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Small Schools and Higher-Order Thinking Skills

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We tested an explanation for an apparent anomaly in the research literature on small rural schools: While those schools offer fewer courses and less comprehensive programs in science and mathematics than do large urban institutions, student achievement in the former is equal to that in the latter. We hypothesized that the more extensive curricula of large schools promote a particular kind of academic achievement: the development of higher-order thinking skills in science and mathematics. These skills have been unexamined in previous studies of the effects of school size on student achievement. Nationally representative data from the Longitudinal Study of American Youth were used to test this conjecture. The hypothesis was not supported: Small and rural high schools are apparently the equals of larger and more urban institutions in imparting higher-order thinking skills to students.

According to traditional arguments, small schools are less effective and less efficient than their larger counterparts. This is not the place to contest the validity of those claims. However, they are plausible when we consider the curriculum adequacy of high schools. There are now numerous studies of the effect of school size on curriculum offerings, and these investigations suggest that large secondary schools are able to offer a greater number of courses than small ones (Barker, 1985; McKenzie, 1989; Melnick, Shibles, & Gable, 1987; Monk, 1987; West, Miller, & Diodata, 1985). Further, it is not simply a matter of course numbers. Large high schools typically offer more comprehensive *programs* than do smaller ones. Particularly relevant to the case at hand, this greater comprehensiveness is evident in science and mathematics (Haller, Monk, Spotted Bear, Griffith, & Moss, 1990; Monk & Haller, 1993).

School size may not be the only important factor in curricular diversity. Research suggests that location in a rural area also may create additional difficulties. For example, rural schools may find recruiting and retaining highly trained teachers difficult; they may be unable to provide their teachers with ample equipment and adequate facilities; the long distances that pupils must travel to school and to area educational centers can present serious scheduling constraints; and lower aspirational levels of both students and parents may lower the demand for advanced courses (Carlsen & Monk, 1992; Haller & Virkler, in press; Monk & Haller, 1986; Cobb, McIntire, & Pratt, 1989).

In regard to curricula, then, it appears that small rural secondary schools do not provide programs of the depth and diversity provided by larger, more urban, institutions. However, the issue becomes more complicated if one asks, "So what?" Presumably the major reason why curricular inequalities are important is because they have important consequences for student achievement and, ultimately, for success in life. Indeed, if such consequences do not exist, it is not obvious why anyone should care. Inequalities are not, *per se*, inequities. When we examine the relation between the size of educational organizations and student learning, the expected results are conspicuously absent.

Numerous studies have examined the relation between school size and student achievement. These studies seem to show that students in small schools are at least as successful as their peers in larger institutions (Eberts, Kehoe, & Stone, 1984; Edington & Martellano, 1989; Fowler, 1992; Fowler

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& Walberg, 1991; Guthrie, 1979; Melnick et. al., 1987). A modest exception to these results has been reported by Friedkin and Necochea (1988). They found that the size-achievement relationship is a contingent one: negative in low socioeconomic status (SES) schools and positive in high-SES schools. Even in the latter case, however, the positive effect of size on achievement was quite small, while, in the low-SES case, its negative effect was substantial. Overall, one is safe in concluding that small school size does not lead to decrements in student achievement. A similar conclusion can be reached in regard to rurality: rural students are at no obvious achievement disadvantage (Coladarci & McIntire, 1988; Downey, 1980; Easton, 1985; Edington & Koehler, 1984; Hand & Prather, 1990; McIntire & Marion, 1989; Ward & Murray, 1985).

These conclusions seem to present an anomaly: How is it that in schools where students are able to study a subject for only two years, they learn as much as students in schools that offer four years of that subject? One possible answer is that researchers have employed inappropriate measures of student achievement. That is, most of the school-size research has relied on one of two kinds of achievement tests, neither of which is suitable to the task.

The first and most commonly used measure of achievement is a nationally standardized achievement battery. The problem here is that such tests are not curriculum-specific. At best, they test knowledge presumably taught in all schools. Alternatively, when curriculum-specific tests (such as many state-mandated competency exams) are used to compare achievement levels in small and large schools, another difficulty arises: These tests typically measure the recall of simple facts garnered during the year or two that students are enrolled in state-mandated courses. But virtually every school—large or small, rural or urban—offers its state's mandated courses. We would be surprised, for example, if students in large and small schools differ in their knowledge of the simple facts of American history, since every public high school has a mandatory course in that subject.

Thus, it is possible that the achievement of students in small rural schools is negatively affected by those schools' restricted curricula, but researchers have failed to detect those effects because they have been using the wrong measures of achievement. Further, the subject matter chosen to search for a school-size effect must be selected carefully. Small schools are more nearly the equals of larger ones in some curricular areas than in others. For example, the social studies programs of small and large schools are more comparable than are their mathematics programs, which, in turn, are more comparable than are their science programs (Haller et al., 1990; Monk & Haller, 1993).

In this investigation, we focus on measures of higher-order thinking skills in science and mathematics. We suggest that extended, in-depth study, such as is possible in large schools that offer many advanced courses in those fields, is likely to result in students having abilities found at the upper end of Bloom's taxonomy of cognitive skills (Bloom, 1956). Thus, students attending larger, urban high schools, *ceteris paribus*, should be better able to apply concepts to real-life problems, relate science and mathematical concepts to those from other disciplines, and make valid inferences to novel situations.

We would not argue that higher-order thinking skills are taught only in advanced courses, although it is plausible that they receive more emphasis there. Rather, we hold that the development of these skills requires practice, and that the more work students have in a particular discipline, the more able they will be to demonstrate these sorts of educational outcomes. Thus, we hypothesize that mean achievement levels on tests of higher-order thinking skills will be greater in large schools than in small ones.

While it is the case that, on average, large urban schools offer more advanced courses than do small rural ones, the relation between size or location and curriculum depth is far from perfect. There are small rural schools with rich mathematics and science curricula and large urban schools that are relatively impoverished in this regard (Haller et al., 1990; Monk & Haller, 1993). Similarly, equal proportions of students may not avail themselves of the opportunity to take whatever advanced courses their schools offer. Thus, a relationship between size or rurality and higher-order skills will depend on both the presence of advanced courses and student course taking patterns. In addition, it will depend on initial differences in those abilities across schools. Finally, any relation between school size and these skills may depend on the SES of the school's clientele. Friedkin and Necochea's (1988) finding that size and SES interact in affecting the usual measures of academic achievement may also hold in regard to measures of higher-order skills.

Based on these considerations, we hypothesized that there would be a positive zero-order relation between high school size and mean school achievement on tests of higher-order thinking skills in science and mathematics. Further, we hypothesized that there would be a negative zero-order relation between location in a rural area and the same skills. As we have noted above, both of these relations may depend on school SES. Finally, we hypothesized that when we control for the number of advanced courses schools offer and for the rate at which students enroll in those courses, the zero-order relations between size and higher-order skills, and between rurality and higher-order skills, will be reduced or eliminated.

Method

The data used in this study were collected for the National Science Foundation under a contract with Northern Illinois University. The project, known as the Longitudinal Study of American Youth (LSAY), is a four-year panel study of middle school and high school science and mathematics education. Data collection began in the fall of 1987. Results reported here are based on the original collection plus the first and second follow-up studies, including information collected in the spring of 1989.

The base-year sample comprised 2,829 students enrolled in the 10th grade in the fall of 1987. These students were drawn from 51 schools across the nation. The sample consisted entirely of public schools selected randomly with probabilities proportional to their enrollment size within twelve sampling strata. These strata were defined in terms of geographic region (four categories) and community type (urban, suburban, rural). Sixty 10th grade students were randomly selected from within each school. When fewer than 60 students were enrolled in the school's 10th grade, all students were included in the sample.

Survey instruments were completed by the sampled students, their teachers, and their parents. In addition, achievement tests that focused on mathematics and science knowledge were administered in the fall of 1987, 1988, and 1989. These tests used items developed by the National Assessment of Educational Progress (NAEP).

In the case of science, NAEP researchers distinguished among three types of cognitive processes: "knowing", "using" and "integrating" (NAEP, 1986a). Tests of the third cognitive process, integrating, provided our first dependent variable (SCIENCE). The NAEP test of science integration comprised 10 items and required students to generalize, hypothesize, interpolate, and extrapolate. Items demanded that students reason by analogy, by induction and deduction, and by synthesizing and modeling. These are the kinds of reasoning aptitudes described by Bloom (1956) as embodying higher-order thinking skills, and the science integration scale was explicitly claimed to measure those skills (NAEP, 1986a, p. 11).

We derived our second dependent variable (MATH) from a test of mathematics problem solving comprised of 23 items. This scale required such processes as identifying and using a problem-solving strategy, screening relevant information, formulating a problem or selecting a model of a problem situation, determining what information would be needed to solve a problem, and organizing given information to represent the problem. Questions required students to formulate generalizations and test their validity, to recognize patterns and describe or symbolize the relationships, and informally make inferences (NAEP, 1986b; Miller, Hoffer, Suchner, Brown, & Nelson, 1992). As with the measures of science integration, these test items were developed explicitly to assess higher-order thinking skills.

These two measures were administered in the fall of 1989, when students were in the 12th grade. Both measures were scaled to a mean of 50 and a standard deviation of 10. The reliability coefficient for the 1988 science integration scale was .71; for mathematics problem solving, .79. We calculated the within-school means of both achievement scores and these school means became the dependent variables of this study.

Equivalent tests of higher-order thinking skills in science and mathematics were administered to the LSAY students when they were in the 10th grade in 1987. We used the scores from these tests, aggregated to the school level, as controls for initial differences among the sampled schools (MATH10, SCI10). These pretest scores were employed to control for other pre-existing factors, such as school SES, that affect 12th grade achievement.

We took as a measure of a school's size its 10th grade enrollment as reported by the school administrator (SIZE). School SES was indexed by taking the average of three z-scores aggregated to the school level: the highest reported educational level of either parent, the highest reported Duncan SEI score for either parent's occupation, and a measure of possessions in the home. Our measure of a school's location in a rural area (RURAL) came from the LSAY sampling stratification code characterizing each school as urban, suburban, or rural. This characterization was based on the Federal Information Processing Standards' classification of U. S. counties as "Metropolitan Statistical Areas" (MSAs). Urban schools were located in the central cities of MSAs, suburban schools outside the central city but within their MSAs, and rural schools were located outside any MSA. Rural schools were coded 1, and urban and suburban were combined as the reference category.

We developed measures reflecting (a) a school's course offerings and (b) students' course-taking patterns within each school. Both measures were based on teachers' responses to questions concerning the classes taken by LSAY students. In each semester, the math and science courses taken by each student were identified. If any of the sampled students in a school were reported as having taken an honors math course or a course in geometry, algebra II, trigonometry, analytic geometry, pre-calculus, calculus, or probability/statistics, the school was credited with offering that course. The number of unique such courses constituted our measure of a school's course offerings in advanced mathematics (MATHOFF). We followed a similar procedure for science course offerings (SCIOFF): all honors courses, second-year biology, anatomy/physiology, chemistry, and physics were counted as advanced science course offerings. Thus, this coding scheme treated courses as advanced if they provide students with an opportunity to go beyond the basic introductory course in math or science (i.e., beyond Algebra I and either Earth Science or Biology I). Advanced courses are typically elective, and they carry an introductory course as a prerequisite.

The extent to which students took a school's advanced course offerings was indexed by calculating the mean number of advanced math courses (MATHTAKE) and science courses (SCITAKE) taken by the sampled students in each school. Finally, we created a multiplicative term for SIZE and SES to test for the possibility of an interaction effect.

After visually checking for curvilinearity, we correlated school size and rurality with the measures of higher-order thinking skills. If our hypotheses were correct, these relationships would be significant and positive. We next regressed each skill measure on size and rurality, controlling for the extensiveness of each school's science and math offerings, the mean number of advance courses taken by its students, initial differences in 10th grade achievement, and an interaction term for size and status. If our speculations were correct, we would expect that the relation between size and higher-order skills, and between rurality and higher-order skills, would decrease (or disappear entirely) once the control variables were held constant.

Results

Table 1 provides means, standard deviations, and intercorrelations for the variables in this study. With listwise deletion of missing cases in effect, 47 schools remained for analysis. It is clear from the zero-order correlations in Table 1 that, unless there is a substantial interaction between school size and SES or there are strong suppressor variables involved, school size has no effect on higher-order skills in either science or mathematics: These correlations hover about zero. Similarly, there is no association between a school's location in a rural area and its students scores on test of higher-order thinking skills.

One also can see from this table that the number of advanced courses a school offers in either science or mathematics is unrelated to its students' higher-order skills in those subjects. However, enrollment levels in advanced courses is related to higher-order skills in both mathematics and science: The higher the average number of semesters of advanced courses taken by students, the higher the school mean on the tests of higher-order skills. As would be expected, school-level achievement in 10th grade science and mathematics is a strong predictor of achievement in the 12th grade.

Both school size and rurality are related to course offerings in the predicted direction for both mathematics and science, and the correlations are significant in three of the four cases. Interestingly, rural students appear to take proportionately fewer advanced mathematics courses than do nonrural students, though this is not true in science. (Compare the correlations of -.31 vs. -.02). In part, this is probably a consequence of differences between rural and nonrural schools' course offerings. That is, whereas it is true that, overall, schools offer more advanced math than advanced science courses, the math curriculum of rural schools is relatively more restricted than is the science curriculum. In this sample, rural schools offer, on average, 4.6 advanced math courses and 4.1 advanced science courses, while nonrural schools, on average, offer 6.3 and 5.1 math and science courses,

Table 1
Correlations, Means, and Standard Deviations ($N = 47$)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	MATH										
(2)	SCIENCE	.87*									
(3)	SIZE	-.10	.00								
(4)	RURAL	.05	.07	-.36							
(5)	MATH10	.76*	.67*	-.08	.03						
(6)	SCI10	.72*	.77*	-.17	.20	.75*					
(7)	MATHOFF	.05	-.02	.39*	-.45*	.07	-.05				
(8)	SCIOFF	.12	.10	.38*	-.24	.15	.08	.44*			
(9)	MATHTAKE	.38*	.32*	.15	-.31	.39*	.29*	.27	.46*		
(10)	SCITAKE	.37*	.28	-.10	-.02	.33*	.42*	.10	.44*	.59*	
	M	62.54	61.26	331.21	.34	59.53	55.33	5.68	4.72	1.56	1.11
	SD	5.80	5.07	201.27	.48	4.34	3.21	1.82	1.84	.41	.41

* $p < .05$

respectively. Put another way, math offerings exceed science offering by one-half course in rural schools but by 1.2 courses in nonrural ones. Thus, rural students are relatively more constrained in math than in science.

Given the relationships shown in Table 1, it seemed prudent to control for prior differences in achievement, course offerings, and enrollment patterns when we regressed higher-order skills on school size and rurality. Table 2 reports the results of these regression analyses and includes the partial correlation coefficients involved. These results suggest that neither school size nor location in a rural area is related to higher-order thinking skills in mathematics or science when prior achievement, course taking, and course offerings are controlled. The only significant predictors of either outcome is prior achievement (MATH10, SCI10). There is no evidence in Table 2 of a significant interaction involving school size and SES, contrary to the findings of Friedkin and Necochea (1988). Nor is there evidence that any variable in the analysis is acting as a substantial suppressor of the relation between school size and achievement.

We had hypothesized that when SES, course offerings, and course taking were controlled, significant zero-order relations between school size and higher-order skills, and between rurality and higher-order skills, would shrink or disappear. Table 1 has shown us that the first part of this hypothesis was not supported: The conjectured zero-order relations did not exist. Table 2 suggests that the second part of the hypothesis was also incorrect: All of the partial correlation coefficients approximate the size of their zero-order counterparts.

Discussion

We began this study by suggesting that a positive relation between school size and student performance has been masked in previous studies by a systematic neglect of precisely those outcomes that large size can be expected to affect. Now, having focused on just those outcomes, we find that school size has no influence. Thus, this study joins the numerous others that have found that school size and student achievement are largely unrelated.

It is possible that our choice of a dependent variable was based on a mistaken notion. More specifically, it is possible that higher-order thinking skills are taught in all mathematics and science courses, regardless of their level, and/or that students acquire the bulk of these skills early in their study of a subject. If this were so, much of the gain associated with course-taking might occur in the introductory courses offered in virtually every high school, regardless of size.

It is also possible that these skills are not taught in *any* course. That is, perhaps these capacities are either largely innate or formed early in life as a consequence of child raising practices in the home. The very high zero-order correlation (.87) between

Table 2
Regression Results ($N = 47$)

	Mathematics achievement			Science achievement		
Variable	*b*	Beta	Partial *r*	*b*	Beta	Partial *r*
SIZE	-.002	-.057	-.079	.003	.120	.162
RURAL	.851	.070	.091	-.197	-.019	-.026
MATH10	.877*	.656*	.615*			
MATHOFF	.016	.005	.007			
MATHTAKE	1.359	.097	.124			
SCI10				1.226*	.777*	.705*
SCIOFF				-.087	-.032	-.038
SCITAKE				-.598	-.049	-.062
SES x SIZE	.005	.098	.110	.005	.109	.139

Note. The adjusted R^2 for mathematics achievement and science achievement is .533* and .572*, respectively.
*$p < .05$.

the tests of math and science higher-order skills is consonant with this suggestion. If either of these conditions were obtained, the skills we have studied would be unaffected by instruction, and, hence, unaffected by variations in course-taking patterns between small and large schools.

There is also a possibility that higher-order skills are more a product of pedagogical strategies than either course content or the number of courses that students take. That is, perhaps these skills are developed as a consequence of teachers who deliberately pose questions that require those skills, who probe students' answers, and who make assignments that force students to think deeply about what they know and how it applies to real problems. If such strategies are the primary means of attaining higher-order thinking skills, then those skills can be acquired in any classroom taught by a teacher with the required talents.

Finally, of course, we have relied on the validity of the LSAY and NAEP measures of higher-order skills. While these tests were carefully constructed, measurement of these skills is fraught with difficulties. It is possible, then, that our results are merely a reflection of the problems surrounding the assessment of complex cognitive processes.

It would be possible to continue spinning explanations for our null results. The fact remains that this study joins the host of others that suggest little advantage to large schools, at least insofar as student achievement is concerned. Thus, in a policy perspective, there is no evidence here to support the renewed press for school consolidation that is evident in some states (Haller & Monk, 1988). In this respect, our study is congruent with those recently reviewed by Fowler (1992). More interestingly, perhaps, the apparent anomaly with which we began this paper remains: While large schools offer more advanced courses than do small ones, those offerings appear to have no influence on average levels of student achievement.

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