Do School Facilities Affect Academic Outcomes?

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On any given school day, about twenty percent of Americans spend time in a school building. The average age of our schools is close to fifty years, and studies by the U.S. General Accounting Office have documented widespread physical deficiencies in many of them. Faced with an aging building stock and growing, shifting student enrollments, states and communities are working hard to build and modernize K–12 facilities.

Those involved in school planning and design see this as an opportunity to enhance academic outcomes by creating better learning environments. Their logic is compelling—how can we expect students to perform at high levels in school buildings that are substandard?

We all know that clean, quiet, safe, comfortable, and healthy environments are an important component of successful teaching and learning. But which facility attributes affect academic outcomes the most and in what manner and degree?

A growing body of research addresses these questions. Some of it is good, some less so; much of it is inconclusive. The research is examined here in six categories: indoor air quality, ventilation, and thermal comfort; lighting; acoustics; building age and quality; school size; and class size.

Indoor Air Quality, Ventilation, and Thermal Comfort

There is a growing body of work linking educational achievement and student performance to the quality of air they breathe in schools. Some of this research is just beginning to make a cumulative mark, and some of the research, for example on thermal comfort, shows how much variation there is between individuals, making guidance for school construction somewhat difficult.

Indoor Air Quality

Poor indoor air quality (IAQ) is widespread, and its effects are too important to ignore. The U.S. General Accounting Office has found that fifteen thousand schools suffer from poor IAQ, affecting more than eight million children or one in five children in America's schools (General Accounting Office 1995). The IAQ symptoms identified—irritated eyes, nose and throat, upper respiratory infections, nausea, dizziness, headaches and fatigue, or sleepiness—have collectively been referred to as "sick building syndrome" (EPA 2000).

Ironically, the high incidence of symptoms stemming from poor IAQ seems to have emerged as an unintended consequence of the electric power brownouts, oil embargoes, and gas lines that characterized the 1970s energy crisis. In response to that national emergency, many buildings, including schools, were fitted with air handling systems and controls that delivered less fresh air than now is considered adequate. Most recommendations from the Occupational Safety and Health Administration (OSHA) and the National Institute of Occupational Safety and Health (NIOSH) now call for between fifteen and twenty cubic feet of air per minute per person. These enhanced ventilation rates not only deliver more adequate supplies of fresh air but also help dilute or remove contaminants, especially chemical (e.g., formaldehyde, toluene, and styrene) and biological (e.g., mold and bacteria) contaminants that have highly demonstrable negative health effects.

Linking IAQ to Student Performance

Most discussions linking IAQ to student performance depend on a series of simple logical links: poor indoor air quality makes teachers and students sick—and sick students and teachers can't perform as well as healthy ones (EPA 2000, Kennedy 2001, Leach 1997). This logic seems unassailable, and researchers are developing the scientific evidence to support it.

Most notably, poor IAQ has been associated with increased student absenteeism. For example, Smedje and Norback (1999) found a positive relationship between airborne bacteria and mold and asthma in children, which in turn increased absentee rates (also Rosen and Richardson 1999, EPA 2000). Further, the American Lung Association (ALA) found that American children miss more than ten million school days each year because of asthma exacerbated by poor IAQ (ALA 2002, EPA 2000).

Rosen and Richardson (1999) found that improving air quality through electrostatic air cleaning technology reduces absenteeism. Their experiment, conducted in two Swedish day-care centers, one old and the other modern, collected data on absenteeism and air quality over three years. The air cleaning technology was operational during only the second of the three test years, and absenteeism fell during that period in both schools. But only in the older school did the change reach statistical significance (absenteeism dropped from 8.31 percent in year one to 3.75 percent in year two, but upon removing the air cleaners, the rate increased to 7.94 percent in year three).

Temperature and Humidity

Temperature and humidity affect IAQ in many ways, perhaps most significantly because their levels can promote or inhibit the presence of bacteria and mold. For example, a study of Florida classrooms with relative humidity levels greater than seventy-two percent found visible mold growth on the ceilings and complaints of allergy symptoms associated with sick building syndrome (Bates 1996). At the other end of the humidity scale, Leach (1997) reported findings of a 1970 study done in Saskatoon, Saskatchewan, Canada, which found absenteeism was reduced in schools by twenty percent as relative humidity in the facilities was increased from twenty-two to thirty-five percent. Wyon (1991) showed that student performance at mental tasks is affected by changes in temperature, and Fang et al. (1998) found that office workers are most comfortable in the low end of temperature and humidity comfort zones. These findings support the idea that students will perform mental tasks best in rooms kept at moderate humidity levels (forty to seventy percent) and moderate temperatures in the range of sixty-eight to seventy-four degrees Fahrenheit (Harner 1974, Wyon, Andersen, and Lundqvist 1979).

Ventilation Effects on Performance

It seems obvious that in a sealed space, without the availability of fresh air from outside, the occupants of that space will die from asphyxiation. Yet despite this knowledge, deaths of workers in confined spaces constitute a recurring occupational tragedy (NIOSH 1986). While we certainly seek to avoid such extreme conditions in schools, a surprising number of classrooms lack adequate ventilation, and evidence is accumulating to support the common-sense notion that occupants of a classroom without good ventilation can't function normally and can't learn at their full capacity.

The purpose of ventilating classrooms and school buildings, at minimum, is to remove or otherwise dilute contaminants that can build up inside. Such contaminants come from people breathing, from their skin, clothes, perfumes, shampoos, deodorants, from building materials and cleaning agents, pathogens, and from a host of other agents that, in sufficient concentrations, are harmful.

Schools need especially good ventilation because children breathe a greater volume of air in proportion to their body weight than adults do (Kennedy 2001, McGovern 1998, Moore 1998) and because schools have much less floor space per person than found in most office buildings (Crawford 1998). But because of the high costs of conditioning the ventilation air in schools to comfortable temperatures before it is circulated, the designers and operators of school buildings can be the unwitting architects of learning spaces that impair learning and health by offering inadequate ventilation—whether this results from economic measures, ignorance, neglect, poor maintenance, or some combination of these factors.

One of the first symptoms of poor ventilation in a building is a buildup of carbon dioxide caused by human respiration. When carbon dioxide levels reach 1000 parts per million (about three times what is normally found in the atmosphere), headaches, drowsiness, and the inability to concentrate ensue. Myhrvold et al. (1996) found that increased carbon dioxide levels in classrooms owing to poor ventilation decreased student performance on concentration tests and increased students' complaints of health problems as compared to classes with lower carbon dioxide levels. The study was conducted at eight different European schools on more than 800 students with results that achieved statistical significance.

Despite the clear need for fresh air in schools, the systems that are the principal source of ventilation other than windows don't always deliver adequate supplies of fresh air. These include not just the ducted systems influenced by the 1970s energy crisis, which often delivered only about one third of the fresh air supplies now deemed adequate (ASHRAE 1989), but a whole variety of ventilation systems with their own unique problems. For example, the through-wall unit ventilators specified in school designs for decades, which connect directly through the wall to an outside air source and are fitted with a fan to draw outside air into the classroom (Strickland 2001), often become shelves for books and other classroom materials, which in turn restricts fresh air flow. The intake vents in these systems, through poor design, siting or neglect, can restrict airflow or can have their flows restricted by snow or debris at ground level, for example, which can result in an accumulation of mold, bacteria, and other contaminants (Crawford 1998). These unit ventilators, beyond creating excessive, sustained background noise that can hinder learning, also tend to filter out less air pollution than more modern ventilation systems, which can lead to higher levels of volatile organic compounds (VOC) in the air (Strickland 2001, 364).

Inadequate ventilation is often a cause of IAQ problems. A 1989 study by the National Institute for Occupational Safety and Health found that more than half of the IAQ problems in the workplace were caused by inadequate ventilation (NIOSH 1989). A 1992 study by Armstrong Laboratory found that the two greatest causes of poor IAQ were inadequate maintenance of heating, ventilation, and air conditioning (HVAC) systems and a lack of fresh air. A 1998 Cornell University study found that workers in poorly ventilated offices are twice as likely to report the symptoms of sick building syndrome as employees in well-ventilated environments. The study also found that a relatively small buildup of carbon dioxide from human respiration—an indicator of poor ventilation—is also related to sick building syndrome (Lang 1998).

In a recent study, twenty-six percent of Chicago public school teachers and more than thirty percent of Washington, D.C., teachers interviewed reported health-related problems caused by the school facility. Most of these problems were related to poor indoor air quality, with teachers reporting that asthma and other respiratory problems were the main adverse health effect (Schneider 2002).

As for scientific evidence for ventilation's effect on performance, two recent papers examining talk times for registered nurses in call centers found that ventilation levels had only a small negative effect on productivity (Federspiel et al. 2002, Fisk et al. 2002). However, Smedje and Norback (1999) and Wargocki et al. (1999) reported stronger links. Wargocki et al. found that ventilation levels in offices affected performance in logical reasoning, typing, and arithmetic (also EPA 2000). The researchers also found that higher carbon dioxide levels increased the incidence of headaches, which appeared "to affect human performance during office work by reducing the inclination to exert effort" (Wargocki et al. 1999, 136). Can we assume that this relationship might extend to students, perhaps even more so because they are growing, developing, and attempting to learn new things?

Smedje and Norback (1999) in a 1993 survey found that students with asthmatic symptoms were less likely to report them two years later if the school they attended had installed a new ventilation system in the meantime. Given that asthma is among the leading causes of absenteeism in American schools, we can assume that improved ventilation can bring about less asthma, better school attendance, and improved academic performance.

Walinder et al. (1997) found that schools in Sweden with the lowest ventilation rates had VOC concentrations two to eight times higher than schools with adequate ventilation, and students in these schools were more likely to have swelling of the nasal mucosa, a symptom associated with sick building syndrome that could lead to absenteeism.

Though we know that some specific components of indoor air quality will likely affect students, rigorous studies comparing the individual effects and the interactive effects of different aspects of air quality still are needed. As Woods et al. note, "Building managers and other fiscal decision-makers still tend to minimize the value of environmental control. This may be in part caused by the absence of scientific, quantifiable data to support decisions addressing health impacts." Woods also argues that most previous field studies have not had adequate control groups, and many studies have been anecdotal. Moreover, most studies have focused on single environmental media, leaving aside the critical issue of interaction effects between daylighting, air quality, noise, thermal comfort, or other factors that affect learning (Woods et al., no date, 1–2).

Given these problems, it is perhaps not surprising that the American Public Health Association (2000) has criticized the U.S. Department of Education for the lack of scientific research in this area.

There may be some improvements in the state of knowledge in the future. One promising study is a three-year research project launched in 2001 by the HP-Woods Research Institute. Based on a rigorous research design with treatment and control groups, the study is to focus on student performance, health, and productivity (improved performance compared to the cost of creating that performance) at differing levels of IAQ and with different mechanisms in place for solving IAQ problems. The study is intended to follow third and fourth graders in six schools from two areas in Montgomery County, Maryland.

The Center for the Built Environment (CBE) at the University of California at Berkeley has placed ventilation's effects on productivity on its research agenda, so perhaps it will find new scientific evidence that will yield better assessments of ventilation's effects on student performance.

The federal government may act as a catalyst for more research. The No Child Left Behind Act of 2001 calls for more research into IAQ and student performance. Specifically, Section 5414 of the bill calls for the Department of Education to conduct a "study regarding the health and learning impacts of environmentally unhealthy public school buildings on students and teachers" (U.S. Congress 2002). The bill goes further, requesting that the Department of Education make recommendations to Congress on how to bring schools into compliance with environmental health standards and the cost of such an effort. While no date exists determining when such a study takes place, it should eventually provide much needed guidance for policy makers.

The current lack of specific knowledge makes it difficult for policy makers to create definitive IAQ standards. However, while scientists, engineers, architects, and others seek to quantify more exactly the precise links between IAQ and student performance, some school districts are investing extra effort and resources to ensure that fresh air in schools is plentiful and readily available to students and teachers. Minneapolis schools—where the design and construction of school buildings is managed to maximize air quality—are a case in point (Leach 1997, 32). The list of such "demonstration" projects is expanding. Indeed, there is a growing movement to construct schools that provide not only good indoor air quality and thermal comfort but also utilize high-performance energy-saving HVAC systems coupled to other advanced building systems, including environmentally preferable building materials and products in order to produce quality schools that promote rather than detract from the health and productivity of occupants over their life (SBIC 2000).

IAQ and Environmental Justice

As with several other areas reported in this publication linking the quality of school facilities to student performance, some researchers are directly concerned about the disproportionate effect of poor air quality in schools on students from racial minority groups and from families having lower socio-economic status.

Most notably, the Children's Environmental Health Network's (CEHN) 1997 conference on the exposure of children to environmental hazards reported that children from racial minorities are more likely to encounter poor IAQ. The proceedings of the CEHN conference stated that Black and Hispanic neighborhoods have a disproportionate number of toxic waste facilities in their neighborhoods and that eighty percent of Hispanics live in neighborhoods where air quality does not meet EPA standards (CEHN 1997). While this finding does not specifically focus on schools, the existence of poor quality air in these neighborhoods may parallel poor quality air indoors in schools.

Statistics from the General Accounting Office report on school facilities in 1996 directly confirm that schools serving poor and minority students do suffer disproportionately from poor IAQ (General Accounting Office 1996). Of schools where less than forty percent of their students were eligible for free lunch, approximately sixteen percent reported unsatisfactory IAQ, but of schools where more than forty percent of students were eligible for free or reduced-cost lunch, almost twenty-three percent reported having unsatisfactory IAQ. Similarly, fewer than eighteen percent of schools with less than twenty and one-half percent minority students reported unsatisfactory IAQ. In contrast, more than twenty percent of schools with minority populations between twenty and one-half percent and fifty and one-half percent reported unsatisfactory IAQ, and almost twenty-three percent of schools with minority populations greater than fifty and one-half percent reported unsatisfactory IAQ.

As with so many other issues linking school facilities to educational outcomes, the demands of environmental justice and social justice overlap to call attention to the disproportionate burden that poor and minority students carry in education.

Thermal Comfort

Researchers have been studying the temperature range associated with better learning for several decades. Harner (1974) found that the best temperature range for learning reading and math is sixty-eight to seventy-four degrees Fahrenheit and that the ability to learn these subjects is adversely affected by temperatures above seventy-four degrees Fahrenheit. As temperature and humidity increase, students report greater discomfort, and their achievement and task-performance deteriorate as attention spans decrease (King and Marans 1979). McGuffey (1982) was one of the first to synthesize existing work linking heating and air conditioning to learning conditions, and her work still is widely cited.

Research also shows that even within commonly acceptable temperature spans, there are specific ranges that increase individual performance. It is not feasible, however, to provide every student in a common space with the temperature or humidity that best suits him or her.

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Thermal factors may seriously degrade teachers' abilities to teach and may also affect their morale. In the 2002 follow-up study to the school daylighting study completed in 1999 by the Heschong Mahone Group, environmental control was found to be an important issue for teachers, especially for those who lacked full environmental control:

> Teachers seemed to hold a basic expectation that they would be able to control light levels, sun penetration, acoustic conditions, temperature, and ventilation in their classrooms. They made passionate comments about the need for improvement if one or more of the environmental conditions could not be controlled in their classrooms (Heschong 2002).

Lowe (1990) found that the best teachers in the country emphasized their ability to control classroom temperature as central to the performance of teachers and students. Lackney (1999) showed that teachers believe thermal comfort affects both teaching quality and student achievement. Corcoran et al. (1988) focused on how school facilities' physical conditions affect teacher morale and effectiveness. They conclude that problems caused by working conditions may result in higher absenteeism, reduced effort, lower effectiveness in the classroom, low morale, and reduced job satisfaction.

Lighting

Classroom lighting plays a particularly critical role in student performance (Phillips 1997). Obviously, students cannot study unless lighting is adequate, and there have been many studies reporting optimal lighting levels (see Mayron et al. 1974, Dunn et al. 1985, 866). Jago and Tanner's review (1999) cites results of seventeen studies from the mid-1930s to 1997. The consensus of these studies is that appropriate lighting improves test scores, reduces off-task behavior, and plays a significant role in students' achievement.

Recently there has been renewed interest in increasing natural daylight in school buildings. Until the 1950s, natural light was the predominant means of illuminating most school spaces, but as electric power costs declined, so too did the amount of daylighting used in schools. According to Benya, a lighting designer and consultant, recent changes, including energy-efficient windows and skylights and a renewed recognition of the positive psychological and physiological effects of daylighting, have heightened interest in increasing natural daylight in schools (Benya 2001).

Lemasters' (1997) synthesis of fifty-three studies pertaining to school facilities, student achievement, and student behavior reports that daylight fosters higher student achievement. The study by the Heschong Mahone Group (1999), covering more than 2000 classrooms in three school districts, is perhaps the most cited evidence about the effects of daylight. The study indicated that students with the most classroom daylight progressed twenty percent faster in one year on math tests and twenty-six percent faster on reading tests than those students who learned in environments that received the least amount of natural light (also Plympton, Conway, and Epstein 2000). There were some questions that could not be answered by the original Heschong study, such as whether the higher performance was driven at least in part by better teachers being assigned to the classrooms that received more daylight. A follow-up study surveyed teachers in one of the districts and added information on teacher characteristics to the analysis. This new report found that the effect of daylighting remained both positive and significant. Other studies are currently in process to try to validate the results in another school district and determine more detail about a possible mechanism for such an effect.

While the scientific foundation linking daylighting to learning is accumulating, there have been distractions and fads that affect school lighting decisions. For example, there has been an ongoing controversy about so-called “full-spectrum” fluorescent lighting, and some schools have been re-lamped at considerable expense to offer this perceived benefit (the lamps themselves are several times more expensive than conventional lamps and produce significantly less light). But according to Gifford, research on the effects of full-spectrum lighting has been “inexpert” (Gifford 1994, 37), and the strong claims made about such lighting have been based on poor research that does not meet even rudimentary standards of scientific investigation. Indeed, in 1986, the U.S. Food and Drug Administration instructed the Duro Test Corporation, makers of Vita-lite and promoters of UV enhanced “full-spectrum” lamps, to cease and desist from making claims about any health benefits from non-clinical applications of this type of light source (Benya 2001, Gifford 1994).

While there are serious questions about the effects of full-spectrum fluorescent lighting, there is sufficient reason to believe that daylight provides the best lighting conditions.

There also have been studies attempting to correlate elements such as color and aesthetic appeal with student achievement. One example is Cash's report (1993) that student achievement improved when walls were painted pastel colors instead of white. The appeal of physical conditions such as color may vary considerably among individuals, and there is a good opportunity here for further work with definitive recommendations.

Acoustics

The research linking acoustics to learning is consistent and convincing: good acoustics are fundamental to good academic performance.

In one of their many syntheses of existing work, Earthman and Lemasters (1998) reported three key findings: that higher student achievement is associated with schools that have less external noise, that outside noise causes increased student dissatisfaction with their classrooms, and that excessive noise causes stress in students (1998, 18).

Crandell et al. (1995) and Nabelek and Nabelek (1994) reviewed the literature linking the acoustical environment in a classroom to the academic achievement of children and have linked levels of classroom noise and reverberation to reading and spelling ability, behavior, attention, concentration, and academic achievement in children (also ASHA 1995, Crandell 1991, Crandell and Bess 1986, and Crandell et al. 1995). Evans and Maxwell (1999) examined 100 students enrolled in two New York City schools, one of which was in the flight path of an airport. The students exposed to the air-traffic noise scored as much as twenty percent lower on a reading test than children in the other school.

There also is evidence of a cumulative effect of excessive classroom noise on a child's academic achievement level. These problems are more acute for children who may have hearing impediments and may affect the detection of such impediments (Nelson and Soli 2000). It also is generally agreed (Fisher 2000) that high noise levels cause stress. Noise levels influence verbal interaction, reading comprehension, blood pressure, and cognitive task success and may induce feelings of helplessness, inability to concentrate, and lack of extended application to learning tasks.

Teachers attach importance to noise levels in classrooms and schools. Lackney (1999) found that teachers believe that noise impairs academic performance. Indeed, it appears that external noise causes more discomfort and lowered efficiency for teachers than for students (Lucas 1981). This factor could lower the quality of teaching and, ultimately, learning.

Clearly, classroom acoustics matter, and yet Feth and Whitelaw (1999) found that the acoustics of many classrooms are poor enough to make listening and learning difficult for children. Their study of thirty-two classrooms in central Ohio primary schools found that only two met the standards recommended by the American Speech-Language-Hearing Association (ASHA).

Other studies cite acoustics problems in schools. For example, a third of the school systems cited in a 1995 General Accounting Office study reported that poor acoustics were their most serious environmental concern (General Accounting Office 1995). Studies of elementary and secondary school classrooms revealed that excessive background noise, which competes with the speech of teachers, aides, classmates, and audio-educational media, is common even in new classrooms (U.S. Architectural and Transportation Barriers Compliance Board 1999).

Acoustical performance is an important consideration in the design of classrooms, according to the U.S. Architectural and Transportation Barriers Compliance Board (2002), an independent federal agency devoted to accessibility for people with disabilities. The board writes:

> Research indicates that high levels of background noise, much of it from heating and cooling systems, adversely affect learning environments, particularly for young children, who require optimal conditions for hearing and comprehension. Poor acoustics are a particular barrier to children with a hearing loss. For the past several years, the Board has worked with the private sector in the development of classroom acoustics standards as an alternative to rulemaking of its own. In 1999, the Board partnered with the Acoustical Society of America (ASA) on the development of a new standard for acoustics in classrooms that takes into account children who are hard of hearing. The standard, completed in 2002, has been approved as ANSI/ASA S12.60-2002, Acoustical Performance Criteria, Design Requirements and Guidelines for Schools. It sets specific criteria for maximum background noise (thirty-five decibels) and reverberation (0.6 to 0.7 seconds for unoccupied classrooms). These and other specifications are consistent with long-standing recommendations for good practice in acoustical design.

When these standards are implemented, schools may face significant costs. For example, many existing HVAC systems, particularly room unit ventilators, will exceed these noise standards.

While science is clearly linking daylighting, acoustics, and indoor air quality to learning outcomes, it is harder to scientifically measure the effects on learning of such factors as building quality and size or the way that a building may be divided into different learning spaces and different-sized classrooms. Almost all the other research discussed here so far is fairly tightly focused on single environmental (or closely related) factors, and many of the conditions can be directly measured (including decibel levels, air flows, lumens, and so on). However, when we begin to look at the effects of more complex variables, such as the overall quality of school buildings, school size, or class size, we immediately see that these factors or "inputs" are multitudinous and multidimensional—making it much harder to identify and isolate precise measures and effects. The outcomes also are harder to isolate and measure accurately, although over the past twenty years, standardized test scores have been a principal measure of learning outcomes. And in much of this work discussed below, higher test scores have become the holy grail of facilities reform.

Building Age, Quality, and Aesthetics

McGuffey's 1982 synthesis of earlier studies correlated student achievement with better building quality, newer school buildings, better lighting, better thermal comfort and air quality, and more advanced laboratories and libraries. More recent reviews by Earthman and Lemasters (1996, 1998) report similar links between building quality and higher test scores. For example, researchers studying Georgia's primary schools found that fourth-grade students in non-modernized buildings scored lower in basic skills assessments than students in modernized or new buildings (Plumley 1978). Similarly, Chan (1979) found that eighth-grade students scored consistently higher across a range of standardized tests if housed in new or modernized buildings. Bowers and Burkett (1987) found that students in newer buildings outperformed students in older ones and posted better records for health, attendance, and discipline. The study attributed approximately three percent of the variance in achievement scores to facility age, after considering socio-economic differences in the student populations. In more recent work, Phillips (1997) found similar improvements in newer facilities, and Jago and Tanner (1999) also found links between building age and student achievement and behavior.

Clearly, there is consensus that newer and better school buildings contribute to higher student scores on standardized tests (Plumley 1978; Edwards 1992; Cash 1993; Earthman and Lemasters 1998; Hines 1996), but just how much varies depending on the study and the subject area. For example, Phillips (1997) found impressive gains in math scores, but Edwards (1992) found much lower gains in social sciences.

Isolating the independent effects of age and building condition is essential to studies such as these but may be difficult to do; a building's age can be ascertained from public records, but its condition is harder to gauge. Building quality actually may have less to do with age and more to do with the budget for that particular building. In older buildings, a lack of maintenance can ruin an otherwise high-quality building; in new buildings, funding limitations can result in a brand new building of inferior quality. Any careful study must account for these factors.

Indeed, some researchers have tried to rigorously identify the effect of building quality independent of building age. Andersen (1999) studied the relationship of thirty-eight middle-school design elements to student scores from twenty-two schools on the Iowa Test of Basic Skills and found positive correlations with twenty-seven elements. Maxwell (1999) found a correlation between newer facilities and student performance levels and a significant relationship between upgraded facilities and higher math scores. But her study also found lower student performance during the renovation process, since classes can be disrupted during renovation. In at least one case (Claus and Girrbach 1985), reading and math scores improved among the better students when buildings were renovated, but the scores fell among the lowest-performing students.

Lewis (2000) tried to identify the independent effects of school quality in a study of test scores from 139 schools in Milwaukee and found that good facilities had a major impact on learning.

Stricherz (2000) notes that student achievement lags in inadequate school buildings but suggests there is no hard evidence to prove that student performance rises when facilities improve well beyond the norm. "Research does show that student achievement lags in shabby school buildings—those with no science labs, inadequate ventilation, and faulty heating systems," Stricherz says. "But it does not show that student performance rises when facilities go from the equivalent of a Ford to a Ferrari—from decent buildings to those equipped with fancy classrooms, swimming pools, television-production studios, and the like."

While many studies link the effects of building quality to academic achievement, other studies tie building quality to student behavior. Vandalism, leaving early, absenteeism, suspensions, expulsions, disciplinary incidents, violence, disruption in class, tardiness, racial incidents, and smoking all have been used as variables in these studies.

More than sixteen studies collated by McGuffey (1982) found fewer disciplinary incidents as building quality improved. Discipline also was better in newer buildings. However, later reports (Edwards 1992; Cash 1993) found that disciplinary incidents actually increased in schools with newer and better buildings—perhaps caused by the stricter discipline standards in these newer schools, among other factors.

In studying how school quality relates to achievement and behavior, the criteria that Earthman et al. (1995) used included factors such as structural differences and open space as indicators of quality. They found that schools farther up the overall quality index had fewer disciplinary incidents, but schools that rated higher only on the structural component had more disciplinary incidents.

A recent study in Great Britain by Pricewaterhouse-Coopers (2001) linked capital investment to academic achievement and other outcomes such as teacher motivation, school leadership, and student time spent on learning. This study combined quantitative and qualitative analysis and was based on interviews with teachers and headmasters. Its quantitative analysis found weak and inconsistent relationships between capital expenditures and outcomes. However, the study's surveys found a stronger link between capital expenditures and motivation and leadership. The researchers concluded (p. 42):

- Good teaching takes place in schools with a good physical environment;
- Good school leadership can also be found in schools with a high-quality capital stock;
- The general attitudes, behavior, and relationships amongst pupils and staff are more conducive to learning in those schools which have had significant capital investments.

A careful look at the data reported by Pricewaterhouse-Coopers shows some weaknesses in the study. For example, most of the data collected by PricewaterhouseCoopers was used in an econometric production function analysis. As with virtually all such studies, the analysis found few, if any, relationships linking capital spending and academic achievement. The study's organizers then turned to interviews and other more impressionistic data upon which to base their findings. But the data they collected were not particularly useful in helping policy makers decide how to allocate monies across different categories of expenses. For example, no one would be able to know from the study whether it would be better to invest in improved air quality or to ensure that classrooms met certain acoustics standards.

While existing studies on school building quality basically point to improved student behavior and better teaching in higher-quality facilities, what is needed is more firm policy advice about the types of capital investments that would be most conducive to learning and to good teaching. This would help those who manage construction dollars better target and maximize the return on such investments.

School Size

Schools in the United States have grown larger and larger, but how this growth affects learning is still being explored. Buildings housing two or three thousand students are not uncommon; high schools in some large cities house five thousand students (Henderson and Raywid 1994). The trend toward large schools stems from several historical processes, including school district consolidation and the belief that large schools can deliver education with major economies of scale. As a result of rural school district consolidation and lack of available sites and population growth in central cities, large schools began appearing in this country as early as 1869. The post-WWII baby boom and concurrent population shift from city to suburbs made larger schools commonplace.

These trends accelerated as a result of the Cold War. When Sputnik was launched in 1957, so too was our nation's desire to quickly graduate scientists to meet that perceived challenge. Close on Sputnik's heels came Conant's 1959 book, *The American High School Today*, calling the small high school America's number one education problem and suggesting its elimination be a top priority (Conant 1959, 37–38).

Although what Conant considered an appropriate size for schools was not that large by today's standards, his book became part of a school facilities planning mentality that saw larger and larger schools constructed routinely. And these newer, larger schools often have been sited away from neighborhoods.

"A specific benefit associated with smaller schools is higher student achievement, an especially significant outcome given the importance now accorded to test scores."

Today, ironically, despite the need for more classrooms because of renewed enrollment growth, many neighborhoods face losing their schools because of declining enrollments or school consolidation. According to estimates of the Building Education Success Together team (BEST), nearly 200 schools in Chicago, Cleveland, Columbus, Cincinnati, and Washington, D.C., may be closed or consolidated because they have smaller student populations than they were originally designed for (BEST 2002). Yet this decision is being made even while evidence accumulates that small schools may work better than large ones, especially for students with lower socio-economic status. Indeed, there's an impressive body of literature linking small school size to positive outcomes. This literature is worth studying—but with three caveats:

First, while the evidence affirms small is generally better, the definition of small varies across studies. At one level there is the question about whether or not policy makers should be aiming to create schools of some specific size. In contrast, many studies are looking at the effects of size as a "continuous" variable. There is some evidence that no matter the size distribution, the smaller schools in the distribution enhance achievement (Howley, Strange, and Bickel 1999). This finding implies that a policy of smaller size, no matter the starting point, and notwithstanding any absolute definition of smallness, is appropriate. And as shown below, this may be especially true in low-income communities. But despite the possibility that any reduction in size is good, the consensus seems to be that small-school benefits are achieved in the 300- to 400-student range for elementary schools and less than 1,000 students for high schools (Cotton 1996).

Second, the evidence on various reforms to create small schools through mechanisms such as schools-within-schools, where large schools are subdivided into "houses" or "academies," is nowhere near as extensive or conclusive as the evidence on school size. This is partly because these reforms are relatively new and partly because arrangements that create schools within a school vary so widely. Cotton (2001) has produced perhaps the best review of what we currently know about these arrangements to create more intimate learning places.

Third, much of the work linking school size to education outcomes derives from case studies and other less quantitative evidence. While the evidence calls for small schools, specific findings will need to withstand stronger scrutiny.

With these caveats in mind, there is a growing body of research linking smaller school size to higher student achievement. In one of the earliest studies, Barker and Gump (1964) used sophisticated sociological concepts and measurements to link the size of a school as an "ecological environment" to the behavior of individual students.

> The large school has authority: its grand exterior dimensions, its long halls and myriad rooms, and its tides of students all carry an implication of power and rightness. The small school lacks such certainty: its modest building, its short halls and few rooms, and its students, who move more in trickles than in tides, give an impression of casual

> or not quite decisive educational environment (p. 195).

Barker and Gump conclude that these outside “views” are wrong and that there are strong forces within small schools that create, stimulate, and even compel students to become more active and involved with school events and learning than in large schools. The authors concentrated on extra-curricular activities and found that the proportion of students engaged in these activities was as much as twenty times higher in the four small schools they studied compared to the largest one. More students in the smaller schools were involved in a wider range of activities, and many more students held leadership positions than in the largest schools. And the students in the smaller schools were not only more involved but more satisfied with their experiences (ch. 12).

Barker and Gump were among the first to demonstrate diminishing returns to increasing school size. While they recognized that big schools may be able to provide some services that small schools cannot, ultimately they concluded that: "It may be easier to bring specialized and varied behavior settings to small schools than to raise the level of individual participation in large schools" (p. 201).

The soundness of these observations has withstood the test of many newer studies. In one recent and well-known study linking school size to beneficial outcomes, Wasley et al. (2000) argue that small schools can:

- improve education by creating small, intimate learning communities where students are well-known and can be encouraged by adults who care for them and about them,
- reduce isolation that adversely affects many students,
- reduce discrepancies in the achievement gap that plagues poor children, and
- encourage teachers to use their intelligence and skills.

In addition, small schools often encourage parental involvement, which benefits students and the entire community (Schneider et al. 2000).

Nathan and Febey (2001) identify similar beneficial outcomes. In their highly regarded study, “Smaller, Safer, Saner, Successful Schools,” they argue that smaller schools, on average, can provide:

- a safer place for students,
- a more positive, challenging environment,
- higher achievement,
- higher graduation rates,
- fewer discipline problems, and
- greater satisfaction for families, students, and teachers.

Raywid (1999) aptly summarizes the value of small schools. She says that students in these schools “make more rapid progress toward graduation, are more satisfied with small schools, fewer of them drop out than from larger schools, and they behave better in small schools.” Indeed, Raywid concludes that: “All of these things we have confirmed with a clarity and at a level of confidence rare in the annals of education research.” (Also see Howley 1994, Irmsher 1997, and Cotton 1996, 2001.)

A specific benefit associated with smaller schools is higher student achievement, an especially significant outcome given the importance now accorded to test scores. Fowler and Walberg (1991) found that school size was the best predictor of higher test scores in 293 New Jersey secondary schools, even considering widely varying socio-economic factors. Lee and Smith (1997) using the National Educational Longitudinal Study linked school size with higher performance, and Keller (2000) showed that small schools consistently outperformed large ones, based on evidence from 13,000 schools in Georgia, Montana, Ohio, and Texas (also Duke and Trautvetter 2001). There is considerable evidence on this point contained in reviews by Howley, Cotton, and Raywid. Here’s how Cotton (1996) summarizes her reading of existing studies:

> About half the student achievement research finds no difference between the achievement levels of students in large and small schools, including small alternative schools. The other half finds student achievement in small schools to be superior to that in large schools. None of the research finds large schools superior to small schools in

> their achievement effects. Consequently, we may safely say that student achievement in small schools is at least equal—and often superior—to student achievement in large schools.

Achievement measures used in the research include school grades, test scores, honor roll membership, subject area achievement, and assessment of higher-order thinking skills.

Perhaps there is even stronger evidence linking the effects of small school size and higher performance in communities having low socio-economic status. Pertinent findings often stem from the Matthew Project, inspired by the 1988 work of Friedkin and Necochea, who presented empirical evidence linking smaller schools with stronger academic performance in impoverished communities. Over time, Friedkin's and Necochea's findings have been replicated in studies conducted in school districts in Arkansas, Georgia, Ohio, Montana, Texas, and West Virginia, and in districts in California other than those Friedkin and Necochea studied (see Howley and Bickel 1999, Howley 1995). While specific effects vary from study to study, and while the definition of small varies across studies, the cumulative evidence in these works is that smaller school size leads to higher performance in poor communities.

In general, school size has been tied to other desirable outcomes besides better academic performance.

• **Small schools can reduce violence and disruptive behavior.** Smaller schools seem to reduce negative student behavior, especially among students of low socio-economic status (see especially Gregory 1992, Stockard and Mayberry 1992, and Kershaw and Blank 1993). The research here tends to be more anecdotal, however, based on case studies, and it lacks the quality of work that links school size to achievement.

• **Small schools can improve a wide range of student attitudes and behavior.** Smaller schools seem to reduce the anonymity and isolation that students sometimes experience (Barker and Gump 1964), and they may increase students' sense of belonging. Fowler and Walberg (1991) argue that both large school size and large district size were associated with reductions in participation in school activities, satisfaction, attendance, feelings of belonging, and other measures of school climate (see also Stockard and Mayberry 1992, Foster and Martinez 1985). Small schools also seem to have lower dropout rates (Toenjes 1989, Pittman and Haughwout 1987, Stockard and Mayberry 1992), higher attendance rates (Fowler 1995, Howley 1994), and higher graduation rates (Farber 1998).

• **Small schools can improve teacher attitudes.** There is less research on this point, but most of it links smaller schools to higher levels of cooperation between teachers, better relations with school administrators, and more positive attitudes toward teaching (see Hord 1997, Gottfredson 1985, Stockard and Mayberry 1992). Lee and Loeb (2000) found more positive teacher attitudes in the small schools that planners created in Chicago as part of a city-wide plan to reduce school size.

• **Small schools may be cost effective.** Many studies dispute the often-heard justification for consolidating smaller schools into larger ones based on economies of scale. These works document the absence of economies of scale in public organizations and especially in public organizations that are labor intensive, such as schools. The evidence is fairly conclusive that economies of scale quickly become dis-economies of scale as schools grow in size (Steifel et al. 2000, Gregory 1992, Walberg 1992, Robertson 1995). Indeed, Gregory (1992, 5) writes:

> The perceived limitations in the program that small high schools can deliver, and their presumed high cost, regularly have been cited as justifications for our steady march toward giantism. The research convincingly stamps both of these views as misconceptions.

Not only does the cost of education increase with larger schools, but related research shows that curricula do not improve with increased school size. Indeed, some research indicates that the supposed improvements in curricula associated with school size face rapidly diminishing marginal returns. Pittman and Haughwout (1987, 337) argue that "It takes a lot of bigness to add a little variety."

• **Public opinion data confirm a preference for small schools.** In February 2002, the public opinion research organization Public Agenda released a study endorsing small schools. Based on surveys of parents, teachers, and students, the report notes that more than two-thirds of the parents interviewed believed that smaller high schools offer a better sense of belonging and community, have administrations that would be more able and likely to identify poorly performing teachers, and would be better able to tailor instruction to individual needs. Conversely, two-thirds of the parents interviewed thought that larger schools were more likely to have discipline problems. Based on these findings, Public Agenda (2002, 1) concluded:

> The latest idea in America's ongoing debate on education reform has been a simple one: when it comes to schools, small is beautiful. A group of influential reformers says the U.S. trend toward larger and larger school buildings is creating schools that are difficult to manage in which students feel alienated and anonymous. These advocates call for high schools of around five hundred pupils, saying teenagers thrive in more personal settings. The kind of comfortable, informal communication that takes place readily in a small institution is simply not feasible, these advocates say, in a larger, more harried one.

In their study about what motivated parents to seek vouchers available through the Children's Scholarship Fund, a nationwide privately funded voucher program targeted at low income families, Peterson et al. (2001) argued that, among other reasons parents chose to participate in the program, "Parents applied for vouchers partly in order to shift from the larger schools in the public sector to the smaller schools generally available in the private sector" (p. 16).

Based on the cumulative findings on school size, Ayers et al. (2000) argue that making schools smaller is the "ultimate reform." While this argument certainly would benefit from better research across all these issues and by a more precise definition of small, findings now indicate that reducing school size can produce considerable benefits across a range of outcomes—and there is little evidence showing that reducing school size will produce negative outcomes. This is especially true for children and communities ranked lower in socio-economic status.

Class Size

Class size is an important factor in school design and drives a host of costly facility-related issues that are part and parcel of the school building's planning, design, construction, cost, maintenance, and operation. Given that education is labor intensive, class size is a big factor in determining the number of teachers needed and, hence, how much education will cost. While social scientists are engaged in an intense debate over the effects of class size on educational outcomes, there is widespread popular belief that smaller classes are better.

Of the teachers surveyed by Public Agenda, seventy percent said that small class size is more important to student achievement than small school size. This preference for smaller classes is being codified in law: nearly half the states have enacted legislation and are spending hundreds of millions of dollars each year to reconfigure school buildings to reduce the student-teacher ratio to twenty or fewer students per teacher (National Association of Elementary School Principals 2000).

At the national level, the Clinton administration made class size reduction a centerpiece of its educational reform efforts, and the Bush administration has followed suit. Despite the popularity of small classes, the scientific evidence linking class size to achievement is mixed—and hotly contested.

The Debate Over Class Size

The debate in the literature over class size is often highly technical and focuses on fights over appropriate methods for using metanalysis to identify patterns in existing work. Much of this work has been done by economists focusing on the efficiency of education measured by the effects of different inputs, such as class size, to educational outputs, such as test scores.

One of the leading scholars in this field, Eric Hanushek, believes that educational inputs, including class size, are not associated with higher performance (Hanushek 1997, 1999). The outputs he gauges usually are test scores measured by the National Assessment of Educational Progress (NAEP), a long-term project administered by the National Center for Education Statistics.

(For more information on NAEP see http://nces.ed.gov/nationsreportcard/about/)

Hanushek has collected a set of studies that begin with the Coleman report and run through 1994, and each of these studies includes estimates of how some school factor (such as class size, for example) affects some desired academic output (such as test scores). Equations that link such inputs to outputs are called a production function, and Hanushek's original database consisted of 377 different production function estimates contained in ninety individual publications. According to Hanushek (1997), of these estimates, 277 include some measure of student/teacher ratios (not class size) and of these, only fifteen percent find statistically significant effects showing that lower student/teacher ratios increased performance, while an almost equal number (thirteen percent) report that lower student/teacher ratios reduced test scores. In the handful of studies that have actual measures of class size, the results also are mixed.

In a number of publications, Greenwald, Hedges, and Laine have attacked Hanushek's methodology and findings. A 1996 article in the *Review of Educational Research* sets forth their reasoning. They argue that, based on their analysis of a larger set of production functions than Hanushek used, "A broad range of school inputs are positively related to student outcomes, and that the magnitude of the effects are sufficiently large to suggest that moderate increases in spending may be associated with significant increases in achievement" (Greenwald, Hedges, and Laine 1996, 362).

Similarly, Krueger (2000) argues that Hanushek's findings are based on a flawed methodology. According to Krueger, Hanushek's reported findings are derived by weighting all the studies included in his database equally, thus placing a disproportionate weight on a small number of studies that use small samples and mis-specified models. Krueger argues further that Hanushek exercised "considerable discretion" in applying his own selection rules. According to Krueger, "Hanushek's procedure of extracting estimates assigns more weight to studies with unsystematic or negative results" (p. 10).

Using a different (and easily defended) weighting rule that corrects for the number of results reported in the same study, Krueger shows that studies with positive effects of class size are almost sixty percent more prevalent than studies with negative effects. In a second exploration of the effects of weighting schemes, Krueger weights the studies in Hanushek's database by the quality of the journal in which it appeared (utilizing impact scores calculated by the Institute for Scientific Information based on the average number of citations to articles published in the journals in 1998). Using this weighting method, positive findings again are twice as likely as negative findings.

"Collectively, the work of Krueger, Greenwald, Hedges, and Laine has undermined the strength of Hanushek's argument—but the issue is far from settled."

Hunt (1997, ch. 3) provides more detail on the rather intense arguments that greeted Hanushek's work. Collectively, the work of Krueger, Greenwald, Hedges, and Laine has undermined the strength of Hanushek's argument—but the issue is far from settled.

While Hanushek has been a driving force in staking out the "class size doesn't matter" position, other researchers using a range of data also have found that reducing class size has no effect on educational outcomes. For example, Hoxby (2000), using naturally occurring variation in class sizes in a set of 649 elementary schools, finds that class size has no effect on student achievement. An analysis of the relationship between class size and student achievement for Florida students using 1993–94 school level data found no relationship between smaller classes and student achievement (State of Florida 1998). Similarly, Johnson (2000) finds no effect of class size on 1998 NAEP reading scores, other things being equal. While many studies use student/teacher ratios, Johnson uses class size, and he compares students' performance in classes that have both more and less than twenty students and finds no difference. However, Johnson notes that the range of class sizes in his database may not be sufficient, since some researchers such as Mosteller (1995) and Slavin (1989) find effects only for very large declines in class size.

In contrast, Robinson and Wittebols (1986), using a related cluster analysis approach of more than one hundred relevant research studies (in which similar kinds of research studies are clustered or grouped together), concluded that the clearest evidence of positive effects of smaller class size is in the primary grades, particularly kindergarten through third grade, and that reducing class size is especially promising for disadvantaged and minority students.

More positive conclusions on the influence of class size have been drawn from an analysis of Texas schools. Using data from more than 800 districts containing more than 2.4 million students, Ferguson (1991) found significant relationships among teacher quality, class size, and student achievement. For first through seventh grades, using student/teacher ratio as a measure of class size, Ferguson found that district student achievement fell as the student/teacher ratio increased for every student above an eighteen to one (18:1) ratio.

Other studies find that class size affects test scores (Ferguson 1991, Folger and Breda 1989, Ferguson and Ladd 1996). Wenglinsky (1997) used data from fourth graders in more than 200 districts and eighth graders in 182 districts and found that smaller class size positively affected math scores for fourth graders and improved the social environment for eighth graders, which in turn produced higher achievement. These effects were greatest for students of lower socio-economic status.

None of these econometric studies, however, have shown very large effects, and many researchers caution about the high cost of implementing this reform relative to its expected benefits. While the econometric evidence has been inconclusive, there have been a series of experiments in which class sizes have been reduced, and the results of these experiments have been interpreted to support the benefits of smaller class size.

In Indiana, the Prime Time project reduced class size from approximately twenty-two to nineteen students in first grade and from twenty-one to twenty students in second grade. The study's design drew criticism, which cast doubt on its modest conclusions. Beginning in 1990, Burke County, North Carolina, phased in a class-size reduction project, with the goal of placing all first, second, and third grade students in classes limited to about fifteen students. This project offered a better design, improved experimental criteria, and results that, according to Egelson et al. (1996), increased time on task and decreased disciplinary problems substantially.

“Smaller classes allow more time for instruction and require less time for discipline.” This conclusion was reported by Molnar et al. (1999) in evaluating the first two years of the five-year Student Achievement Guarantee in Education (SAGE) program in Wisconsin, which was implemented in 1996. This study compared thirty schools that entered the SAGE program to a group of approximately fifteen comparison schools having similar demographics in order to gauge SAGE researchers' claims that reduced class sizes in early grades leads students to higher academic achievement. Targeted toward low-income schools, the SAGE class-size reduction was quite large, ranging from twelve to fifteen students per teacher compared with twenty-one to twenty-five students per teacher in the comparison group. This reduction was larger than in the better-known STAR (Student/Teacher Achievement Ratio) experiment in Tennessee. The gain in test scores was similar to gains attained with STAR, and also consistent with STAR. The greatest gains were posted by African-American students.

Of numerous experiments around the country to reduce class size, the STAR program authorized by the Tennessee legislature in 1985 has received the most attention. Even before the Hanushek, Hedges, and Krueger controversies, it was evident that the statistical evidence relating smaller class size to academic outcomes was uncertain. In turn, legislators in Tennessee launched the STAR project as a random-assignment experiment to more rigorously identify the effects of class size. The program established a class size of approximately fifteen students per teacher. It embraced seventy-nine schools, more than 300 classrooms, and 7,000 students, and followed their progress for four years. STAR compared classes containing thirteen to seventeen students to those containing twenty-two to twenty-six students. Teachers and students were randomly assigned to different-sized classes so that the independent effect of class size could be measured more precisely. The results were clear:

- students in small classes did better in math and reading tests at the end of kindergarten,
- the kindergartner achievement gap between the two class sizes remained the same in first, second, and third grades,
- students from smaller classes behaved better than students from larger classes, and these differences persisted through at least fourth grade,
- the effects were stronger for students of lower, rather than higher, socio-economic status, and
- the effects were stronger for African-American students.

These outcomes have been identified by several researchers (most notably Mosteller 1995 and in a series of papers by Krueger—for example, Krueger 2000 and Krueger and Whitmore 2000). While much of the early work based on STAR data sought to identify short-term effects, many researchers wondered how durable the effects were. Because the STAR experiment began in the 1980s, sufficient time has passed to allow researchers to begin identifying longer-term effects of small classes.

Nye et al. (1999) explored these longer-term effects using data from the Lasting Benefits Study (part of the STAR experiment) to show that the positive effects of small classes are evident in test scores for math, reading, and science at least through eighth grade. Controlling for a variety of confounding factors, such as attrition and variable time in small classes, the authors found that more time spent in small classes is positively related to higher achievement. This work clearly extends the time span for benefits attributed to small class size.

Krueger and Whitmore (2000) also examined STAR's long-term effects. Their main finding was that students who were assigned to small classes were more likely to take the ACT and SAT exams—and that this effect was substantially greater for Blacks than for Whites. Thus while the percentage of students who took the test increased for Whites from forty percent to almost forty-four percent, for Blacks, the increase was from thirty-two percent to more than forty percent. These results withstood a series of increasingly rigorous statistical tests. Moreover, minority students increased their test scores more than White students did, narrowing differences in performance between White and Black students. The time elapse between the STAR experiment and their study was still too short to allow Krueger and Whitmore to link enrollment in STAR's smaller classes to actual enrollment in college (or performance in college once enrolled). However, taking the SAT or ACT exams is the first step toward college, and the higher rate of students who were in small STAR classes taking these tests should ultimately translate into higher enrollment in college.

Conclusion

What is to be concluded from the research presented here?

- School facilities affect learning. Spatial configurations, noise, heat, cold, light, and air quality obviously bear on students' and teachers' ability to perform. Empirical studies will continue, focusing on fine-tuning the acceptable ranges of these variables for optimal academic outcomes. But we already know what is needed: clean air, good light, and a quiet, comfortable, and safe learning environment. This can be and generally has been achieved within the limits of existing knowledge, technology, and materials. It simply requires adequate funding and competent design, construction, and maintenance.
- Building age is an amorphous concept and should not itself be used as an indicator of a facility's impact on student performance. Many schools built as civic monuments in the 1920s and 1930s still provide, with some modernization, excellent learning environments; many newer schools built in the cost-conscious 1960s and 1970s do not.
- There is a definite consensus about the positive effects of small school size, and the effects seem to be the strongest with students from lower socio-economic groups. This is an area, however, where policy makers need the support of studies that better establish the tradeoffs between small schools and other community needs and resources.
- The class size debate is unresolved, although few would argue against smaller classes, where possi-

ble. This is an educational issue that has a serious impact on school planning and design, since smaller classes require more classrooms or more schools, a fact that may seem self-evident but often is lost in the debate.

- There is little standardization of facilities-related definitions. For example, the definition of small schools varies among studies, and overall student-teacher ratios are often (and wrongly) taken as a proxy for class size.
- The quality of facilities-related research ranges widely. Much of it is case-based and verges on the anecdotal, and many literature reviews use simple counts of articles, or they present undocumented summaries of findings. More rigorous approaches to summarizing large bodies of literature, such as metanalytic techniques, are few, and these studies often lead to disagreements over the methods themselves. Better research offering more definitive findings is needed.

Decisions about school facilities, once translated into brick-and-mortar, affect the daily performance of the generations of teachers and students who use them. These decisions are based on tradition, available technology, experience with "what works," and the changing needs of the times. Good facilities research allows us to productively sort through this mix and can help produce long-term, positive effects on academic outcomes.

References

The URLs herein were accurate on the date of publication. References identified with "ED" are documents abstracted in the Educational Resources Information Center (ERIC) database. They are available from the ERIC Document Reproduction Service at 1-800-443-3742 or at http://www.edrs.com

ALA (American Lung Association). 2002. Asthma in children fact sheet. New York, N.Y.: American Lung Association. Retrieved 07/19/02 from http://www.lungusa.org/asthma/ascpedfac99.html

American Public Health Association. 2000. Creating healthier school facilities. Washington, D.C.: American Public Health Association. Retrieved 06/18/02 from http://www.apha.org/legislative/policy/policysearch/index.cfm?fuseaction=view&id=215

Andersen, S. 1999. *The relationship between school design variables and scores on the Iowa Test of Basic Skills.* Athens, Ga.: University of Georgia.

Armstrong Laboratory. 1992. Occupational and environmental health doctorate. Brooks Air Force Base, Tex.: Armstrong Laboratory.

ASHA (American Speech-Language-Hearing Association). 1995. Guidelines for acoustics in educational environments. *American Speech-Language-Hearing Association,* 37, Suppl. 14, pp. 15–19.

ASHRAE (American Society of Heating Refrigerating and Air-Conditioning Engineers). 1989. Ventilation for acceptable indoor air quality. ASHRAE Standard 62-1989. Atlanta, Ga.: American Society of Heating Refrigerating and Air-Conditioning Engineers.

Ayers, W., G. Bracey, and G. Smith. 2000. The ultimate education reform? Make schools smaller. Milwaukee, Wis.: Center for Education Research, Analysis and Innovation, University of Wisconsin, Milwaukee. Education Policy Project CERAI-00-35. Retrieved 07/03/02 from http://www.uwm.edu/Dept/CERAI/documents/archives/00/cerai-00-35.htm

Barker, R. G., and P. V. Gump. 1964. Big school, small school: High school size and student behavior. Stanford, Calif.: Stanford University Press. (ED001132)

Bates, J. 1996. Healthy learning. *American School & University* 68(5), pp. 27–29.

Benya, J. R. 2001. Lighting for schools. Washington, D.C.: National Clearinghouse for Educational Facilities. Retrieved 07/03/02 from http://www.edfacilities.org/pubs/lighting.html

BEST (Building Educational Success Together). 2002. BEST overview and policy agenda. Retrieved 07/03/02 from http://21csf.org/csf-home/Documents/BEST/BEST_Policy.pdf

Bowers, J. H., and C. W. Burkett. 1987. Relationship of student achievement and characteristics in two selected school facility environmental settings. Paper presented at the 64th Annual International Conference of the Council of Educational Facility Planners. Edmonton, Alberta, Canada, October 3–7, 1987. (ED286278)

Cash, C. S. 1993. A study of the relationship between school building condition and student achievement and behavior. Blacksburg, Va.: Virginia Polytechnic Institute and State University.

CEHN (Children's Environmental Health Network). 1997. Conference Report: First National Research Conference on Children's Environmental Health. Washington, D.C.: Children's Environmental Health Network. Retrieved 09/09/02 from http://www.cehn.org/cehn/Resconfreport.html

Chan, T. 1979. The impact of school building age on pupil achievement. Greenville, S.C.: Office of School Facilities Planning, Greenville School District. (ED191138)

Claus, R. N., and C. J. Girrbach. 1985. An assessment of the Saginaw successful schools project. Paper presented at the Meeting of the Evaluation Research Society and the Evaluation Network. Toronto, Ontario, Canada, October 1985. (ED264285)

Conant, J. 1959. *The American high school today: A first report to interested citizens.* New York: McGraw-Hill.

Corcoran, T. B., L. J. Walker, and J. L. White. 1988. Working in urban schools. Washington D.C.: Institute for Educational Leadership. (ED299356)

Cotton, K. 2001. New small learning communities: Findings from recent research. Portland, Ore.: Northwest Regional Educational Laboratory. Retrieved 07/03/02 from http://www.nwrel.org/scpd/sirs/nslc.pdf

———1996. School size, school climate, and student performance. Portland, Ore.: Northwest Regional Educational Laboratory. Retrieved 07/03/02 from http://www.nwrel.org/scpd/sirs/10/c020.html

Crandell, C. 1991 . Classroom acoustics for normal-hearing children. Implications for rehabilitation. *Educational Audiology Monographs* 2 (1): 18–38.

Crandell, C., and F. Bess. 1986. Speech recognition of children in a "typical" classroom setting. *American Speech-Language-Hearing Association* 29: 87–98.

Crandell, C., J. Smaldino, and C. Flexer. 1995. *Sound field FM amplification: theory and practical applications.* Los Angeles, Calif.: Singular Press.

Crawford, G. N. 1998. Going straight to the source. *American School and University* 70 (6): 26, 28.

Duke, D. L., and S. Trautvetter. 2001. Reducing the negative effects of large schools. Washington, D.C.: National Clearinghouse for Educational Facilities. Retrieved 07/19/02 from http://www.edfacilities.org/pubs/size.html

Dunn, R., J. S. Krimsky, J. B. Murray, and P. J. Quinn. 1985. Light up their lives: A review of research on the effects of lighting on children's achievement and behavior. *Reading Teacher* 38 (9): 863-69.

Earthman, G. I., and L. Lemasters. 1998. Where children learn: A discussion of how a facility affects learning. Paper presented at the annual meeting of Virginia Educational Facility Planners. Blacksburg, Va., February 1998. (ED419368)

———1996. Review of research on the relationship between school buildings, student achievement, and student behavior. Paper presented at the annual meeting of the Council of Educational Facility Planners International. Tarpon Springs, Fla., October 1996. (ED416666)

Earthman, G., I., C. Cash, and D. Van Berkum. 1995. A statewide study of student achievement and behavior and school building conditions. Paper presented at the annual meeting of the Council of Education Facility Planners. Dallas, Tex., September 1995. (ED387878)

Edwards. M. 1992. Building conditions, parental involvement and student achievement in the D.C. public schools. Master's thesis, Georgetown University. (ED338743)

Egelson, P., P. Harman, and C. M. Achilles. 1996. Does class size make a difference? Recent findings from state and district initiatives. Greensboro, N.C.: Southeastern Regional Vision for Education. Retrieved 07/19/02 from http://www.serve.org/publications/DCS.pdf

EPA (Environmental Protection Agency). 2000. Indoor air quality and student performance. EPA report number EPA 402-F-00-009. Washington, D.C.: Environmental Protection Agency. Retrieved 06/10/02 from http://www.epa.gov/iaq/schools/performance.html

Evans, G. W., and L. Maxwell. 1999. Chronic noise exposure and reading deficits: The mediating effects of language acquisition. *Environment and Behavior* 29 (5): 638–56.

Fang, L., G. Clausen, and P. O. Fanger. 1998. Impact of temperature and humidity on the perception of indoor air quality. *Indoor Air* 8 (2): 80–90.

Farber, P. 1998. Small schools work best for disadvantaged students. *Harvard Education Letter* (March/April).

Federspiel, C. C., G. Liu, M. Lahiff, D. Faulkner, D. L. Dibartolomeo, W. J. Fisk, P. N. Price, and D. P. Sullivan. 2002. Worker performance and ventilation: Analyses of individual data for call-center workers. In *Indoor Air '02.* The Ninth International Conference on Indoor Air Quality and Climate. International Academy of Indoor Air Sciences.

Ferguson, R. F. 1991. Paying for public education: New evidence on how and why money matters. *Harvard Journal on Legislation* 28 (2): 465–98.

Ferguson, R. F. and H. Ladd. 1996. Additional evidence on how and why money matters: A production function analysis of Alabama schools. In *Holding Schools Accountable: Performance-Based Reform in Education,* ed. Helen F. Ladd. Washington, D.C.: The Brookings Institution.

Feth, L., and G. Whitelaw, 1999. Many classrooms have bad acoustics that inhibit learning. Columbus, Ohio: Ohio State University. Retrieved 07/03/02 from http://www.acs.ohio-state.edu/units/research/archive/rmsound.htm

Fisher, K. 2000. A critical pedagogy of space. Ph.D. diss., University of South Australia.

Fisk, W. J., P. Price, D. Faulkner, D. Dibartolomeo, C. Federspiel, G. Liu, and M. Lahiff. 2002. Productivity and ventilation rate: Analyses of time-series data for a group of call-center workers. In *Indoor Air '02.* The Ninth International Conference on Indoor Air Quality and Climate. International Academy of Indoor Air Sciences.

Folger, J., and C. Breda. 1989. Evidence from project STAR about class size and student-achievement. *Peabody Journal of Education* 67 (1): 17–33.

Foster, C. M., and I. Martinez. 1985. The effects of school enrollment size in the middle and junior high school on teacher and student attitude and student self-concept. *Research in Rural Education* 3 (2): 57–60.

Fowler, W. J., Jr. 1995. School size and student outcomes. In *Advances in Educational Productivity*, vol. 5, ed. H. J. Walberg. Greenwich: Conn. JAI Press, Inc., pp. 3–26.

Fowler, W. J., Jr., and H. J. Walberg. 1991. School size, characteristics, and outcomes. *Educational Evaluation and Policy Analysis* 13 (2): 189–202.

Friedkin, N., and J. Necochea. 1988. School system size and performance: A contingency perspective. *Educational Evaluation and Policy Analysis* 10 (3): 237–49.

General Accounting Office. 1996. School facilities: America's schools report differing conditions. GAO report number HEHS-96-103. Washington, D.C.: General Accounting Office. (ED397508)

General Accounting Office. 1995. School facilities: America's schools not designed or equipped for 21st century. GAO report number HEHS-95-95. Washington, D.C.: General Accounting Office. (ED383056)

Gifford, R. 1994. Scientific evidence for claims about full-spectrum lamps: past and future. In *Full-Spectrum Lighting Effects on Performance, Mood, and Health,* ed. Jennifer A. Veitch. IRC Internal report number 659, June 1994. Ottawa, Ontario, Canada: Institute for Research in Construction. Retrieved 07/03/02 from http://irc.nrc-cnrc.gc.ca/fulltext/ir659/gifford.pdf

Gottfredson, D. C. 1985. School size and school disorder. Baltimore, Md.: Center for Social Organization of Schools, Johns Hopkins University. (ED261456)

Greenwald, R., L. V. Hedges, and R. D. Laine. 1996. The effect of school resources on student achievement. *Review of Educational Research* 66 (3): 361–96.

Gregory, T. 1992. Small is too big: Achieving a critical anti-mass in the high school. Position paper prepared for the Hubert H. Humphrey Institute for Public Affairs and the North Central Regional Educational Laboratory. Retrieved 10/02/02 from http://www.gatesfoundation.org/NR/downloads/ed/evaluation/smallistobig.pdf

Hanushek, E. A. 1999. Some findings from an independent investigation of the Tennessee STAR experiment and from other investigations of class size effects. *Educational Evaluation and Policy Analysis* 21 (2): 143–63.

———1997. Assessing the effects of school resources on student performance: An update. *Educational Evaluation and Policy Analysis* 19 (2): 141–64.

Harner, David P. 1974. Effects of thermal environment on learning skills. *The Educational Facility Planner* 12 (2): 4–6.

Henderson, H., and M. A. Raywid. 1994. "Small" revolution in New York City. *Journal of Negro Education* 63 (1): 28–45.

Heschong Mahone Group. 1999. Daylighting in schools: An investigation into the relationship between daylighting and human performance. San Francisco, Calif.: Pacific Gas and Electric Company. Retrieved 07/03/02 from http://www.pge.com/003_save_energy/003c_edu_train/pec/daylight/di_pubs/SchoolDetailed820App.PDF

———2002. Re-analysis report: Daylighting in schools, additional analysis. Sacramento, Calif.: California Energy Commission (CEC Contract to New Buildings Institute number 400-99-013). Retrieved 11/01/02 from http://www.newbuildings.org/pier/downloads/DL_Schools_Re-analysis.pdf

Hines, E. W. 1996. Building condition and student achievement and behavior. D. Ed. diss., Virginia Polytechnic Institute and State University.

Hord, S. M. 1997. Professional learning communities: What are they and why are they important? *Southwest Educational Development Laboratory, Issues about Change* 6 (1): 1–9. Retrieved on 07/19/02 from http://www.sedl.org/change/issues/issues61.html

Howley, C. B. 1995. The Matthew principle: A West Virginia replication? Education Policy Analysis Archives. 3 (18): 1–25.

Howley, C. 1994. The academic effectiveness of small-scale schooling (an update). ERIC digest. Charleston, W. Va.: ERIC Clearinghouse on Rural Education and Small Schools. Retrieved on 07/19/02 from http://www.ed.gov/databases/ERIC_Digests/ed372897.html

Howley, C. B., and R. Bickel. 1999. The Matthew project: National report. Randolph, Vt.: Rural Challenge Policy Program. (ED433174)

Howley, C., M. Strange, and R. Bickel. 2000. Research about school size and school performance in impoverished communities. ERIC digest. Charleston, W. Va.: ERIC Clearinghouse on Rural Education and Small Schools. Retrieved 07/19/02 from http://www.ael.org/eric/digests/edorc0010.htm

Hoxby, C. M. 2000. The effects of class size on student achievement: New evidence from population variation. *The Quarterly Journal of Economics* 115 (3): 1239–84.

Hunt, M. 1997. How science takes stock: The story of metanalysis. N.Y.: Russell Sage Foundation.

Irmsher, K. 1997. School size. ERIC digest. Eugene, Ore.: ERIC Clearinghouse on Educational Management. Retrieved 07/22/02 from http://www.ed.gov/databases/ERIC_Digests/ed414615.html

Jago, E., and K. Tanner. 1999. Influence of the school facility on student achievement: Lighting; color. Athens, Ga.: Dept. of Educational Leadership; University of Georgia. Retrieved 07/22/02 from http://www.coe.uga.edu/sdpl/researchabstracts/visual.html

Johnson, K. A. 2000. Do small classes influence academic achievement? What the national assessment of educational progress shows. Washington, D.C.: Heritage Foundation. Retrieved 07/23/02 from http://www.heritage.org/Research/Education/CDA00-07.cfm

Keller, B. 2000. Small schools found to cut price of poverty. *Education Week* 19 (22): 6. Retrieved 07/22/02 from http://www.edweek.com/ew/ewstory.cfm?slug=22size.h19

Kennedy, M. 2001. Into thin air. *American School & University* 73 (6): 32.

Kershaw, C. A., and M. A. Blank. 1993. Student and educator perceptions of the impact of an alternative school structure. Paper presented at the annual meeting of the American Educational Research Association, Atlanta, Ga., April 12–16, 1993. (ED360729)

King, J., and R. W. Marans. 1979. The physical environment and the learning process. Report number 320-ST2. Ann Arbor: University of Michigan Architectural Research Laboratory. (ED177739)

Krueger, A. B. 2000. Economic considerations and class size. Working paper number 447. Princeton, N.J.: Princeton University, Industrial Relations Section. Retrieved 07/03/02 from http://netec.mcc.ac.uk/WoPEc/data/Papers/fthprinin447.html

Krueger, A. B., and D. M. Whitmore. 2000. The effect of attending a small class in the early grades on college-test taking and middle school test results: Evidence from project STAR. Working paper number w7656. Cambridge, Mass.: National Bureau of Economic Research. Retrieved 07/03/02 from http://papers.nber.org/papers/W7656

Lackney, J. A. 1999. Assessing school facilities for learning/assessing the impact of the physical environment on the educational process. Mississippi State, Miss.: Educational Design Institute. (ED441330)

Lackney, J. A. 1994. Educational facilities: The impact and role of the physical environment of the school on teaching, learning, and educational outcomes. Milwaukee, Wis.: University of Wisconsin-Milwaukee, Center for Architecture and Urban Planning Research.

Lang, S. 1998. Poor ventilation is implicated in sick building syndrome. Retrieved 09/30/02 from http://www.news.cornell.edu/Chronicle/98/3.5.98/sick_building.html

Leach, K. 1997. In sync with nature: Designing a building with improved indoor air quality could pay off with improved student health and performance. *School Planning and Management* 36 (4): 32–37.

Lee, V. E., and J. B. Smith. 1997. High school size: which works best and for whom. *Educational Evaluation and Policy Analysis* 19 (3): 205–27.

Lee, V. E., and S. Loeb. 2000. School size in Chicago elementary schools: Effects on teachers' attitudes and students' achievement. *American Educational Research Journal* 37 (1): 31.

Lemasters, L. K. 1997. A synthesis of studies pertaining to facilities, student achievement, and student behavior. Blacksburg, Va.: Virginia Polytechnic and State University. (ED447687)

Lewis, M. 2000. Where children learn: Facilities conditions and student test performance in Milwaukee public schools. Scottsdale, Ariz.: Council of Educational Facility Planners International. Retrieved 07/22/02 from http://www.cefpi.org/pdf/issue12.pdf

Lowe, J. M. 1990. The interface between educational facilities and learning climate in three elementary schools. Ph.D. diss. College Station, Tex.: Texas A&M University.

Lucas, J. 1981. Effects of noise on academic achievement and classroom behavior. Sacramento, Calif.: California Department of Health Services.

McGovern, M. A. 1998. A breath of fresh air. *School Planning and Management* 37 (10): 14.

McGuffey, C. 1982. Facilities. In *Improving educational standards and productivity: The research basis for policy,* ed. H. Walberg. Berkeley, Calif.: McCutchan Pub. Corp.

Maxwell, L. E. 1999. School building renovation and student performance: One district's experience. Scottsdale, Ariz.: Council of Educational Facility Planners, International. (ED443272)

Mayron, L. W., J. Ott, R. Nations, and E. L. Mayron. 1974. Light, radiation, and academic behavior. *Academic Therapy* 10 (1): 33–47.

Molnar, A., P. Smith, J. Zahorik, A. Palmer, A. Halback, and K. Ehrle. 1999. Evaluating the SAGE program: A pilot program in targeted pupil-teacher reduction in Wisconsin. *Educational Evaluation and Policy Analysis* 21 (2): 165–77.

Moore, D. 1998. Improve your schools' atmosphere. *School Planning and Management* 37 (10): 18.

Mosteller, F. 1995. The Tennessee study of class size in the early grades. *The Future of Children* 5 (2): 113–27.

Myhrvold, A. N., E. Olsen, and O. Lauridsen. 1996. Indoor environment in schools: Pupils' health and performance in regard to CO_2 concentrations. In *Indoor Air '96*, vol. 4, pp. 369–71. The Seventh International Conference on Indoor Air Quality and Climate. International Academy of Indoor Air Sciences.

Nabelek, A., and L. Nabelek. 1994. Room acoustics and speech perception. In *Handbook of clinical audiology* (3rd ed.), ed. J. Katz. Baltimore, Md.: Williams and Wilkins.

Nathan, J., and K. Febey. 2001. Smaller, safer, saner, successful schools. Washington, D.C.: National Clearinghouse for Educational Facilities and Minneapolis, Minn.: Center for School Change, Humphrey Institute of the University of Minnesota. Retrieved 07/03/02 from http://www.edfacilities.org/pubs/saneschools.pdf

National Association of Elementary School Principals. 2000. Does size really matter? The debate over class size. Alexandria, Va.: National Association of Elementary School Principals. Retrieved 07/03/02 from http://www.naesp.org/comm/c1200.htm

NIOSH (National Institute for Occupational Safety and Health). 1989. Indoor air quality: selected references. Cincinnati, Ohio: National Institute for Occupational Safety and Health.

NIOSH. (National Institute for Occupational Safety and Health). 1986. NIOSH Alert: Request for assistance in preventing occupational fatalities in confined spaces. DHHS (NIOSH) publication no. 86-110. Retrieved 09/04/02 from http://www.cdc.gov/niosh/86110v2.html

Nelson, P. B., and S. Soli. 2000. Acoustical barriers to learning: Children at risk in every classroom. *Language, Speech, and Hearing Services in Schools* 31 (4): 356–61.

Nye, B., L. V. Hedges, and S. Konstantopoulos. 1999. The long-term effects of class size: A five year follow-up of the Tennessee class size experiment. *Educational Evaluation and Policy Analysis* 21 (2): 127–42.

Peterson, P. E., D. E. Campbell, and M. R. West. 2001. Who chooses? Who uses? Participation in a national school voucher program. Paper presented at the Annual Meeting of the American Political Science Association. San Francisco, Calif., September 2001. Retrieved 07/19/02 from http://www.hoover.org/publications/books/fulltext/choice/51.pdf

Phillips, R. 1997. Educational facility age and the academic achievement of upper elementary school students. D. Ed. diss., University of Georgia.

Pittman, R. B., and P. Haughwout. 1987. Influence of high school size on dropout rate. *Educational Evaluation and Policy Analysis* 9 (4): 337–43.

Plumley, J. P. 1978. The impact of school building age on the academic achievements of selected fourth grade pupils in the State of Georgia. Athens, Ga.: University of Georgia.

Plympton, P., S. Conway, and K. Epstein. 2000. Daylighting in schools: improving student performance and health at a price schools can afford. Paper presented at the American Solar Energy Society Conference. Madison, Wisc., June 16, 2000. Retrieved 07/22/02 from http://www.deptplanetearth.com/nrel_student_performance.htm

PricewaterhouseCoopers. 2001. Building performance: An empirical analysis of the relationship between schools' capital investment and pupil performance. United Kingdom: Department for Education and Employment.

Public Agenda. 2002. Sizing things up: What parents, teachers and students think about large and small high schools. New York, N.Y.: Public Agenda. Retrieved 07/03/02 from http://www.publicagenda.org/specials/smallschools/smallschools.htm

Raywid, M. A. 1999. Current literature on small schools. ERIC digest. Charleston, W. Va.: ERIC Clearinghouse on Rural Education and Small Schools. Retrieved 07/22/02 from http://www.ael.org/eric/digests/edorc988.htm

Robertson, P. 1995. Reinventing the high school: The coalition campus school project in New York City. Paper presented at the Annual Meeting of the American Educational Research Association. San Francisco, Calif., April 1995.

Robinson, G. E., and J. H. Wittebols. 1986. Class size research: A related cluster analysis for decision-making. Arlington, Va.: Education Research Service.

Rosen, K. G., and G. Richardson. 1999. Would removing indoor air particulates in children's environments reduce rate of absenteeism—a hypothesis. *The Science of the Total Environment* 234 (3): 87–93.

SBIC (Sustainable Buildings Industry Council). 2000. High performance school buildings resource & strategy guide. Retrieved 07/03/02 from http://www.sbicouncil.org/store/resources.php?PHPSESSID=bf1012012ab624a26b843db42de38597#pubs

Schneider, M. 2002. Survey of Chicago teachers. Unpubl. manuscript, State University of New York, Stony Brook, Department of Political Science.

Schneider, M., P. Teske, and M. Marschall. 2000. *Choosing schools*. Princeton, N.J.: Princeton University Press.

Slavin, R. 1989. Achievement effects of substantial reductions in class size. In *School and classroom organization*, ed., R. Slavin. Hillside, N.J.: Erlbaum.

Smedje, G., and D. Norback. 1999. The school environment: Is it related to the incidence of asthma in the pupils? In *Indoor Air* '99, vol. 5. 445–50. The Eighth International Conference on Indoor Air Quality and Climate. International Academy of Indoor Air Sciences.

State of Florida. 1998. The relationship of school and class size with student achievement in Florida: an analysis of statewide data. Tallahassee, Fla.: Department of Education, Office of Policy Research.

Steifel. L., R. Berne, P. Iatarola, and N. Fruchter. 2000. High school size: effects on budgets and performance in New York City. *Educational Evaluation and Policy Analysis* 22 (1): 22–39.

Stricherz, M. 2000. Bricks and mortarboards. *Education Week* 20 (14): 30–32. Retrieved 07/03/02 from http://www.edweek.org/ew/newstory.cfm?slug=14facilities.h20

Strickland, G. 2001. No sweat. *American School and University* 74 (3): 363–64.

Stockard, J., and M. Mayberry. 1992. Resources and school and classroom size. In *effective educational environments*. Newbury Park, Calif.: Corwin Press, Inc.

Toenjes, L. A. 1989. Dropout rates in Texas school districts: influences of school size and ethnic group. Austin, Tex.: Texas Center for Educational Research. (ED324783)

U.S. Architectural and Transportation Barriers Compliance Board, 2002. Progress toward a new standard on classroom acoustics for children with disabilities. Retrieved 07/22/02 from: http://www.access-board.gov/publications/acoustic-factsheet.htm

———1999. Response to petition for rulemaking on classroom acoustics. 36 CFR Chapter XI [Docket No. 98-4]. Published in The Federal Register November 8, 1999. Retrieved 07/19/02 from http://www.access-board.gov/publications/acoustic.htm

U.S. Congress. No child left behind act of 2001. Public Law 107-110. January 8, 2002.

Walberg, H. J. 1992. On local control: Is bigger better? In *Source book on school and district size, cost, and quality*. Minneapolis, Minn.: Minnesota University, Hubert H. Humphrey Institute of Public Affairs and Oak Brook, Ill.: North Central Regional Educational Laboratory, pp. 118–34. (ED361164)

Walinder, R., D. Norback, G. Wieslander, G. Smedje, and C. Erwall. 1997. Nasal mucosal swelling in relation to low air exchange rate in schools. *Indoor Air '96.,* pp. 198–205. The Seventh International Conference on Indoor Air Quality and Climate. International Academy of Indoor Air Sciences.

Wargocki, P., D. P. Wyon, Y. K. Baik, G. Clausen, and P. O. Fanger. 1999. Perceived air quality, SBS-symptoms and productivity in an office at two pollution loads. In *Indoor Air* '99, vol. 2, pp.107–12. The Eighth International Conference on Indoor Air Quality and Climate. International Academy of Indoor Air Sciences.

Wasley, P. M., M. Fine, N.E. Gladden, S. P Holland, E. King, E. Mosak, and L. C. Powell. 2000. Small schools: Great Strides. A study of new small schools in Chicago. Retrieved 07/03/02 from http://www.bnkst.edu/html/news/SmallSchools.pdf

Wenglinsky, H. 1997. When money matters: How educational expenditures improve student performance and how they don't. Princeton, N.J.: The Educational Testing Service, Policy Information Center. (ED412271)

Woods, J. E., B.A. Penney, P.K. Freitag, G. Marx, B. Hemler, and N.P. Sensharma. n.d.. Health, energy, and productivity in schools: Overview of the research program. Herndon, Va.: HP-Woods Research Institute.

Wyon, D. P., I. B. Andersen, and G. R. Lundqvist. 1979. The effects of moderate heat stress on mental performance. *Scandinavian Journal of Work, Environment, and Health* 5, pp. 352–61.

Wyon, D.P. 1991. The ergonomics of healthy buildings: Overcoming barriers to productivity. In IAQ '91: Post Conference Proceedings. Atlanta, Ga.: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., pp. 43–46.

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Additional Information

See the NCEF resource lists *Impact of Facilities on Learning, Classroom Acoustics, Classroom Color Theory, Daylighting, Healthy School Environments, High Performance School Buildings, Lighting, Indoor Air Quality, Mold in Schools, and School Size* online at http://www.edfacilities.org/rl/

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