PUBLIC SCHOOL FACILITIES AND TEACHING: WASHINGTON, DC AND CHICAGO

A Report Prepared by

Mark Schneider, Ph.D.
Professor of Political Science
State University of New York at Stony Brook
Stony Brook, NY 11794-4392

E-mail: Mark.Schneider@stonybrook.edu

Table of Contents

Facilities and Teaching:
Teachers in Chicago and Washington DC Assess How
Well School Buildings Support Teaching

Introduction

This report was written by Mark Schneider, Professor of Political Sciences at the State University of New York, Stony Brook. It was commissioned by the 21st Century School Fund as part of their Building Educational Success Together initiative. Funding for this study was provided by the Ford Foundation as part of their commitment to educational excellence and equity.

This study was designed to assess the effect of school facilities on teaching. A survey of Chicago and Washington, DC public school teachers was used:

- To identify what teachers feel supports their ability to teach.
- To assess the adequacy of school conditions and school design as experienced by teachers.
- To examine the distribution of quality school facilities.
- To identify the impact of facilities on learning outcomes.

This study contains the results of these surveys and links conditions as reported by teachers to student demographics and test scores, official school building assessments, and current research on the effect of K-12 educational facilities on learning.

Public school teachers in Chicago and Washington, DC were surveyed to collect data for this study. In Chicago, the Survey Research Center at SUNY, Stony Brook, drew a random sample of teachers from a list of all members of the Chicago Teachers Union (CTU) supplied by the union. In May and June of 2002, 688 Chicago teachers were interviewed by phone (Appendix 2 provides more technical information on the survey). At the same time, a paper version of the survey was distributed to teachers in all the Washington DC public schools by the building representatives of the Washington Teachers Union. Completed surveys were returned by over 25% of the District's teachers (See Appendix 3 for a list of schools from which responses were obtained and response rates).

During the 2001-2002 school year, the Chicago Public Schools had 600 operating schools, with an average age of 61 years. In that year, these schools were comprised of approximately 437,618 students and 26,700 teachers. (source: CPS). At the same time, the District of Columbia Public Schools had 150 operating schools, with an average age of 67 years. The District's schools that year were comprised of approximately 68,000 students and 5000 teachers. (source: DCPS).

Since 1995, the Chicago Public Schools has spent more than $2.4 billion dollars for the construction of 17 new schools and 30 additions, and for hundreds of major capital renovations and educational enhancements. Chicago public schools has appropriated $512 million in its fiscal year 2003 capital budget, but estimates the need for over $2 billion more in capital investments.

Since 1995, when the District of Columbia Public Schools issued a Long Range Preliminary Educational Facilities Master Plan that called for spending $1.2 billion to modernize all public school facilities, they have spent approximately $500 million. These funds have paid for design and construction at 9 schools; design work for an additional 21 schools; and hundreds of health, safety, and component replacement projects throughout the system. The District of Columbia Public Schools has $221 million in its fiscal year 2003 capital budget. However, the gap between current capital funds and the school system's estimated need over the next six years is $848 million.

Section 1: School Facilities: An Essential Component of Educational Success

Improving educational performance is high on the list of national, state and local policy agendas. The attention of policy makers and members of the education research community has been focused on such things as school choice, curricula reforms, teacher quality, test scores and accountability. Conspicuously missing from this debate is a concern for the physical infrastructure of the school that supports learning.

Despite the rapid growth in home schooling, the vast bulk of education takes place in school buildings, and there is extensive literature that links the quality of facilities to the quality of education, and to the morale and productivity of teachers.[1] Serious deficiencies in school buildings have also been well documented (see for example, GAO 1995). Moreover, since school buildings in the United States are, on average, over forty years old, just the time when rapid deterioration often begins, we should expect problems with school facilities to worsen.

Focusing on two large American cities, Chicago and Washington DC, the goal of this study is to document the condition of educational facilities as experienced by teachers and to explore how these conditions affect their ability to teach. The argument of this report is quite simple: if school facilities are inadequate or inappropriate then the educational enterprise will likely fall short, despite any other efforts at school reform.

This report focuses on how teachers evaluate the *design* of schools— rating such things as the adequacy of lighting, the availability and adequacy of specialized facilities (such as science labs and music rooms), and the size of the school. The report then examines how teachers evaluate the *condition* of

---

[1] In the Appendix 2, I review some of the relevant literature linking educational outcomes to the quality of school facilities. Also see the extensive archive maintained by National Clearinghouse for Educational Facilities (www.edfacilities.org).

various aspects of their schools— including such things as indoor air quality, noise levels, and thermal comfort. Existing research has found these aspects of schools to be important in achieving better educational outcomes. In addition, the survey data was merged with objective measures of the school environment, including school demographics, data on building conditions, and school test performance. Using these merged data we can assess the relationship between these objective school characteristics and school quality and we can assess the effect of facilities on academic achievement.

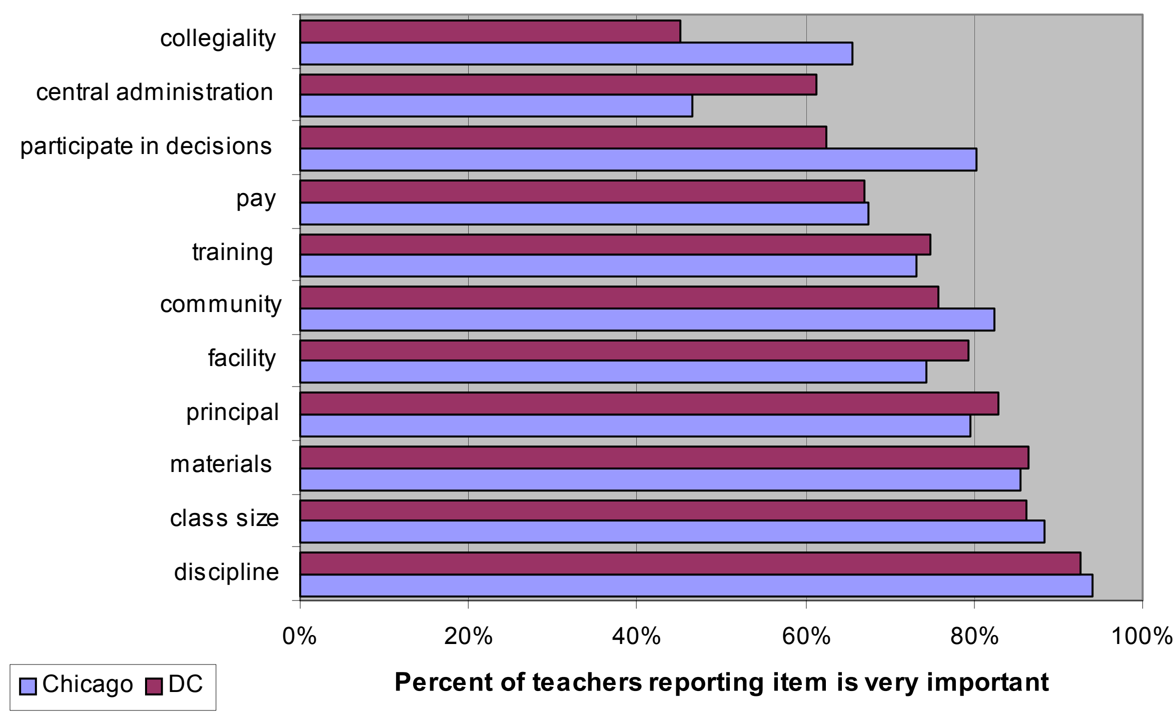
How Do Facilities Compare to Other Important Factors?

The survey begins by asking active classroom teachers which inputs they find important to their overall performance as a teacher. In Figure 1, I report the percent of teachers in each city who say that a particular input is *very important* to their performance. In this figure, the responses are ranked by the average teacher responses given in both cities combined, with the average importance increasing as we move from top to bottom. The results are displayed separately for each city, allowing the reader to identify differences between the cities, while at the same time noting the importance of each input overall. For example, combining responses from both cities, collegiality ranks last in importance, but in Chicago, it is actually ranked higher than the central administration. Despite a few instances of differences such as these, even a quick visual inspection of Figure 1 shows a high level of consistency between the two cities.

Of the 11 inputs about which teachers were queried, on average, over 75% of the teachers found their school facility, the participation of the community, a good principal, good materials, appropriate class size, and discipline very important to their overall performance as teachers. Ranking as the least important, overall, were the central administration and collegiality.

While most teachers may not have read the extensive literature linking facilities to educational outcomes, their day-to-day experiences confirm what research has found: Teachers understand that good facilities are important to their classroom success.

Figure 1: What do teachers find very important to teaching quality?

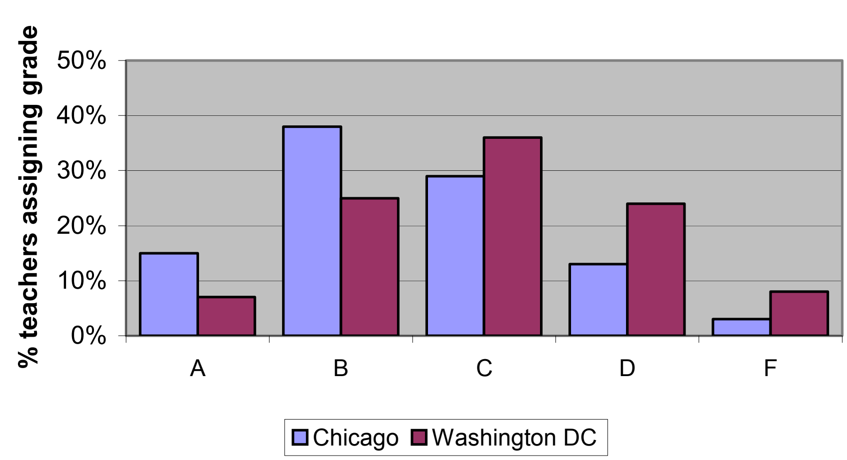


How Do Teachers Rate Their Schools?

Although they recognize the importance facilities have on their ability to teach, teachers in both Chicago and DC report many school infrastructure problems they face on a daily basis. In this analysis, I begin with a general overall picture of teacher facility evaluations, and then move towards a comparative analysis of responses and specific independent indicators of building design and building condition.

As a first cut at assessing the extent to which teachers encounter problems affecting school facilities, we asked teachers to assign a letter grade (using the A-F scale with which every teacher is familiar) to the condition of their school facilities. In Figure 2, we begin to get a sense of the extent of facility problems—especially in Washington DC.

Figure 2: How do teachers grade their school's facilities?



First, notice how few teachers give the grade of A to their schools. Second, consider the low average grade assigned to facilities: If we convert the letter grades to numerical scores (where A=4, B=3…F=0), the overall numerical average across the two cities is just above C (2.17). As evident in Figure 2, teachers in Washington DC are even more critical, where the graded average is actually less than C (1.98). Teachers in Chicago, on the other hand, rate their schools higher, at about a 'C+' (average score=2.5).

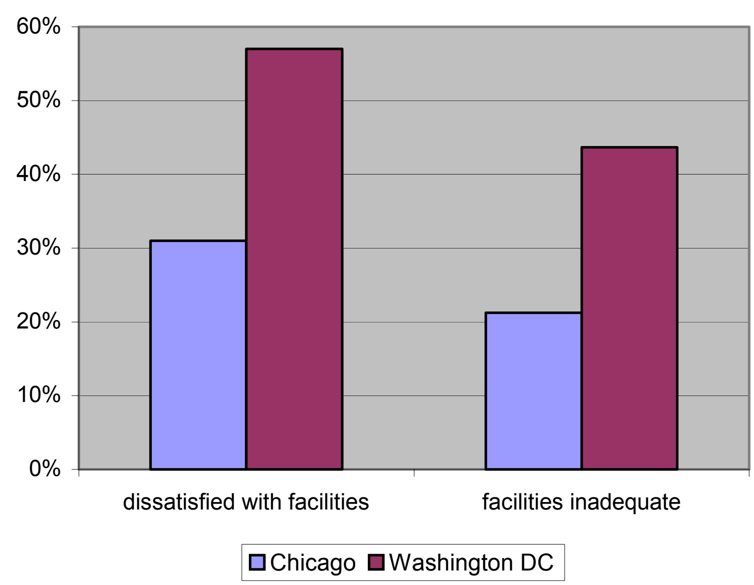
These survey data provide evidence that teachers are experiencing problems with the facilities in which they work. As reflected in Figure 3, there is a high level of dissatisfaction among teachers with the condition of their schools— and, not surprisingly, dissatisfaction is much higher in Washington, DC than Chicago. For example, over half of the DC teachers we interviewed said that they were either very or somewhat dissatisfied with their school's facilities. Teachers in Chicago were not as critical, but still a high level of dissatisfaction is evident, with about one-third of Chicago's teachers reporting a high level of dissatisfaction with their school's facilities.

It is important to note that there may be a difference between feeling satisfied with a facility and finding a facility to be educationally adequate for effective teaching. Indeed, while a satisfied work force is important to delivering high quality education, the center of current policy debates concerning education is aimed at ensuring the adequacy of education, while teacher satisfaction and working conditions are not often part of the policy debate. Therefore, teachers were also asked to judge the educational adequacy of their schools.

Returning to Figure 3, over 40% of DC teachers believe that their students are not being taught in a facility that is educationally adequate, almost twice as high as the percentage of Chicago teachers who report inadequate facilities. Despite these differences between cities, far too many teachers find their schools failing the basic test of adequacy.

While identifying the extent of overall problems teachers have with school facilities is important, as policymakers turn attention to the importance of facilities, they are going to need more guidance about the specific aspects of schools generating

Figure 3: Teachers are Dissatisfied with Their School Facilites



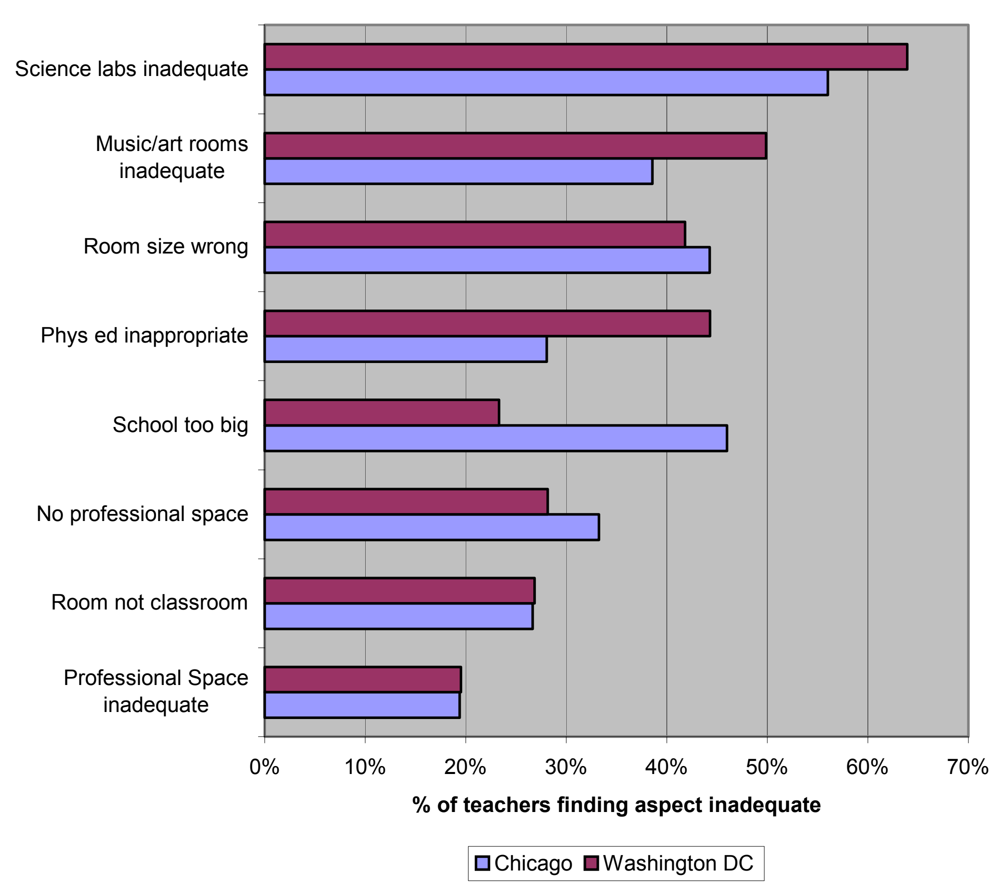
the most problems. Fixing schools is an expensive undertaking, and given the perennial construction funding shortage school systems face, it is critical to identify where the problems are most severe. To do this, we examine teacher evaluations of specific aspects of the design and the condition of school facilities.

Problems with the Design of School Facilities

In addition to survey questions about the overall building conditions, teachers were queried about specific aspects of the design of their school's facilities. The results reflect significant problems in our schools. In Appendix 1, I discuss evidence that supports both small classes and small schools as important to a high quality educational experience for both students and teachers. The survey results show that over a quarter of the teachers in Washington thought that their school had too many students, and about the same number were dissatisfied with the number of students in their classes. The level of problems reported by Chicago teachers is significantly higher than those reported in DC. As evident in Figure 4, over 40% of Chicago teachers felt that their school was too big and 38% were dissatisfied with the number of students in their classes— and this dissatisfaction exists despite a strong citywide program to reduce class size. This is consistent with the fact that Chicago has communities experiencing serious overcrowding in schools, while the student population in Washington, DC is still in decline.

Another common design problem was inadequate or lack of specialized classrooms. Educational policy makers have been concerned for some time about the poor quality of science education in the United States, as evident by many states having enacted a more

Figure 4: Teachers Find Many Problems with the Design of Their Schools



demanding science curriculum. However, adequate science laboratories are clearly one of the fundamental building blocks for a quality science education. As evident in Figure 4, almost 60% of teachers in each city reported that the science labs in their school were somewhat or very inadequate to meet curricula standards, or that they had no science labs at all (a major form of inadequacy). The study finds that even teachers in schools with labs frequently report that these facilities are inadequate. Specifically, 40% of the teachers in Chicago's elementary schools and junior high schools that had labs reported they were inadequate, and 31% of Chicago high school teachers reported that their labs were inadequate.

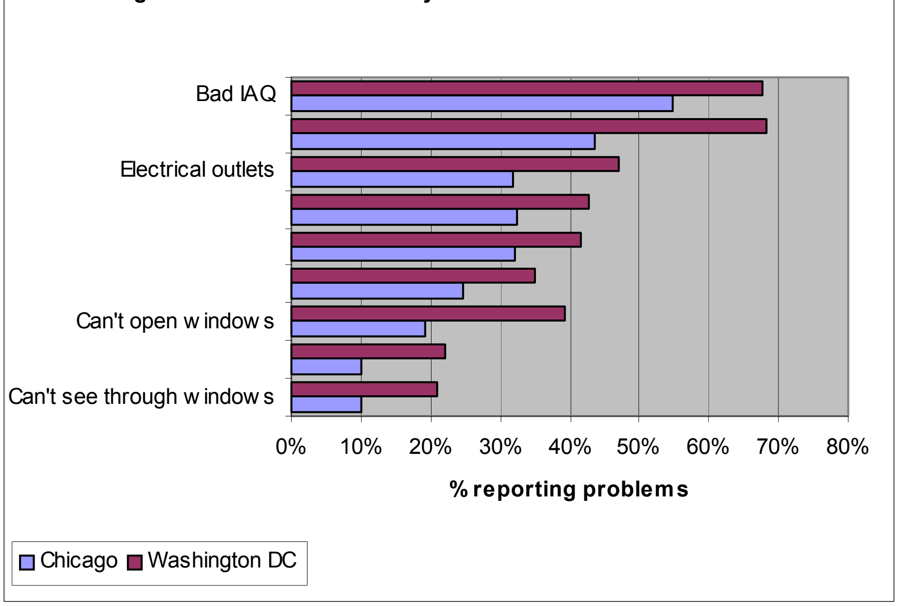
When we asked teachers about art and music rooms, fewer teachers reported that these specialized facilities were inadequate to meet state standards. Still, over one-third of Chicago teachers and one-half of Washington teachers judged these facilities to be somewhat or very inadequate.

Physical education and recreational facilities are also essential to the well-being of students. Yet large numbers of teachers report that these facilities were not appropriate for the needs of their students: about 30% of Chicago teachers felt that these facilities met the needs of their students not very well or not at all, and over 40% of Washington teachers said the same.

We also asked teachers about several other design characteristics that are important to the quality of education, and again we find substantial problems. For example, over 40% of teachers in both cities reported that their class room was the wrong size for the type of education they were trying to deliver. Even more distressing is the fact that over 25% of the teachers surveyed report having taught in space that was not a classroom.

Education is an increasingly complex task, and like professionals in other industries, teachers need space to work with their colleagues to discuss problems and techniques. Yet our study finds that schools all too often do not provide professional work space. Almost one-third of the teachers in Chicago said that they did not have adequate professional space and about 30% of Washington's teachers said the same. Even when professional space was provided, one-fifth of the teachers thought the space was inadequate.

Figure 5: Teachers Find Many Problems with the Condition of



Problems with the Condition of School Facilities

Clearly, there are design problems in the schools. However, even when schools are well-designed, they are often not well maintained. Many conditions in classrooms and in schools in Chicago and Washington are deleterious to learning and to the health of the students and teachers. There is a substantial body of research linking indoor air quality (IAQ), thermal comfort, lighting and noise to educational outcomes (see Appendix 1). I begin with these conditions and then investigate how teachers evaluate several other aspects of their school.

The most important problem noted by teachers in both cities is poor indoor air quality. Approximately two-thirds of the teachers in Washington find the air quality fair or poor. In Chicago, over half of the teachers surveyed also find problems with IAQ. The issue is so important that I return to it in the next section.

There are other problems with condition reported by teachers that are worth noting. For example, we know that thermal comfort affects the performance of teachers and student learning— yet over 30% of Chicago teachers and over 40% of teachers in Washington report that their rooms were uncomfortable. See Figure 5.

Similarly, a body of research has pointed out how noise interferes with the educational process; but over 40% of Chicago teachers and almost 70% of Washington teachers report that their classrooms and hallways are so noisy that this affects their ability to teach. Similarly, while studies show that adequate lighting is essential for learning, over 20% of teachers in Washington and 10% of teachers in Chicago report inadequate lighting.

On an even more basic level, it is important to note how many teachers complain about the inadequacy of electrical outlets. Teachers need access to a growing number of multimedia devices, such as VCRs, LCD projectors, and overhead projectors. All of these require electrical outlets that are accessible, yet over 40% of the teachers in Washington and about one-third of the teachers in Chicago report that the number and placement of outlets was inadequate.

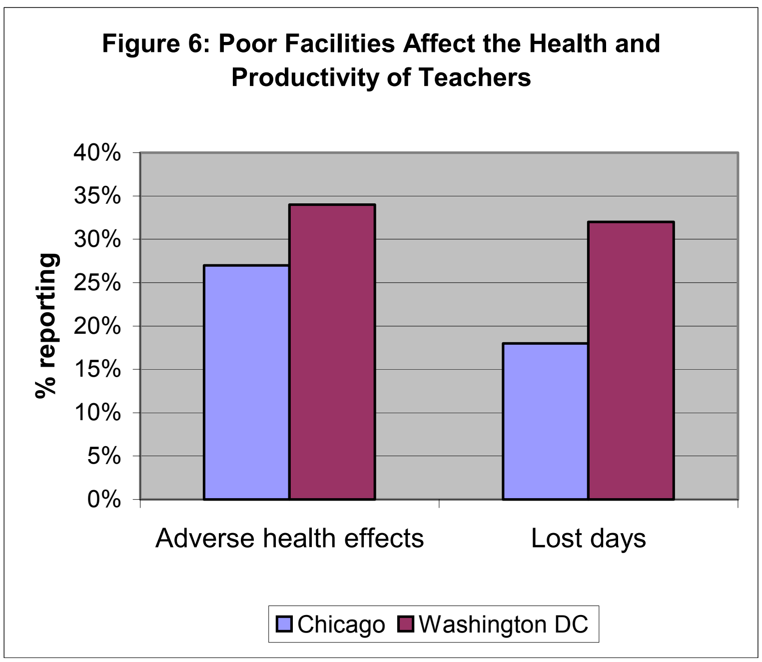
A substantial number of teachers also report that their lunchrooms are inadequate and that their restrooms are dirty and poorly maintained.

Finally, there is increasing agreement among design professionals that natural daylight is essential in classrooms (see Appendix 1)— but if windows become so deteriorated that teachers can't see through them it's unlikely that enough light is getting into the classroom to benefit students. In Washington DC, over 20 % of the teachers say they cannot see through their windows (about 10% of Chicago teachers say the same). Furthermore, 40% of the teachers in Washington and almost 20% of the teachers in Chicago report that they can't open their windows, which can contribute to poor indoor air quality and can help explain the high reported rates of that problem.

Sick Buildings and Sick Teachers

As indicated in the previous section, we return to one of the most serious problems that teachers report— poor indoor air quality (IAQ). Fully two-thirds of Washington teachers reported poor indoor air quality, as did well over half of the teachers in Chicago. Our data show that, similar to well-known studies of student health problems, a high incidence of poor IAQ is reported by teachers.

Current student-focused asthma studies show that students lose considerable school time because of the poor conditions of schools. It is not surprising to find that poor facilities also affect teachers health. In Chicago, over one-quarter of the teachers we talked with reported that they had suffered adverse health effects because of problems in their school. In Washington, DC over one-third of the teachers reported such effects. As shown in Figure 6, these health problems translate into lost teaching time. About one-third of teachers in Washington reported lost time because of health problems caused by facilities, while in Chicago, just about 20% reported losing time. Furthermore, in both cities, teachers that were out of work because of such problems reported losing slightly more than 4 days over the course of the school year. Given the average daily salary of a teacher, this translates into a serious financial loss for financially strapped school districts.



In Chicago, we were able to query teachers about the kinds of health problems they experienced. Given the prevalence of complaints about IAQ, not surprisingly over one-quarter of Chicago teachers reported asthma and respiratory problems as the most frequent problems. Another 16 % reported other problems (such as sinus infections) that may also be linked to poor IAQ.

There is a relatively simple solution to these air quality and health problems available to schools. Fully 63% of the teachers who could not open their windows reported adverse health effects, which was far greater than the 36% incident rate among teachers who could open them. Clearly, schools should ensure that windows meant to be open are not painted shut, and that teachers are able to open them safely.

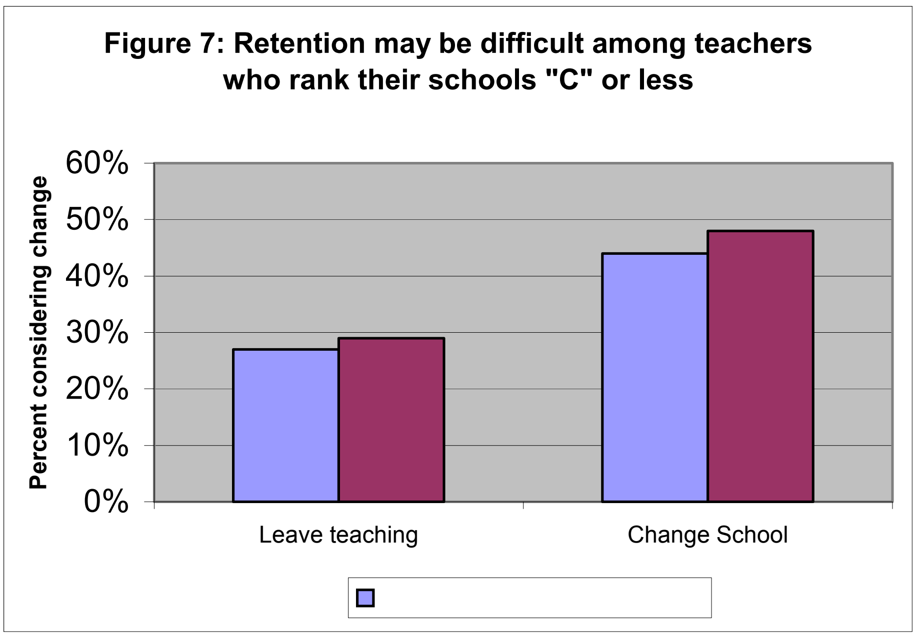
It is important to compare these self-reported health rates with national health-related reports generated by the Occupational Safety and Health Administration (OSHA). OSHA's nationwide data found only about 4% of teachers reporting job-related illnesses or injuries, which is far below the incidence reported by teachers in these inner-city school districts.[2]

[2] Part of this difference is traceable to a difference in how the data are collected. OSHA collects its data from employers, our data are collected from employees.

Facilities and Retention Decisions

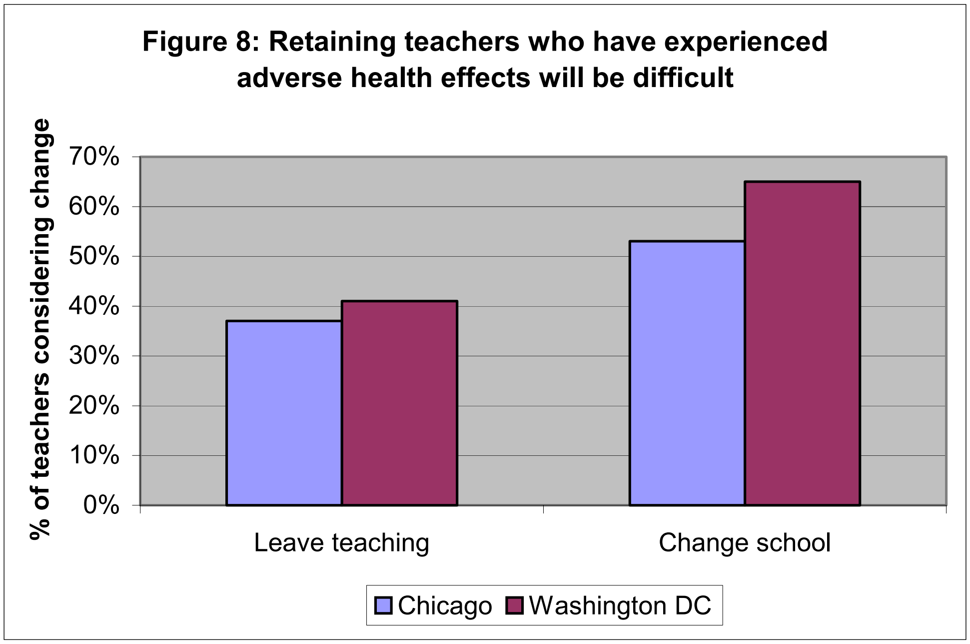
These survey results paint a picture of school facilities rife with problems in design and in maintenance. Moreover, many teachers are reporting that these facilities are adversely affecting both their productivity and their well-being. Not surprisingly, poor facilities may also affect the career decisions of teachers. Among teachers who rated their facilities C or below, over 40% said that these poor conditions have led them to consider leaving their school and almost 30% of these teachers are thinking about leaving the profession entirely. This is shown in Figure 7.

To the extent that school conditions are causing teachers to become ill, teacher retention becomes more difficult. As evident in Figure 8, around 40% of teachers who experienced adverse health effects are thinking about leaving the profession and well over half of those teachers are thinking about leaving their school.



Why is this so important? Many analysts have argued that school staffing problems are caused not so much by the failure to hire new teachers, but by too many teachers leaving teaching. Indeed, research has shown that nearly about 20% of recent college graduate who began teaching in the public schools in 1994–95 had left the profession by 1996–97 and other work has found that approximately one-fourth of all beginning teachers leave the classroom within four years. High teacher turnover has obvious consequences. It forces states, districts, and schools to devote attention, time, and financial resources to initiatives designed to attract additional candidates to replace those who leave the profession. High teacher turnover can also undermine efforts to implement reforms; successful school reform requires sustained and shared commitment by school staff. Furthermore, high turnover clearly affects student learning; researchers have shown that that new teachers are less effective at teaching students than more experienced teachers.

Given the high turnover rates as cited from the study and the negative consequences, schools must address all the sources of low retention; and clearly correcting poor facilities is relational to policies designed to attract and retain high quality teachers.



Section 2: School Demographics and Facilities Relationship

Much of the existing research has shown that the relationship between the quality of facilities and educational outcomes is particularly strong in schools serving low income and minority students—that is, better facilities in these schools may lead to the largest increases in desired educational outcomes. In addition, norms of social justice and equity demand that the quality of schools should not be determined by race or social class. In this section, I look at the relationship between the quality of school facilities and the demographic makeup of schools.

In our previous analysis, I analyzed teacher evaluations across a number of indicators of school quality (e.g., space, class size, science labs, etc). In the next step of this analysis, rather than analyzing each indicator separately, I take advantage of the fact that there is a correlation across all these individual measures of school design and school condition. Building on these correlations, I created a scale using all the indicators and response patterns shown in section 1.[3] In the analysis presented below, I use this scale score as an overall indicator of the quality of the school facility, with higher numbers representing more problems.

I begin with a simple analysis in which I regress the facility score based on teacher reports against five measures of the school demographics for each school: 1) the percent of the student body that is English Language Learners (ELL), 2) the percent of low income students, 3) the school enrollment, 4) the percent of the student body that is African-American, and 5) the percent of students that are Hispanic.

---

[3] This scale was based on Cronbach's alpha statistic and had a reliability coefficient of over .70—which is respectable by most standards.

These measures are all for 2001 academic calendar year, and are reported by the central administration of each city's school system.

In each city's grouping of Table 1, I report the size of the coefficient on the top line with the standard error of the estimate in parentheses below it. Using widely accepted standards, a coefficient needs to be roughly twice the size of its standard error to achieve statistical significance at the most widely used .05 level. Coefficients that reach this level of statistical significance (.05) are marked with (*). Results are reported separately for each city.

Table 1: Regression Analysis:
The Effects of School Demographics on the Design and Condition Scale

	% English Language Learners	% Low Income (Free/Reduced Lunch)	Size of School	% African American	% Hispanic
Washington, DC					
Facility Scale	.54 (*) (.19)	-.01 (.03)	.02 (*) (.01)	.09 (*) (.04)	-.23 (.15)
(*) *p<.05*					
Test Statistics: R^2 = .02, *significance=.001*					
Chicago					
Facility Scale	.002(*) (.001)	-.00 (.00)	.014 (*) (.008)	.00 (.00)	.00 (.00)
(*) *p<.05*					
Test Statistics: R^2 = .02, *significance=.01*					

By looking at the overall test statistics (R^2), we see immediately that there are no strong relationships between school demographics and the conditions of schools as reported by teachers. The fit of the equations to the data while statistically significant is weak— only 2% of the variance in the scale is explained by these demographic measures.[4] As for specific school conditions, in both cities higher concentrations of students with limited English language skills are associated with poorer school facilities, and in both cities larger schools have worse scores than in smaller schools. In Washington, DC, as the concentration of black students increases so does the facility score— indicating worse conditions in schools with higher percentages of black students.

This simple regression analysis is designed to assess the *linear* relationship between school demographics and problems with school facilities. It is possible, however, that problems may be concentrated at the extreme of the scale— perhaps the student demographics in the best schools are substantially different than those of the schools in the worst condition.

To assess this hypothesis, I looked at the demographics in the schools that were 1 standard deviation above the mean score on each scale in each city (given that higher scores indicated more problems, these are the *worst* schools) and compared these demographics to those schools that were 1 standard deviation below its city's mean (the *best* schools). In Tables 2a (Washington DC) and 2b

[4] The variance explained can range from 0% to 100%, with higher numbers indicating that the model fits the data better. With only 2% of the variance explained, the analysis suggests that school demographics are not strongly related to the school conditions reported by teachers.

(Chicago), I compare the student makeup across these two types of schools. (Cells represent the average for each demographic measure for the best schools and the worst schools in each city. These means were compared and differences that reached the .05 level of statistical significance are marked with (*)).

Table 2a: How Do the Best and Worst Schools on Overall Design and Condition Measures Differ on Demographics: Washington DC

	% English Language Learners	% Low Income	Standardized Size of Enrollment	% African American	% Hispanic
Schools with worst facility scale scores	9% (*)	60%	.12 (*)	82%	13%
Schools with best facility scale scores	6%	62%	-.07	82%	11%

(*) *p<.05*

Turning to Washington DC, I find some statistically significant differences in the demographic make-up of the worst and the best schools. Consistent with Table 1, the schools that are in the worst condition are bigger schools, and they also have a higher concentration of students who are English Language Learners. However, there are no differences in the concentration of African American students at the two extremes of the quality scale.

In Chicago, there are no statistically significant differences in the student demographics in the best and the worst schools. See Table 2b. These results show that there is no consistent relationship between school demographics and design and facility problems.

Table 2b: How Do the Best and Worst Schools on Overall Design and Condition Measures Differ on Demographics: Chicago

	% English Language Learners	% Low Income	Standardized Size of Enrollment	% African American	% Hispanic
Schools with worst facility scale scores	13%	83%	.06	53%	32%
Schools with best facility scale scores	12%	83%	-.04	47%	37%

In both Washington and Chicago, the problems of bad design and bad maintenance are widespread across all schools. Clearly, there are problems of social justice and equity in the distribution of good schools and good maintenance across the nation and between cities and suburbs, however, these may not be problems *within* these cities.

Section 3: Facilities and Test Outcomes

While education has many goals, society's focus in school reform is on improving test scores as the definitive benchmark to measure progress (or lack of). In this section of the report, I examine the extent to which school facilities as evaluated by teachers are related to standardized test results from the 2001-2002 school year. Clearly, many factors can affect test scores and there is a large literature linking school conditions to test outcomes. My objective here is not to create and test a full scale production function linking school conditions to test outcomes, but rather to develop a relatively simple model to control statistically for other factors (e.g., demographics, income) that can affect test scores, while testing for the independent effects of school conditions. Further research using more complicated models will ultimately be necessary to test the robustness of the findings I report here— but the results of these simple models do comport with what other research has already indicated: good facilities are linked to better test scores.

While the models are straightforward, there are some specifications to note. First, each city uses a different achievement test. Washington uses the Stanford Achievement Test (SAT-9), while Chicago has traditionally relied on the Iowa Test of Basic Skills (ITBS). Correspondingly, the variable I use as an indicator of performance differs across the two cities.[5]

Following standard procedures for the SAT-9, Washington reports the distribution of student scores in each school across four categories of performance: below basic, basic, proficient, and advanced. For this analysis, I use the percent of students in the two highest categories for math and reading separately as the indicator of test performance. Chicago reports several indicators of performance on the ITBS, including the percent of students reading or performing math at or above grade level, which is the indicator used in the following analysis.

It is well known that test performance in a school is closely related to its ethnic and economic make-up; in general test scores decrease as the concentration of students from minority racial groups increases and as the lower socio-economic status increases. In turn, I include in my models measures of the percent of school enrollment that is African American, percent Hispanic, and percent English Language Learners (ELL). Given the documented importance of school size, I include the total number of students enrolled in the school.[6] In Chicago, I also include a measure of the percent of the student body that is low income, but a similar measure in the Washington models had to be excluded because of how strongly that variable was related to the other independent variables.[7]

---

[5] Illinois has recently been emphasizing the Illinois Scholastic Aptitude Test (ISAT) over the Iowa tests. We replicated the analysis using ISAT and the results are virtually the same as we report below.
[6] Given that high schools are so much larger than other schools, the enrollment figure included is the standardized score (z-score) of each school relative to other schools of its same type. For example, each high school in Chicago has a standardized score that ranks its size relative to all the other high schools in that city.
[7] Technically, the variable was "multicollinear" with other measures and could not be included in the estimation of the regression equation.

The Effects of Facilities on Test Outcomes in Washington DC

In Table 3, I report the relationship between test scores and these demographic variables and then report the effect of facilities in Washington DC controlling for these conditions. In Table 4, I report the relationship of these conditions on test performance in Chicago.

Using this relatively small number of variables, I achieved a good fit to the data. In Washington, the model explains 64% of the variance in reading scores, and 59% of the variance in math scores. More importantly, we see that after controlling for school demographics, there is an independent effect of facilities on both math and reading test performance.

Table 3a: Regression Analysis:
The Effects of School Conditions on Test Performance, Washington DC

	% English Language Learners	% African American	% Hispanic	Facility Score	Enrollment
Reading: Percent above basic	-.51 (*) (.12)	-.86 (*) (.02)	-.41 (*) (.09)	-.05 (*) (.02)	-.01 (*) (.00)
Test Statistics: R^2 = .64, significance $p<.001$					
Math: Percent above basic	-.33 (*) (.12)	-.76 (*) (.02)	-.40 (*) (.10)	-.06 (*) (.02)	-.02 (*) (.00)
(*) *$p<.05$*					
Test Statistics: R^2 = .59, significance $p<.001$					

In Table 3b, I present another way of looking at the impact of facilities, by comparing the percent of students scoring above basic in schools with the best facilities score and those with the worst scores. We can see that this shift from the best facilities to the worst decreases the percentage of students performing in the two highest categories of the SAT-9 by 3% for both math and reading.

While this may not seem like a substantial change, the effect of the change among the schools with the best conditions to the worst conditions is virtually identical to the effect of the change in performance among the smallest schools compared to the largest— a factor that has garnered considerable research attention and is advocated by many as one of the most reliable ways to improve academic outcomes. Therefore, improving facilities may be just as helpful as reducing school size.

Table 3b: Difference in Test Performance in Schools with Best Facility's Score versus Worst Facilities Score and Biggest and Smallest Schools, Washington DC

	Schools with Best Facility Score	Schools with Worst Facility Score	Smallest Schools	Biggest Schools
Reading: Percent above basic	28%	25%	28%	26%
Math: Percent above basic	24%	21%	25%	21%

All differences in means are significant at p<.05

The Effects of Facilities on Test Outcomes in Chicago

In Table 4, I replicate this analysis using the data from Chicago. As in Washington, these relatively simple regression equations fit the data quite well, explaining over 76% of the variance in the distribution of reading test scores and 65% of the variance in math scores. Again I find that even after controlling for demographic factors, the facility score has an independent effect on test performance.

Table 4a: Regression Analysis:
The Effects of School Conditions on Test Performance, Chicago

	% English Language Learners	% Low Income	% African American	% Hispanic	School Size	Facility Score
Reading: Percent above grade level	-.14 (*) (.05)	-.72 (*) (.03)	-.19 (*) (.02)	-.06 (*) (.03)	.38 (.45)	-.07 (*) (.02)
Test Statistics: R^2 = .76, significance p<.001						
Math: Percent above grade level	-.04 (.06)	-.64 (*) (.03)	-.19 (*) (.03)	-.09 (*) (.04)	1.11 (*) (.55)	-.11 (*) (.02)
(*) *p<.05*						
Test Statistics: R^2 = .65, significance p<.001						

Somewhat surprisingly in Chicago, I find that the size of the school did not have the anticipated effect on test scores. Therefore in Table 4b, I report only the size of the change in test scores for the best versus the worst schools as measured by the facilities index. We find that the change between the best and the worst schools to be virtually the same as in Washington DC— good facilities can add 3-4 points to the percent of students who are working at or above grade level.

Table 4b: Difference in Test Performance in Schools with
Best Facility's Score versus Worst Facilities Score, Chicago

	Best Facility Score	Worst Facility Score
Reading: Percent above grade level	51%	48%
Math: Percent above grade level	61%	57%
All differences in means are significant at p<.05		

Section 4: How Do Conditions Affect Teacher Evaluations?

In this final section, I use standard regression techniques to measure the extent to which three objective measures of school facilities— total capital expenditures per square foot, building age, and square feet per student— affect how teachers assess the design and the condition of their schools, using the scales employed earlier.

While Tables 5 and 6 report the effects of these three factors, the full equations upon which these coefficients are based also included measures of the student body demographics in each school (percent black, percent Hispanic, percent low income, and percent English language learners) to control for the possible effects of these conditions on teacher evaluations.

The Effect of Objective Measures on Teacher Evaluation of School Design

Table 5: Regression Analysis: The Effects Of Capital Expenditures, Building Age and Crowding On Design Scale, Controlling for School Demographics

Total Expenditures Per Sq. foot	*Building age*	*Sq. Feet per student*
	Washington DC	
.00	.00	-.003 (*)
.00	.00	.00
	(*) *p<.05*	
	Test Statistics: R^2=.04, significance=.001	
	Chicago	
.00	.001 (*)	-.0003 (*)
.00	.000	.000
	(*) *p<.05*	
	Test Statistics: R^2=.06, significance=.001	

In the top half of Table 5, I report how teachers in Washington, DC assess the *design* of their schools as a function of capital expenditures, building age, and crowding. In the bottom half, I report the results for Chicago. As in other parts of this analysis, I again find that the relationship between these three objective measures of school facilities and teacher evaluations are not particularly strong.

In the District of Columbia, neither capital expenditures per square foot, nor building age are related to teacher evaluations of school design. However, space does matter— as the space available to students increases, teachers find fewer problems with the design of their schools. The change in the design scale is considerable: overall the average of the design scale in Washington was .38. As was discussed in the earlier analysis, higher scales coincide with greater facility problems. In this case, our hypothesis is confirmed where in the most crowded schools, the average score was .42; in contrast, the average in the least crowded schools was much lower at .35— a significant reduction in the design problems teachers report.

In Chicago, as in DC, school crowding affects how teachers evaluate the design of their schools. In Chicago, as in Washington DC, teachers in the most crowded schools averaged .42 on the design scale, significantly higher than the .35 average found in the least crowded schools.

Finally, after testing school building age against teacher evaluations of school design, the study finds a contrast in results. Unlike Washington, the test finds that in Chicago building age significantly affected teacher evaluations, as indicated by teacher reports of greater design problems in older schools. The data reflects that Chicago teachers in the oldest schools (1 standard deviation above the city-wide average) scored .42 on the design scale, significantly higher than the .37 in the newer schools.

The Effect of Objective Measures on Teacher Evaluation of School Condition

In Table 6, I look at the correlation of teachers' evaluations of the condition of their schools in relation to capital expenditures, building age, and crowding. In Washington, crowding does not affect how teachers evaluate the condition of their building. Capital expenditures per square foot has a negative relationship: as the amount of spending increases, teachers report fewer problems. However, the coefficient just misses being statistically significant at the traditional .05 level. Among schools in DC with the lowest total capital expenditures per square foot, the condition index stands at .43, which is slightly, but statistically significantly higher than the .41 index score among teachers who are in schools with the highest expenditures.

Table 6: Regression Analysis: The Effects Of Capital Expenditures, Building Age and Crowding On Condition Scale, Controlling for School Demographics

Total Expenditures Per Sq. foot	*Building age*	*Sq. Feet per student*
Washington DC		
-.001(**)	-.0006 (*)	.00
.001	.0003	.00
(*) *p<.05;* (**) *p<.10*		
Test Statistics: R^2*=.02, significance=.001*		
Chicago		
-.0004(**)	.001 (*)	.00
.0002	.000	.00
(*) *p<.05;* (**) *p<.10*		
Test Statistics: R^2*=.03, significance=.005*		

Similarly in Chicago, the effect of total capital expenditures per square foot just misses the .05 level of statistical significance. However, in the schools with the lowest capital expenditures, teachers had an average score of .30 on the condition scale, which is higher than the .27 average score among teachers in schools with the highest level of expenditures.

In both Washington and Chicago, building age affects teacher evaluations. Surprisingly, the effect is in the opposite direction. In Washington, teachers in older schools actually report having somewhat fewer problems with the conditions in their schools, while in Chicago, teachers in newer schools report more problems with their schools conditions. Keeping in mind that the average score in Washington (.42) is considerably higher than the average .29 score reported among Chicago teachers, I find that in Washington, teachers in the newer schools score .44 on the condition scale, significantly higher than the .41 average among teachers in the older schools. In contrast, among Chicago teachers, problems with conditions rise from an average score of .26 among teachers in the newest schools to .32 among teachers in the oldest schools.

In short, the evidence reflects that capital expenditures, at least within the boundaries of what is being spent now and how they are being spent, does not affect the fundamental design problems (absence of science labs, inappropriate physical education and recreational facilities, and the like) that teachers in both cities have identified. What the data does support, however, is that capital expenditures indeed reduce the number of problems teachers report with the *condition* of their school facilities. In both cities, more space alleviates design problems. Teachers have greater flexibility to reconfigure extra space for improving instructional spaces. Not surprisingly, more space does not affect the way in which teachers perceive the condition of the buildings.

Finally, we see some interesting results concerning the age of school buildings. Schools in both cities are old— in our sample, schools in DC were on average over 55 years old, while in Chicago, schools averaged close to 70 years of age. But age does not automatically mean bad facilities or poor conditions. A properly maintained old building can be just as functional and pleasing, if not more, than a poorly constructed or badly maintained new building. Indeed in Washington, DC teachers in older school report fewer problems with their facility's condition than teachers in the District's newer schools. However, in Chicago's oldest schools, teachers report more problems with both the design and the condition of their buildings.

Conclusions

Teachers in both Washington and Chicago report many shortcomings in the facilities that are essential to delivering a high quality education. They further report that much of the infrastructure they work in is inadequate to meet the increasingly strict standards of academic achievement that are now being set by the school districts, states, and federal government.

As teachers pursue an ambitious educational reform agenda, policymakers have focused on a wide-range of issues. However, as reform is pursued, policymakers must keep in mind that education is labor intensive, and ultimately the success of any reforms must be built on a high quality and satisfied workforce that is given adequate tools for meeting the new challenges and standards of education. As the need for more highly qualified teachers becomes central to the nation's educational reform agenda, we are asking schools to attract, retain and train the kinds of teachers that children need, while asking these highly educated professionals to work in inadequate working environments that can literally be dangerous to their health. This study confirms that poor facilities contribute to the high turnover rates endemic to central urban school districts; in turn, high teacher turnover leads to increased recruitment and training efforts that drain schools of financial and human capital, both of which are essential to educational success.

Good school facilities form a bedrock upon which other educational reforms can be built. Decaying and educationally inadequate school facilities, such as reported by far too many teachers in Chicago and Washington, DC, can undermine other efforts to improve education.

Appendix 1: Existing Research Links Facilities to Learning

Given the focal point of this report on the condition of facilities and how facilities affect teachers and teaching, in this appendix I explore some of the existing research that confirms the link between facilities and educational outcomes.

There is a large literature linking both the design and the condition of school facilities to educational achievement.[8] In one of the earliest works to gain widespread attention, McGuffey (1982) synthesized a set of studies linking student achievement with better building quality, newer school buildings, better lighting, thermal comfort and air quality, and such features as laboratories and libraries. More recent reviews by Earthman and Lemasters (1996; 1998) show similar links between building quality and test scores. Lewis (2000) identified 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. Andersen (1999) studied the relationship of 38 middle-school design elements to student scores (from 22 schools) on the Iowa Test of Basic Skills (ITBS) and found positive correlations with 27 of them. Maxwell (1999) found a correlation between newer facilities and student performance levels and a significant relationship between upgraded facilities and higher math scores. Stricherz (2000) also linked lagging student achievement to inadequate school buildings.

Additional studies tie the quality of school facilities to outcomes other than test scores. For example, a recent study in Great Britain by PricewaterhouseCoopers (PwC 2001) linked capital investment to teacher motivation, school leadership, and student time spent on learning. Other studies tie building quality to student behavior: Vandalism, absenteeism, suspensions, expulsions, disciplinary incidents, violence, disruption in class, lateness, dropping out, racial incidents, and smoking all have been linked to the quality of school buildings (see, for example, McGuffey 1982, Edwards 1992, Cash 1993, Earthman, Cash, and van Berkum 1995). Clearly, quality facilities help achieve desirable outcomes, but identifying the specific aspects of facilities that matter the most is still open to debate.

Design Issues

Among the most important design factors that have been discussed in existing research are those relating to school size and class size. Considerable research links small schools and small classes to better outcomes, especially for low income and African American students.

School Size

There is strong evidence that small schools are generally better than large ones and that the benefits of small schools are particularly pronounced in enhancing student achievement in lower income communities (Howley, Strange, and Bickely 1999). Fowler and Walberg (1991) found that school size was

[8] See for example the extensive archive maintained by National Clearinghouse for Educational Facilities (www.edfacilities.org). For a recent review see Schneider 2002.

the best predictor of higher test scores in 293 New Jersey secondary schools, even considering widely varying socio-economic factors. Lee and Smith (1997) and Keller (2000) also show that small schools consistently outperformed large ones (also see Duke and Trautvetter 2001and Cotton 1996).

Wasley et al. (2000) argue that small schools can improve education by creating small, intimate learning communities where students are well-known to each other and to their teachers and can be encouraged by adults who care for them and about them. These smaller, more intense communities, in turn, reduce the isolation that adversely affects many students; reduce discrepancies in the achievement gap that plagues poor children; and encourage teachers to be more creative in their ways of thinking and teaching styles. In addition, small schools often foster parental involvement, which benefits students and the entire community (Schneider, Teske, and Marshall 2000, also see Nathan and Febey 2001).

Raywid (1999) summarizes the value of small schools. She says that students in small schools "make more rapid progress toward graduation, are more satisfied with small schools, and fewer of them drop out than from larger schools, and they behave better in small schools." Indeed, she 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).

Small schools have also been linked to higher levels of cooperation between teachers, better relations between teachers and school administrators, and more positive attitudes towards teaching (see, for example, 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.

Class Size

While the research linking school size and desired outcomes has accumulated in a relatively straightforward manner, the research linking class size to learning outcomes has been much more contentious— although there is a growing consensus that students in smaller classes do better.

On the negative side, one of the leading scholars in this field, Eric Hanushek, argues that educational inputs, including class size, are not associated with higher performance (see, for example, Hanushek 1997). Hanushek has collected a set of studies that include estimates of how some school factor (such as class size) 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 90 individual publications. According to Hanushek, of these estimates, 277 include some measure of student/teacher ratios (not class size) and of these, only 15% find statistically significant effects in a positive direction, while an almost equal number (13%) report statistically significant *negative* effects. In the handful of studies that have actual measures of class size, the results also are mixed. Based on these results, Hanushek has argued that class size doesn't matter. But this conclusion has been vigorously attacked.

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

Other researchers using a range of data also have also 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. 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 20 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.

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 18 to 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 (SES).

While this econometric evidence has been intensively fought over, there have been a series of experiments in which class sizes have been reduced, and the results of these experiments clearly support the benefits of smaller class size.

In Indiana, the Prime Time project reduced class size from approximately 22 to 19 students in first grade and from 21 to 20 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 15 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 at low income schools, the SAGE class-size reduction was quite large, ranging from 12 to 15 students per teacher compared with 21 to 25 students per teacher in the comparison group. This reduction was larger than in the more well-known STAR (Student/Teacher Achievement Ratio) experiment in Tennessee (discussed below). 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 the 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, Hedge, and Krueger controversies, it was clear that the statistical evidence relating smaller class size to academic outcomes was unclear. 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. The project embraced 79 schools, more than 300 classrooms, and 7,000 students, and it followed their progress for four years. STAR compared classes containing 13 to 17 students with those containing 22 to 26 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 lower SES students than for higher SES ones;
- 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 these effects were. Because the STAR experiment began in the 1980s, sufficient time has passed to allow researchers to start identifying longer-term effects of small classes.

Nye, Hedges, and Konstantopoulos (1999) explored these longer-term effects using data from the Lasting Benefits Study that was 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. 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.

Thus while there is still debate about smaller class size, there is a substantial and growing body of research that shows smaller classes produce benefits— especially for lower income students and for students from racial minority groups.

The Effects of School Conditions

There is a strong body of research linking a number of poor facility conditions, such as indoor air quality, lighting, and noise, to adverse educational outcomes. In the next few paragraphs, I highlight the areas in which the research is clearest. In this study, I measure how teachers evaluate the conditions highlighted in this review, but I also report teacher evaluations across a wider range of indicators .

Indoor air quality

Poor indoor air quality (IAQ) is widespread, and its effects too important to ignore. The General Accounting Office found that 15,000 schools suffer from poor IAQ, affecting well over 8 million children or one in five children in America's schools (GAO 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" (see, for example, EPA 2000). Most discussions linking IAQ to student performance depend on a simple logical link: poor indoor air quality makes students sick— and sick students can't work or study as well as healthy ones (see EPA 2000, Kennedy 2001, Leach 1997). Indeed, 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 see 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 (see the ALA 1999. also see EPA 2000 and Rosen and Richardson 1999).

Poor IAQ can be exacerbated by poorly controlled temperature and humidity, perhaps most significantly because their levels can promote or inhibit the presence of bacteria and mold (Bates 1996, also see Leach 1997, Wyon et al. 1991, and Fang et al. 1998). Ventilation also matters. A 1989 study by the National Institute for Occupational Safety (NIOSH) found that more than half of IAQ problems in the workplace were caused by inadequate ventilation (NIOSH 1989. Also see Cornell University 1998, Myhrvold et al. 1996). Schools need especially good ventilation since children breathe a greater volume of air in proportion to their body weight than do adults (Kennedy 2001, McGovern 1998, Moore 1998) and because schools have much less floor space per person than found in most office buildings (Crawford 1998).

The Effects of Temperature

Uncomfortable temperatures affect the ability of students to learn (Harner 1974) and degrade teachers' abilities to teach. Uncomfortable temperature also affects teacher morale. Lowe (1990) found that the best teachers in the country (winners of State Teachers of the Year awards) emphasized their ability to control classroom temperature as central to the performance of both 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 the physical condition of school facilities, including thermal factors, affects teacher morale and effectiveness (also see Heschong 2002).

Lighting

Classroom lighting plays a particularly critical role in student performance (Phillips 1997). Jago and Tanner (1999) cite 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 the achievement of students. Obviously, students cannot study unless lighting is adequate, and there have been many studies reporting optimal lighting levels (see for example, Mayron, Ott, Nations, and Mayron 1974 or Dunn et al. 1985, 866).

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 utilized in schools. But 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 53 studies pertaining to school facilities, student achievement, and student behavior reports that daylight fosters higher student achievement. The study by the Heschong Mahone Group, 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 20% faster in one year on math tests and 26% faster on reading tests than those students who learned in environments that received the least amount of natural light (Heschong Mahone Group 1999; also see Plympton, Conway and Epstein 2000).

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 (1997) 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 (1997, 18). Crandell, Smaldino, and Flexer (1995) and Nabelek and Nabelek (1994) linked levels of classroom noise and reverberation to reading and spelling ability, behavior, attention, concentration, and academic achievement in children (also see ASHA 1995; Crandell 1991; Crandell and Bess 1986; and Crandell, Smaldino, and Flexer 1995, Evans and Maxwell 1999). Teachers also attach importance to noise levels in classrooms and schools. Lackney (1997) 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 could lower the quality of teaching and eventually learning as well.

Appendix 2: Methodology Used in Survey of Chicago Teachers

The Center for Survey Research at SUNY Stony Brook conducted telephone interviews with 688 teachers in the Chicago Public School System, beginning on May 10th, 2002 and ending on June 10th, 2002.

All interviewing was conducted using a Computer Assisted Telephone Interviewing (CATI) based system. Calls were made between the hours of 6 and 10 P.M (Central Time) Monday thru Friday and 12:00 to 6:00 P.M. on Saturday thru Sunday. As a means of achieving the highest possible response rate, numbers were called a maximum of 15 times, and all initial refusals were re-contacted up to two additional times by refusal converters.

Sample Design

The sample was drawn from a list provided by the Chicago Teachers Union that contained the names of 24,319 teachers from 591 schools in the Chicago Metropolitan area. However, not all of these 24,319 entries contained valid phone numbers – in some instances there was no phone number given while in other cases the appropriate number of digits was missing in either the area code or the phone number field. All such non-valid numbers were deleted from the list, leaving the new total of 23,930 teachers (98.4% of the original entries). In order to ensure that the sample represented teachers from across the Chicago public school system, a self-weighting sampling method was employed, meaning that an unequal number of teachers was drawn from each school, with teachers from large schools having a better chance of being selected than those from small schools. Out of the original 23,930 teachers, a total of 1,796 (from 383 schools [63% of the total district]) were randomly drawn and included in the sample.

Response Rate

Of the 1,796 numbers for teachers that were included in the sample, 476 (approximately 27%) were coded as non-households once the interviewing process was completed. These 476 numbers fall into one of the following categories: technical phone problem (N=12), fax/data line (N=25), non-working/disconnected (N=189), or wrong number (N=250) (See Table 1 for a complete listing of all final disposition codes). Finally, another 68 numbers were non-valid as those individuals were not currently teaching in the Chicago public schools. Thus, the total number of valid numbers in the sample was 1252. A total of 688 interviews were completed, resulting in a response rate of 55% (See Table 2).

Table 1: Final Disposition Codes

Contacts	
Complete	688
Hang-up	4
Refusal	95
Not currently teaching	68
Callback	102
Household, But No Contact With Eligible Respondent	
Ans. machine, message	195
Busy	59
No answer	109
Non-Households	
Technical phone problems	12
Fax/data line	25
Non-working/disconnected number	189
Wrong number, new number not given	250
Total	***1796***

Table 2: Response Rate

All Numbers	1796
Current Teachers	1252
Completed Interviews	688
Response Rate (688/1252)	55%

Appendix 3: Study of Washington, DC Teachers, Schools Surveyed and Response Rates

School Name	# of Teachers	# of Surveys Returned	Return Percentage
Adams	27	14	51.85%
Amidon	33	13	39.39%
Barnard	33	13	39.39%
Beers	38	14	36.84%
Benning	19	12	63.16%
Birney	39	10	25.64%
Bowen	24	16	66.67%
Brookland	25	11	44.00%
Browne	25	4	16.00%
Bruce-Monroe	33	15	45.45%
Bunker Hill	28	24	85.71%
Burrville	22	9	40.91%
Cardozo	71	19	26.76%
Cook, J.F.	21	8	38.10%
Coolidge	73	21	28.77%
Davis	32	9	28.13%
Deal	55	24	43.64%
Draper	24	10	41.67%
Drew	30	12	40.00%
Dunbar	47	22	46.81%
Eastern	90	32	35.56%
Ellington	40	13	32.50%
Evans	23	11	47.83%
Ferebee-Hope	25	3	12.00%
Francis	30	13	43.33%
Garfield	36	17	47.22%
Garnet-Patterson	22	21	95.45%
Garrison	30	12	40.00%
Gibbs	40	12	30.00%
C.W. Harris	39	11	28.21%
P.R. Harris	54	11	20.37%
Hendley	39	11	28.21%
Janney	30	7	23.33%
Jefferson	46	18	39.13%
Johnson	40	19	47.50%
Kenilworth	27	10	37.04%
Ketcham	33	8	24.24%
Key	13	5	38.46%
Lafayette	30	14	46.67%
Lee, Mamie D.	33	18	54.55%
Lincoln	32	9	28.13%
Ludlow-Taylor	27	17	62.96%
Malcolm X	51	22	43.14%

Mann	14	12	85.71%
Marshall	20	7	35.00%
Maury	21	18	85.71%
McGogney	29	8	27.59%
Merritt	33	15	45.45%
Meyer	40	14	35.00%
Moore Academy	12	12	100.00%
Murch	32	23	71.88%
Nalle	33	15	45.45%
Noyes	23	14	60.87%
Orr	33	19	57.58%
Oyster	30	8	26.67%
Park View	36	9	25.00%
Patterson	27	9	33.33%
Phelps	35	12	34.29%
Prospect	24	7	29.17%
Randle Highlands	28	17	60.71%
Reed	40	11	27.50%
River Terrace	19	14	73.68%
Ross	16	12	75.00%
Rudolph	37	21	56.76%
Savoy	31	15	48.39%
School Without Walls	23	9	39.13%
Shaed	22	10	45.45%
Sharpe	37	18	48.65%
Shaw	39	17	43.59%
Simon	33	6	18.18%
Slowe	33	20	60.61%
Spingarn	43	14	32.56%
Stanton	39	17	43.59%
Stoddert	15	5	33.33%
Stuart-Hobson	23	14	60.87%
Takoma	30	6	20.00%
M.C. Terrell	19	11	57.89%
Thomas	29	21	72.41%
Thomson	28	5	17.86%
Truesdell	34	18	52.94%
Tubman	50	42	84.00%
Van Ness	22	14	63.64%
West	24	19	79.17%
Whittier	33	13	39.39%
J.O. Wilson	36	5	13.89%
W Wilson	108	23	21.30%
Winston	38	13	34.21%
Woodson	56	34	60.71%
Young	35	33	94.29%
89 Schools Returning Surveys	2991	1273	42.56%
Total from all Schools	4821	1273	26.41%

References

American Lung Association. 1999. Asthma in children fact sheet. New York, N.Y.: Author. Retrieved 07/19/02 from: http://www.lungusa.org/asthma/ascpedfac99.html

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

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

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

Boser, U. 2000. A picture of the teacher pipeline: Baccalaureate and beyond. Education Week Quality Counts 2000, 19(18), 17.

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.

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. 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

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

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

Crandell, C., and F. Bess. 1986 . Speech recognition of children in a 'typical' classroom setting. American Speech-Language-Hearing Association, 29, pp. 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), pp. 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 07/193/02 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), pp. 863-69.

Earthman, G. I. and L. Lemasters. 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. 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)

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. Unpublished Master's Thesis. Washington, D.C.: 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

Environmental Protection Agency. 2000. Indoor air quality and student performance. EPA Report number EPA 402-F-00-009. Washington, D.C.: Author. 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), pp. 638-656.

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), pp. 80-90.

Ferguson, R. F. 1991. Paying for public education: new evidence on how and why money matters. Harvard Journal on Legislation, 28(2), pp. 465-498.

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.

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

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

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

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.: Author. (ED383056)

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), pp. 361-396.

Hanushek, E. A. 1997. Assessing the effects of school resources on student performance: an update. Educational Evaluation and Policy Analysis, 19(2), pp.141-64.

Hare, D., & Heap, J. L. 2001. Teacher recruitment and retention strategies in the Midwest: Where are they and do they work? Naperville, IL: North Central Regional Educational Laboratory.

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

Hawley, W. D. (2000, Spring/Summer). Quality induction is crucial. State Education Leader, 18 (2). Retrieved March 6, 2002, from http://www.ecs.org/clearinghouse/11/87/1187.htm - Quality

Heschong Mahone Group. 1999. Daylighting in schools: an investigation into the relationship between daylighting and human performance. Fair Oaks, Calif.: Author. Retrieved 07/03/02 from:

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. 1995. The Matthew principle: a West Virginia replication? Education Policy Analysis Archives 3(18), pp. 1-25.

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), pp. 1239-1284.

http://www.pge.com/003_save_energy/003c_edu_train/pec/daylight/di_pubs/SchoolDetailed820App.PDF

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

Ingersoll, R. 2001. Teacher turnover and teacher shortages: An organizational analysis. American Educational Research Journal, 38 (3), 499-534.

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), p. 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), p. 32.

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. 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.

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. September 17, 1999.(ED441330)

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), pp. 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, No. 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, No. 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. Unpublished 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.

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), pp. 33-47.

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

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), pp. 165-177.

Mosteller, F. 1995. The Tennessee study of class size in the early grades. The Future of Children, 5 (2), pp. 113-127.

Nabelek, A. and L. Nabelek. 1994 . Room acoustics and speech perception. In Handbook of Clinical Audiology, 3rd Edition, 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. 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

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), pp. 127-142.

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

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), pp. 87-93.

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. The Eighth International Conference on Indoor Air Quality and Climate. vol.5. pp.445-450.

Stockard, J. and M. Mayberry. 1992. Resources and school and classroom size. In Effective Educational Environments. Newbury Park, Calif.: Corwin Press, Inc.

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

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

U.S. Department of Education. 2000. Eliminating barriers to improving teaching. Washington, DC: Author.

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)

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. 352-361.

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.