (U.S. Department of Education, NCES, June, 2000).

The GAO (1995) estimates that over half of the 42 million public school students attend school in a building that needs at least one or more major building component or feature extensively repaired. As a result of this situation, research exploring the relationship between building condition and student performance is critical.

In addition, many school districts throughout the country have a large number of old, worn-out buildings in which to educate students. The National Center for Educational Statistics stated the average age of school buildings in the United States was 40 years old. This would mean that half of the existing school buildings were completed before 1959 (NCES, 2000).

Many old buildings simply do not have the features, such as control of the thermal environment, adequate lighting, good roofs, and adequate space that are necessary for a good learning environment. Or if older buildings have such components, oftentimes they are not

functioning because of poor maintenance practices. School buildings that can adequately provide a good learning environment are essential for student success (USDOE, 2000). The bridge between good physical environment and effective student learning is quite important.

III. BUILDING COMPONENTS AND STUDENT PERFORMANCE

A. Thermal Quality

Good thermal environment of a classroom is very important to efficient student performance. Various researchers have provided a long history of research on thermal conditions in the business and industrial workplace. McGuffey (1982) lists such researchers as Vernon, Bedford, and Warner (1927), Osborne and Vernon (1922), McConnell and Yaglou (1926), Mackworth (1926), Winslow and Herrington (1949), Herrington (1952), and Karpovich (1959). The conclusion of these researchers was that increases in temperatures in the workplace tends to decrease worker efficiency and increases the risk of work related accidents. As a result, proper control of the thermal environment is needed in the workplace.

These studies have provided some of the motivation for research efforts on the influence the thermal quality of the classroom has upon students. Specific research studies cited by McGuffey (1982) regarding the influence the thermal quality of the classroom has upon students have been completed by Mayo (1955), Nolan (1960), Peccolo (1962), Stuart and Curtis (1964), McCardle (1966), Harner (1974). Lemasters (1997) also cited Chan (1980). In almost all of these studies, the importance of a controlled thermal environment was stressed as necessary for satisfactory student performance.

Harner (1974) concluded based upon an analysis of existing research that temperatures above 74°F adversely affected reading and mathematics skills. A significant reduction in reading speed and comprehension occurred between 73.4º F and 80.6º F. According to his analysis, the ideal temperature range for effective learning in reading and mathematics is between 68º and 74º F. Lanham (1999) reported that after the socioeconomic status of the students, the most influential building condition variable that influenced student achievement was air conditioning.

In all of the above cases, the researchers presented convincing data that supports the seminal work done 61 years ago by the New York Commission on Ventilation (1931). The Commission endeavored to determine optimal air temperatures in classrooms for the healthiest environment for students. The experiments were conducted in regular city and rural classrooms as well as experimental laboratories at a local college. Students were subjected to varying temperatures while in the classroom and measures of the number of reported illnesses were taken to compare with the temperatures. The Commission reported that when classrooms are not maintained within the narrow band of temperature and humidity tolerances of 67° - 73°F and 50 percent relative humidity, there were more reported cases of student illnesses than students in a properly controlled thermal environment.

The results of the Commission Study confirmed earlier studies conducted in the workplace that found excessively high temperatures tends to produce harmful physiological effects on workers. That part of the study that dealt with overheating showed that 15 percent less physical work was performed at 75° F than at 68° F with humidity at 50 percent; while at 86° F with 80 percent humidity, the decrease was 28 percent as compared to that performed at 68° F with humidity at 50 percent. In spite of the age of this research, these findings are just as germane today as they were three quarters of a century ago.

B. Acoustic Quality

Proper and accurate hearing is essential to student's ability to learn in the classroom. Many studies have determined the level of noise in the classroom that interferes with student learning. As far back as 1917, Morgan concluded that noise distraction interfered with learning and that students reported being tense in noisy classrooms (McGuffey, 1982). Laird (1930) concluded that students learn more when the classroom noise level is reduced to 40 decibels (Ibid). McGuffey identified more recent researchers that have found similar results. Cohen, Evans, Krantz, and Stokols (1980), Zentall and Shaw (1980), Cohen, et al (1981), Hyatt (1982), and Duffy (1992) have completed research studies conducted in public schools that investigated relationships between noise level and various student behavioral and performance variables. The methodology used by these researchers is appropriately controlled for other factors, thereby isolating the relationship between acoustic conditions and student health and achievement.

An excellent study completed by the Department of Health Services in California (1981) investigated the relationship between student performance and classroom and community noise. The study was well conceptualized and executed, using exacting measurements, and appropriate statistical analysis. Students in grades three and six in schools that were near highways and expressways were compared with similar students in schools in quiet neighborhoods. A very rigorous methodology and analysis were used for the comparison of scores on the California Test of Basic Skills. The mean grade equivalent achievement scores of all students in socioeconomically matched noisy and quiet schools were compared. Students in grades three and six in the quiet schools scored considerably higher in reading scores than students in noisy schools. In mathematics, the researchers found a measurable impact upon student test scores, but not as large as that found in reading. Based upon these results, the conclusion was reached that a negative relationship exists between classroom noise levels and reading achievement.

The results of the California study support the findings of Bronzaft and McCarthy (1975) who measured students in schools near elevated train tracks in New York City and found that students in classrooms nearest the trains scored below those students in classrooms on the opposite side of the school building in reading scores. In a follow-up study, Bronzaft (1981) compared the California Achievement Test scores of student in classrooms on the noisy side of the building with those students on the quiet side of the building after certain noise abatement measures were installed. In three of the classrooms on the noisy side of the building, acoustical treatment was applied to the ceilings. In addition resilient rubber pads were installed on the elevated rail track. These measures effectively reduced the extraneous noise level for students. In comparing the test scores, she found no differences between the scores of students in the noisy and quiet side of the building, whereas before there had been differences..

All of these studies are seminal works that aptly demonstrate the devastating effect of unwanted noise in the classroom. The findings of these studies are important and can be relied upon because appropriate methodology was used and the researchers were able to control the student population. The ability to clearly hear and understand what is being spoken is a prerequisite for effective learning. When this ability is impaired through unwanted noise students do not perform well.

C. School Building Age

The age of the school building has been tested as a factor in relationship to student achievement. Age of building in and of itself is usually not an important factor in influencing student performance, but the building components that are necessary for good student learning (e.g. thermal quality and acoustical control) are usually absent in older buildings. If older buildings do have some of the important components, these components may well be compromised because of poor maintenance or retrofitting practices. In my own survey of the research, a clear conclusion follows that older buildings usually do not have the main attributes of a modern building that are associated with a positive physical environment conducive to student learning (Earthman & Lemaster October, 1996). Normally such buildings do not have positive thermal control in the classrooms where the temperature can be controlled. Even when an older building has classroom control of the heating/cooling/ventilation, the old shell of the building is not sound enough to eliminate drafts of air coming into the space. Likewise, older structures characteristically do not have proper illumination. In most modern buildings acoustical control measures have been installed, but older buildings do not have such measures to control noise. Many of the building factors that are necessary for proper learning environments are simply absent in older buildings, but are present and functioning in new buildings.

As a result, many researchers have used age of the building as a variable that might help explain student achievement. McGuffey & Brown (1978), Plumley, (1978), Chan, (1979), Garrett (1981), Bowers and Burkett (1988), and Phillips (1997) have all found age of school building to explain a percentage of the variance of student learning. For example, Plumley found that building age accounted for 3.3 percent to 6.4 percent of the variance on 3 of the 5 subtests and 5.3 percent of the variance of student learning when age of building is correlated with the composite score of students on the Iowa Test of Basic Skills. In other words, these percentages represent how much the building age accounts for in the difference between the scores of students in new and old buildings. Phillips found a difference between the mean test scores of fifth grade students in old and modern buildings to be 2.55 points for reading and 7.67 points for mathematics. In the third grade, the differences in mean test scores were 3.25 points for reading

and 5.7 points for mathematics. All things being equal, students in modern buildings perform better on achievement tests than students in older buildings.

IV. OVERALL BUILDING CONDITION AND STUDENT PERFORMANCE

Some of the more recent studies, including my own, compare the building condition obtained through an assessment of certain components or features that have a direct influence on student achievement. These studies are very similar to those that used the age of the building as a variable in correlating student achievement, but in these studies the evaluative instrument provides a more complete assessment of the condition of the building. These correlation studies are very focussed in their approach and use measurable data for statistical analysis. As a result, the data from these types of studies document in rather precise terms the amount of differences in academic achievement of students in substandard buildings and those students in functional buildings.

Four well-designed studies have used a composite building condition to measure the relationship it has upon student achievement. Berner (1993) compared the condition of elementary schools in Washington, DC to student standardized achievement scores. She used data from the survey of school buildings conducted by the D.C. Committee on Public Education (COPE). The Committee organized several groups of maintenance workers, engineers, and architects who were charged with the responsibility of assessing the building condition and determining whether the building was in overall poor, fair, or excellent condition. Based upon this classification, she correlated that building rating with student achievement scores. The percent of students participating in the free/reduced lunch program, mean income in the census tract, and percentage of white students in the census tract were used as a control for the socioeconomic status of the school. She found a significant difference of 5 percentile points in the achievement scores of students in poor buildings compared with scores of students in excellent buildings. She also stated that based upon the parameter estimate that if a school were to improve its conditions from poor to excellent, the achievement scores would increase by an average of 10.9 points. Cash (1993) developed an instrument to measure the condition of school buildings. To construct her evaluative instrument, she used previous research studies to identify building components or features that had measurable influence upon student achievement. She

combined these components into the instrument used to determine building condition. Her population consisted of all rural high schools and students in Virginia. Socioeconomic differences were controlled by using the percent of student participation in the free/reduced lunch program as a variable. She found the achievement scores of students in substandard buildings to be from 2 to 5 percentile points below the scores of students in above standard buildings. I conducted a replication of the Cash study along with several colleagues using all of the high schools in North Dakota (Earthman, et al, 1996). The results of this study confirmed the findings by Cash. Hines (1996) completed a similar study using basically the same instrument and methodology as Cash, but with a population consisting of large urban high schools in Virginia. All of these researchers found the same range of differences in achievement scores of students in substandard verses above standard buildings when controlling for socioeconomic differences between the various school districts. The North Dakota study produced a difference of 5 percentile rank points on the composite or total achievement scores for students in substandard buildings versus students in above standard buildings and differences of 7 and 9 percentile rank points on the reading vocabulary and spelling sub-tests. Hines found higher differences in his study of urban high schools. These differences between students in substandard buildings and students in above standard buildings were 14 percentile rank points on the composite achievement scores and as high as 15 and 17 percentile rank points on reading and mathematics sub-tests respectively.

Subsequent research studies (Andersen, 1999; Ayres, 1999, O'Neill, 2000) have provided some support for the results of previously cited researchers who found the average difference between students in old or substandard buildings and those students in modern or above standard buildings to be from 5-17 percentile points. Taken together, the research studies cited above, along with the studies dealing with age of buildings, presents a formidable body of research findings that demonstrate that the condition of the school building has a sizeable and measurable influence upon the achievement of students (Earthman, 1998).

V. BUILDING CONDITION AND TEACHER EFFECTIVENESS

The condition of a school building not only influences student achievement, but can also influence the work and effectiveness of a teacher. Although it is very difficult to measure

teacher effectiveness quantifiably, perception studies of teachers in good and poor school buildings provide a rich source of data relative to the effect the physical environment has upon these professionals. Such ethnographic studies are an important source of findings regarding the influence the physical environment has upon teachers and students.

Lowe (1990) investigated the relationship between learning climate and physical conditions in three elementary schools in Texas. The learning climate was defined as the ethos of expectations and perceptions of teachers, students, parents about self, student achievement, organizational rules and policies and the facility itself. A researcher designed perception questionnaire was used to obtain data from teachers regarding the effect the building condition had upon their performance. Teachers in buildings in poor condition stated that the design and appearance of the facility had a negative impact upon the learning climate. Conversely, teachers in building in good condition reported the building had a positive influence upon the learning climate. The size and organization of instructional space was reported as having an influence upon learning climate. The maintenance of the building, according to the teachers, seemed to impact the learning climate, as did the design and appearance of the building.

Corcoran, Walker, and White (1988) described the working conditions of teachers in urban schools. The teachers stated that the physical environment was sub-standard even in the newer buildings primarily because of the lack of proper maintenance and repair. The researchers reported that the working condition of urban teachers is marginal and would not be tolerated by any other profession. Good working conditions in the "best" schools in the study included an adequately maintained physical plant.

Dawson and Parker (1998) provide a descriptive analysis of the feelings of teachers about the building before, during, and after a renovation project is done on their schools. Teachers reported that there were many aspects of the renovation project they did not like and they had negative feelings about their work before and during that period of time. After the renovation, however, teachers reported that morale among the faculty was high and their frustration level was much lower than during the renovation. The faculty reported that the changes and improvements to the physical environment greatly enhanced the teaching and learning environment and in a way compensated for the inconveniences the renovation work caused.

The studies cited above have amply documented the fact that poor schools do reduce the effectiveness of the teachers and subsequently have a negative influence upon the ability of the students to learn.

VI. OVERCROWDED SCHOOLS AND STUDENT ACHIEVEMENT

Overcrowding of school buildings occurs for many reasons. Whatever the reasons, the result is very troublesome for both the students and teachers, as well as the organization itself. An overcrowded building is normally defined in terms of there being more students assigned to the building than it is designed to accommodate. The type and kind of educational program offered in a school also has relevance for the capacity of the building. When the capacity of the building is exceeded extreme pressure is exerted upon all of the facilities and areas that teachers, administrators, and students need to use for an effective educational program.

Although there are not as many research studies on the effect overcrowding has on student learning as there are with other physical environmental factors, nevertheless available research shows that overcrowding causes a variety of problems and the findings indicate that students in overcrowded schools and classrooms do not score as high on achievement tests as students in non-overcrowded schools and classrooms. Corcoran et al. (1988) reported that overcrowding resulted in a high rate of absenteeism among teachers and students. Teachers reported that overcrowding resulted in stressful and unpleasant working conditions. The population Corcoran used consisted of the teachers in 31 elementary, middle, and high school buildings in 5 major cities across the nation. The authors of the study observed that the working conditions of the teachers in these schools would be considered intolerable in another profession.

During the period of time between 1990 and 1996, the New York City Public Schools experienced severe overcrowding throughout the city. Three major studies were conducted to determine the effect of overcrowding on the student population and the city school organization. The first study dealt with the causes of overcrowding conditions and offered some remedies to alleviate the condition (Fernandez and Timpane, 1995). This report focussed on school crowding, physical conditions of buildings, and class sizes. Also included in this report was a discussion of the impact overcrowded conditions had upon student achievement and teachers

efficiency. According to the report, "Teachers say that overcrowded schools are noisier, that they create more non-instructional duties and paperwork, and that, without question, they inhibit teaching and learning." (p.6).

Rivera-Batiz and Marti (1995) completed the other report dealing with the consequences of overcrowding. They surveyed 599 students and 213 teachers in overcrowded schools to obtain their reactions to the overcrowded conditions. More then 75 percent of the teachers reported that overcrowding negatively affected both classroom activities and instructional techniques. Close to 40 percent of the students reported they had problems concentrating in their classes when learning something new. The researchers also reported that teacher burnout was much more common in overcrowded buildings than in underutilized buildings. They also stated that in overcrowded schools teachers reported they had only time to cover the basic material and could not have any time for further exploration.

Rivera-Batiz and Marti used data from the Board of Education school profile on elementary and high schools to examine the linkage between overcrowded conditions and student achievement. The influence of overcrowding on student achievement was analyzed by multiple regression statistical analysis. Student achievement was measured by the percentage of students passing the Degrees of Reading Power Test and the Pupil Evaluation Program Test for mathematics. The reading test is given to all students in the city in grades 2-10. The mathematics test is administered to students in grades 3 and 6. To control for the socioeconomic background, separate analyses were conducted for: (1) schools with a high proportion of students from families with high socioeconomic status, and (2) schools with a high proportion of students from families with low socioeconomic status. The analysis for the schools with a high percentage of low socioeconomic students indicated that…."the proportion of sixth graders in overutilized facilities passing the minimum standard for the DRP reading examination was between 4 to 9 percentage points *below* that in schools that were not overcrowded, holding other things constant"(p. 10, emphasis in original). For the mathematics test, "the proportion of sixth graders who passed the exam was between 2 to 6 percentage points *below* that in schools that were not overcrowded, other things held constant" (p.10, emphasis in original). The analysis for the schools that had higher socioeconomic families indicated students passing the minimum

standard was approximately 2-4 percentage points above the schools that were not overcrowded, other things held constant. Overcrowding in these schools resulted because areas of high socioeconomic status and high academic achievement attract more students to these schools and cause overcrowding. The results of the analysis indicate that among schools with a high proportion of students from low socioeconomic status families, overcrowding has a definitely negative impact on student achievement.

Contrasted to these findings are those of the class-size study in Tennessee (Finn and Achilles, 1999). These researchers studied the effect small class size (15-17 students per classroom) has upon primary grade student achievement. Over 12,000 students participated in the study over the four years. Incoming kindergarten students were randomly assigned to one of three types of classrooms: small classes (13-17 students), regular classes (22-26 students), or regular classes with a teacher's aide. The researchers compared the achievement scores of students using results of the Stanford Achievement Test, the Comprehensive Tests of Basic Skills, and the Tennessee Basic Skills First Tests. The findings relating to achievement test scores indicated statistically significant differences were found among the three classroom types on all achievement measures. Students in the small classes evidenced superior academic performance compared to those students in the regular classrooms, both with and without a teacher's aide. Further, they found that the differences in test scores were higher for minority students and those in urban areas. They also found there was a long-term improvement of those students in small classes in the primary grades when they returned to regular-sized classrooms. Additional benefits of the class reduction program was that smaller classes can enhance the student/teacher interaction, the amount of attention available to any student, the amount of individualized instruction, as well as the level of disruptive behavior that can be tolerated. Obviously, from the research findings above concerning overcrowded classrooms the above activities would be severely curtailed or would not even occur.

The Public Advocate for the City of New York investigated the effect overcrowding had upon the school district organization (December, 2000). He stated that in smaller classes students receive more individual attention, ask more questions, and participate more fully in discussions. Teachers reported they spend more time maintaining order and keeping the noise

level down. The author of the Public Advocate Report quoted from a US Department of Education press release (USDOE, September 2000) which stated: "Evidence continues to accumulate that shows that reducing class size improves student achievement, reduces discipline problems, and provides a lasting benefit to both students and teachers."(Public Advocate, p.1).

In spite of the fact that some of the results of studies dealing with overcrowded conditions are limited, excellent studies conducted in the New York City Public Schools and other states provide ample evidence that overcrowding conditions are a negative influence upon students and teachers. The United States Department of Education (USDOE, 2/14/02) completed a review of several major analyses and concluded that the research results indicate that class size reduction in the primary grades leads to higher student achievement and that if class sizes are reduced below 20 students, the related increase in student achievement moves the average student from the 50^{th} percentile up to somewhere above the 60^{th} percentile. Achievement results for disadvantaged and minority students are somewhat larger.

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