

CHAPTER 2

SCHOOL BUILDINGS AND EDUCATIONAL PERFORMANCE³

It is often assumed that the quality of educational facilities makes no difference on bottom line academic achievement. Mayor John Norquist of Milwaukee was quoted during debate over a school construction referendum (*The Milwaukee Journal*, October 28, 1992) as saying that there was "no clear relationship between how well kids do in school and the facilities they occupy ... none of this [referring to proposals for school building renovations and expansions] will necessarily improve education." School referendum issues have been defeated across Wisconsin and in many other states. A partial interpretation is that in many cases the public does not believe that improving school buildings themselves will lead to improvements in bottom-line educational performance, i.e., academic achievement scores.

On the contrary, many researchers and educational proponents now assert that school facilities *are* important to education. There are a number of excellent empirical studies of the explicit relationship between facility characteristics and educational outcomes (see, for example, the 1990 book, *The Quality of the Physical Environment of the School and the Quality of Education*, edited by Ronald Colven from Sweden, the review by Paul Gump on "School and classroom environments" in the 1987 *Handbook of Environmental Psychology*, and a series of recent articles on school buildings by Ted Fiske [e.g., 1990] in the *New York Times*). Looked at empirically, there is now considerable evidence that certain design characteristics like school size, classroom size, location, and the provision of secluded study spaces all make substantial differences in learning outcomes, and, in particular, that school size and classroom size make a difference in academic achievement.

An excellent review of the research on the physical environment of the schools was published by Carol Weinstein in the *Review of Educational Research* (1979). Only part of what Weinstein concluded in 1979, however, is still true: "When classrooms varying in terms of furniture arrangement, aesthetic appeal, and the presence or absence of windows are compared, differences in achievement are nonsignificant. . . . On the other hand, there is considerable evidence that the classroom environment can affect *nonachievement* behaviors and attitudes" (her emphasis, meaning secondary measures of student and teacher attitudes and behavior, like decreased social interaction or increased aggression; we will use the term prosocial behaviors for what Weinstein called "nonachievement behaviors"; see footnote 2).

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While there is still strong evidence for the effects of school buildings on *prosocial* behaviors and attitudes, there is newer evidence that two critical architectural variables directly effect *academic achievement*, and two others may effect academic achievement through mediating attitudes and behaviors.⁴

School Size

Between the early 1960s and 1980, 344 articles were published pertaining to the effects of school size on academic achievement and other achievement-related variables (Garbarino, 1980). Prior to the '60s, many educators and policy makers believed that increasing the size of schools was an important reform idea. This belief led in part to *comprehensive schools* (large campuses from primary to pre-college education) in Great Britain and regional schools in the United States. Larger schools were more cost-effective and believed to be more educationally efficient.

In the now-classic *Big School, Small School*, Barker and Gump (1964) conducted a study of a sample of very big (over 2,000 students) and very small (100-150 student) high schools in Kansas. They concluded, however, that small schools offered students greater opportunities to participate in extracurricular activities and to exercise leadership roles. In particular, participation in school activities, student satisfaction, number of classes taken, community employment, and participation in social organizations were all superior in small schools relative to large schools. A review of some of the subsequent studies appeared in the 1980 *Journal of Youth and Adolescence* (Garbarino, 1980). Small schools (those on the order of 500 students) also have lower incidence of crime levels and less serious student misconduct. Larger schools discourage a sense of responsibility and meaningful participation, particularly among students who have academic difficulty and come from lower socio-economic backgrounds.

All the above findings relate to design variables other than achievement outcomes (lower incidence of crime levels, less student misconduct, greater participation in extracurricular activities, etc.). In order to differentiate them from bottom-line educational performance, Weinstein termed these and other variables "nonachievement behaviors." The argument presented here is, however, that these prosocial behaviors are better conceptualized as mediating variables which may in turn effect academic achievement, that is that

⁴ Many things are not yet known about the relationship between achievement and class size. Perhaps most important is the shape of the curve relating achievement to size. For instance, we know that reductions from 30 to 20 can yield a gain of 6 percentage points, and that another reduction from 20 to 10 may yield another 13 percentage points. But what happens in between? Is the optimal size 10, which would be very expensive, or does the achievement curve flatten out at 15, or even at 18 or closer to 20? And what other variables effect this relationship? Is it the same for all teacher styles, for all school educational philosophies? Changes in pedagogic strategies are crucial too--active learning and participation mean that teachers may need to increase time spent on small-group, hands-on activities. While changing class size effects academic performance, more profound effects would be expected by changing both class size *and* teaching methods.

school size effects, for instance, less incidence of student misconduct which will in turn lead to greater performance.

Other, more recent studies, however, have looked directly at the question of the impact of school size on academic performance. In a report written while at the U.S. Department of Education's Office of Educational Research and Improvement, Fowler (1992) argued that the issue of school size effects at the elementary school level, based upon "the number of students and the general agreement of the findings" (p. 1), is conclusive. In his review, small schools were defined as those between 100-200, with large schools being those in the range 1,500 to 4,000. Examples of the effects of size include: (1) negative relationship between math and verbal ability tests and elementary school size, even controlling for socio-economic differences (Kiesling, 1967); (2) larger elementary schools being detrimental to student achievement, even holding student income differences constant (Michelson, 1972, cited but not referenced in Fowler, 1992); (3) smaller elementary schools particularly benefitting African-American students' achievement in Philadelphia (Summers & Wolfe, 1977); and (4) negative relationship between school size and student performance being most prevalent in urban schools based on data reported by 4,337 K-6 schools in California (Plecki, 1991, cited in Fowler, 1992; cf. Fowler, 1992 for a number of other corroborating studies).

Classroom Size and Density

Many studies over the past 10 years have looked at classroom size and classroom density and their impacts on educational outcomes. The results, in short, are that high density conditions have been found to lead to increased aggression, decreased social interaction, and non-involvement, all mediating variables. However, small class sizes also lead to better scores on learning achievement tests, as we will now review.

First let's look at some of the "non"-achievement findings. The synthesis report written by Fowler (1992) concluded that attitudes, voluntary participation, *and* achievement all increase in smaller relative to larger classrooms. In classrooms with less students, teachers can have more interactions with each student, can provide a rich and vastly differing array of interactions, can establish learning centers, student learning teams, peer tutors, and other instructional strategies, all of which improves the quality of interactions with each student. These effects may in turn lead to increased educational performance, though we know of no study testing this relationship empirically and directly.

Teacher attitudes also improve as class size is reduced from 30 to 20. Students in small classes participate more than those in large classes (Pate-Bain, Boyd-Zaharias, Fulton, & Wallenhorst, 1992). Student participation in elementary school classrooms is essential for learning to occur. Students were rated in terms of active participation (initiative-taking behavior) versus minimally adequate effort and non-participatory or disruptive behavior. Holding all other things equal, elementary students in the smaller classrooms (like 15:1

classrooms) showed much higher levels of educational participation in school than any other students. Student participation was also linked to staying in school longer.

All of these improvements in teacher attitudes, increased student participation, and increased student-teacher interaction may best be conceptualized, however, as mediating factors. But other studies have looked directly at the impact of class size and density on educational achievement.

Project STAR (Student/Teacher Achievement Ratio Project) was a \$12 million, four-year, randomized, longitudinal, experiment in Tennessee involving 79 different schools from 42 state-wide school districts and a consortium of four universities. After selecting the schools for the study, students and teachers were randomly assigned to class types. This was a clear advance methodologically over most previous studies, which were for the most part correlational in nature, not true randomized experiments. As reported in various places (e.g., Achilles, 1992; Finn & Achilles, 1990; cf. Miner, 1992), Project STAR followed some 6,500 children from kindergarten through third grade. Children in smaller classes (13-17 per room) outperformed those in regular-sized classes (22-25 per room) as measured by test scores such as the Stanford Achievement Test. In the early grades, children in smaller classes outperformed children from regular class sizes in all subjects, but especially in reading and mathematics test scores. Smaller classes were especially helpful for children in inner-city schools. And while the improvement was immediately clear in small kindergarten rooms, the benefits increased in first grade and remained stable over second and third grades.

The study demonstrated that students in small classes improved statistically and educationally⁵ (average improvements of 15%) on various reading and mathematics achievement measures in comparison with students in regular classes and in comparison with regular classes with the added benefit of full-time teacher aides. This finding was consistent at each grade level (K-3) and across all locations--rural, urban, suburban, and inner city (Nye, Achilles, Zaharias, Fulton, & Wallenhorst, 1992a, 1992b).

A follow-up study using the same schools, pupils, and tests, called the Lasting Benefits Study (LBS), has been looking to see if there are any long-term effects of small class size (e.g., Achilles, 1992). What happens for students who benefited from small class sizes during the K-3 years when they return to larger classrooms (25:1) in grade 4? The LBS analysis yielded clear and consistent results across 4,500 of the students able to be tracked from the earlier STAR study. Students previously in small classrooms demonstrated statistically significant advantages two years later over students previously in regular size

⁵ The distinction here is that many findings reported in the literature may be statistically significant at, say, even the .001 level, but may not mean much educationally. The raw magnitude of differences between, say, experimental and control groups may be marginal. The findings from the Project STAR study, however, are not only statistically significant but also of great significance educationally.

classrooms and even those with an extra teacher's aid. Performance gains ranged from 11-34%. The results were consistent across rural, urban, suburban, and inner city schools. The greatest achievement advances appear to be for inner-city and suburban classes, and for minority students.

These findings are corroborated by other independent studies which have shown that smaller class sizes can lead to greater mathematics achievement (Bourke, 1986).

These and the Project STAR results are buttressed by studies from other states and Canada. In an initiative called Prime Time, Indiana reduced some K-2 classes from an average of 23 students for each teacher in 1981 to 14 to 18 per teacher in 1983 (Howley, 1989). The results were impressive, with 14% more students in the small classes scoring above average on standardized reading and mathematics achievement tests than student from larger classes. These findings were consistent for the United States and for Canada, as found by Shapson and colleagues in a large-scale randomized experiment conducted in Toronto in the late 1970s (Shapson, Wright, Eason, & Fitzgerald, 1980).

A meta-analysis⁶ of previous studies on the effects of class size was conducted in 1982 by Glass, Cahen, Smith, and Filby in *School Class Size: Research and Policy*. Meta-analyses were performed on only those studies from the research literature that met criteria for investigative design and control. A recent chapter by Gump (1987) has concluded that the studies included in the meta-analysis by Glass and his colleagues are the methodologically best in the literature. The authors concluded, without qualification, that "reduced class-size can be expected to produce increased academic achievement" (p. iv). Though now eleven years old, this meta-analysis across a wide range of studies indicated that reducing class size from 30 to 20 can yield a gain of 6 percentage points on various standardized reading and mathematics achievement tests, whereas a reduction from 20 to 10 students per classroom yields *another* 13 percentage points in achievement. Reductions in class size begin to make substantial differences in academic achievement around 15 students to a class.

Many things are not yet known about achievement as a function of small sized classrooms. Perhaps most important is the shape of the curve relating achievement to size. We know that reductions from 30 to 20 have yielded a gain of 6 percentage points, and that another reduction from 20 to 10 yielded another astonishing 13 percentage points. But what happens in between? Is the optimal size 10, which would be very expensive, or does the achievement curve flatten out at 15, or at 18, or closer to 20? And what other variables effect this relationship? Is it the same for all socio-economic levels? for all teacher styles? for all educational philosophies?

⁶ For clear definitions, discussion, and examples of meta-analyses in environment-behavior studies, see Gifford, Hine, and Veitch (in press).

Location and Noise

Other physical planning and design variables may also effect important mediating variables. For instance, the location of new schools is now known to be important. A series of studies in the United States between 1980 and 1986 reviewed by Gary Evans and his colleagues (Evans, Kliever, & Martin, 1991) in *New Directions in Health Psychology Assessment* concluded there are significant increases in blood pressure associated with schools being near noisy urban streets. Other findings related to location include German and Russian studies (Berglund & Lindvall, 1986, cited in Evans et al., 1991) again indicating increased systolic and diastolic blood pressure in middle-school children in schools close to noisy urban streets and abnormally high blood pressure in children residing around Soviet airports. Exposure to traffic noise at elementary schools also has been associated with deficits in mental concentration, making more errors on difficult tasks, and greater likelihood of giving up on tasks before the time allocated has expired. Furthermore, as found by Cohen, Evans, Stokols, and Krantz (1986) in Los Angeles, elevated blood pressure does not habituate or decline with continued noise exposure over time--children don't get used to noise.

While blood pressure, concentration, and task persistence are neither academic achievement nor prosocial outcomes, they are important mediators of educational outcomes. The appropriate location of new schools and their proper design should be able to alleviate these noise-related problems.

Secluded Study Spaces

Secluded study spaces within classrooms are also important to student development, and have been found empirically to be related to various educational outcome measures. Creating small learning centers within classrooms reduces classroom visual and auditory interruptions, makes learning materials more accessible, increases privacy, and leads to more questions asked by students. A study some time ago in the 1982 *Elementary School Journal* (Morrow & Weinstein, 1982) reported that structured reading areas significantly increase literature use by students.

Research conducted out of our Center has discovered that for preschool children, architecturally well-defined behavior settings (in contrast with partially defined and poorly articulated settings) contribute to significantly greater degree of engagement with learning activities, longer attention span, more teacher involvement with children, less teacher interruptions, and more exploratory behavior, social interaction, and cooperative behaviors among the children (Moore, 1986).

Again these "outcomes" may best be conceptualized as mediating factors which in turn would be expected to influence more bottom-line educational performance (minimizing

disruptions and helping to increase attention span through appropriate architectural design would be expected to lead to higher academic achievement).

So, are Educational Outcomes Affected by Architectural Design?

We mention these areas of research because in the policy community, at least in the United States, there is a widespread-but quite mistaken-impression that there is no relationship between how well children do in school and the school buildings they occupy. To the contrary, there now is considerable evidence reported in the past 15 years that school size and classroom size directly lead to significant and substantial differences in learning achievement, and that location and the provision of secluded study areas within classrooms effect various beneficial mediating factors (like more student-teacher interaction, less interruptions, and greater student participation in learning) which there is good reason to believe will in turn lead to higher educational achievement.⁷

⁷ Other pathogenic factors are critical not only to performance but to the overall physical health of children. Children in 20% of new preschools built in the Stockholm area since 1975 have been effected by the *sick building syndrome*, showing clear signs of sensory irritation, skin rashes, and mental fatigue due to the tightening of those buildings for energy conservation purposes (Berglund & Lindvall, 1986, cited in Evans et al., 1991).

