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ABSTRACT

A review of the literature indicates that, compared to larger, urban schools, small, rural secondary schools have limited course offerings in mathematics and science; the review also indicates, however, that the achievement of students in small, rural schools is equivalent to or even higher than, that of students in larger, urban schools. Such an anomaly may be due to a mismatch of the conventional measurement of achievement outcomes and the neglect of higher-order cognitive skills taught in advanced courses offered only in larger schools. This study examines another possible explanation for the anomaly by focusing on the measures of higher-order thinking skills in science and mathematics. The data used in this study were collected beginning in 1987 by the Longitudinal Study of American Youth (LSAY), an on-going 4-year panel study of middle and high school science and mathematics education. The base-year sample consisted of 2,829 10th grade students from 51 randomly selected public schools. Survey instruments were completed by the sampled students, their teachers, and parents. Achievement tests that focused on mathematics and science knowledge and higher-order thinking skills were administered in the fall of 1987, 1988, and 1989. Zero-order statistics and regression analyses were performed with the data. Results of the study refute the hypothesis and indicate that while large schools offer more advanced courses than do small ones, those offerings appear to have no influence on student achievement and higher-order thinking skills. (LP)

SMALL SCHOOLS AND HIGHER ORDER THINKING SKILLS

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Small Schools and Higher Order Thinking Skills

Introduction

In the social sciences theories frequently collide with facts. That is hardly news, of course, but the collisions are interesting; they incite speculation and inquiry. Seemingly, such an anomaly has occurred in studies of school size and student achievement.

Consider. On the one hand, there are good theoretical grounds for believing that small (usually rural) high schools will not offer as comprehensive programs as larger (usually urban) ones. The notion of economies of scale compels us, *a priori*, to such a conclusion. Further, this conclusion has ample empirical support; small schools offer fewer courses and less comprehensive programs than do larger ones (Barker, 1985; Monk, 1987; Haller, Monk, Spotted Bear, Griffith and Moss, 1990). It would seem to follow, then, that student achievement would be lower in small rural schools. After all, when only two years of mathematics is offered by a high school, all else equal, students will presumably learn less math than if they were attending institutions that offered four years of that subject.

On the other hand, there are the facts. Many studies show that the achievement of students in small and rural schools is as high as that of students in larger, more urban institutions (e.g., Kiesling, 1968; Edington & Martellano, 1984; Summers & Wolfe, 1977). Indeed, by some accounts their achievement is *higher* (e.g. Fowler & Walberg, 1991). Thus, the puzzle: How can students who are able to study only one or two years of a subject learn as much (perhaps more) than students who are able to study four?

In this paper we examine one possible explanation for this apparent anomaly: Perhaps the usual measures of achievement are inappropriate for the comparisons being made. We suggest that instead of relying on common standardized achievement tests to measure learning outcomes, researchers might better focus on competencies that are the likely outcomes of advanced study in a curricular area. We have in mind such competencies as the ability to synthesize information, to evaluate facts and procedures, and to apply abstract concepts to practical problems. Schools that are able to offer a rich variety of courses in a subject area may have little advantage over more impoverished ones in so far as basic skills are concerned, but might have large advantages when higher-order cognitive skills are the criterion. In short, the theory may be right, but we may have been looking at the wrong facts.

Background

According to traditional arguments, small schools are inferior to their larger counterparts (see e.g., Knezevich, 1984). These arguments have not been mere academic exercises. They have had the very practical consequence of causing the disappearance of tens of thousands of schools and school districts during this century (Pipho, 1987). Every state has sought to improve its educational system by policies that either promote or require school consolidation.

These arguments are particularly compelling when we consider curriculum adequacy. There are now numerous studies of the effect of school size on curriculum offerings. Several authors have shown 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 schools typically offer more comprehensive *programs* than do smaller ones, and especially relevant to the case at hand, this greater comprehensiveness is evident in science and mathematics. While curricular comprehensiveness varies by subject area, in no area, whether academic or vocational, are the smallest schools the curricular equals of the largest (Haller *et al.*, 1990; Monk & Haller, 1991).

Of particular relevance to this study is the finding that most high schools of whatever size offer a basic introductory course in each subject area. In mathematics, for example, most high schools offer a course in Algebra. As they become larger, more advanced courses are added, e.g., Analytic Geometry, as well as courses targeted at either talented students, e.g., Honors Algebra, or those needing remedial work, e.g., Consumer

Mathematics (Haller et al., 1990; Monk & Haller, 1991). Thus, comparing students from small and large schools on measures of basic concepts and skills taught in introductory courses, especially when those courses are required by states (as they often are), is unlikely to turn up either substantively or statistically significant findings.[1] Rather, it would seem necessary to seek differences in those skills that are the products of courses offered by large but not small schools.

School size may not be the only factor of importance. There is research to suggest that a school's location can add significant constraints to its curricular offerings. Specifically, location in a rural area may further hinder the capacity to offer curricula that are comparable in quality to those offered in more urban places. Such constraints stem from several sources. For example, rural schools have difficulty in recruiting and retaining teachers with credentials that are comparable to those found in suburban and urban areas. In particular, Carlsen and Monk (1992) found that secondary science teachers in rural schools were less likely to have majored and science as undergraduates and reported taking fewer science and mathematics courses than their counterparts in suburban and urban schools. These teachers may also have less adequate equipment and facilities. The long distances that pupils must travel to school and to area educational and

[1] In this regard it is important to note that the relationship between school size and course offerings appears to be curvilinear, where the degree of the departure from linearity varies depending on the subject area (Monk & Haller, 1991).

technical centers present serious scheduling constraints on students' programs (Monk & Haller, 1986). Finally, lower aspirational levels on the part of students and parents (Cobb, R. A., McIntyre, W. G. & Pratt, P. A., 1989) may lower the probability that rural schools will offer advanced, academically-oriented courses, or that students will take them when they are offered.

It would seem hard to escape the conclusion that in regard to curricula at least, small rural secondary schools do not provide equal educational opportunities to their students. If one asks "So what?" however, the issue becomes more complicated. Presumably the major reason why curricular disparities 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. But when we examine the relation between the size of educational organizations and student learning, the expected results are conspicuously absent.

There have been numerous studies of the relationship between school size and student achievement. With few exceptions, these studies seem to show that students in small schools are at least as successful as their peers in larger institutions. For example, Eberts, Kehoe and Stone (1984), Edington and Martellaro (1989), Fowler and Walberg (1991), Guthrie (1979), and Melnick, Shibles and Gable (1987) suggest that either school size has no effect on achievement or that its effect is slightly negative. A modest exception to this evidence was reported in New York State, where Monk & Haller (1986) found that in the very smallest high schools (i.e., those that enroll fewer than 200 students) achievement in certain subjects was slightly below the state mean. As another modest exception, Friedkin & Necochea (1988) found that the size-achievement relationship is a contingent one, i.e., that it is negative in low SES schools and positive in high SES schools. Even in the latter case, however, the positive effect of size on achievement is quite small, while in the low SES case its negative effect is substantial. Overall, it seems safe to conclude that small school size does not lead to noticeable decrements in pupil achievement.

A similar conclusion can be reached in regard to rurality: rural students are at no obvious disadvantage in so far as their achievement is concerned. For example, while Downey (1980) found that rural students in Kansas scored slightly below their urban counterparts on the ACT, he concluded that the difference was so small as to be negligible. In contrast, Easton (1985), Edington & Martellaro (1984), McIntire & Marion (1989) and Ward & Murray (1985), found no significant differences in achievement between rural and urban youth. Examining university GPAs, Hand & Prather (1990) found that students from rural high schools generally outperformed their urban counterparts when SAT scores and SES were controlled. Presumably, having experienced the restricted curricula rural schools offer, ceteris paribus, their students would be at a disadvantage in university courses.

As we noted in the introduction to this paper, these conclusions--that small, rural secondary schools have sharply restricted curricular offerings and that their instructional programs are qualitatively inferior, while the achievement of their students is equivalent to that of students in larger more urban schools--present an anomaly. One possible resolution of this oddity is that researchers have relied on inappropriate measures of student achievement. That is, most of the research comparing the achievement of students in different size schools has relied on either of two kinds of achievement tests, neither of which is very suitable to the task.

The first and most commonly used measures of achievement are the nationally standardized achievement batteries. The problem here is that these tests are not curriculum-specific. At best they test a sort of generalized knowledge presumably taught in all schools. Hence, they are unable to detect knowledge differences among students who vary in the amount of a subject they have studied.

Alternatively, when curriculum specific tests (such as New York's "Regents' Examinations") have been used to compare achievement levels in small and large schools, another sort of difficulty arises. The problem here is that these tests are typically focused on measuring 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. It would be surprising, for example, if students in large and small schools differ in their knowledge of the simple facts of American history. Virtually every public school offers at least one course in that subject; thus, equivalent numbers of students will know what the Bill of Rights is, regardless of the size of their high school. However, only large schools are likely to offer a social studies course devoted to the U.S. Constitution. Hence, only their students are likely to understand the tension between the Establishment and Free Exercise Clauses of the First Amendment.

Thus, it is possible that students in small rural schools are negatively affected by their schools' restricted curricula, but researchers haven't detected those effects because they have been using the wrong measures of achievement. In short, the appropriate tests should be both curriculum-specific and should measure the kinds of outcomes that are more likely to be the product of extended study in a subject, i.e., from taking the sorts of courses offered by larger schools.

Further, the subject matter areas chosen to search for a school-size effect must be selected carefully. As we noted above, small schools are more nearly the equals of larger ones in some subjects than in others. For example, the social studies programs of small and large schools are more nearly comparable than are mathematics programs, which, in turn, are more nearly equivalent than are science programs (Haller et al., 1990; Monk & Haller, 1991).

In this paper 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 the 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, to relate science and mathematical concepts to those from other disciplines, and to 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 to suggest that they receive more emphasis there. Clearly, for example, a teacher of Algebra I might emphasize such skills while a teacher of calculus might accent rote learning, giving no attention to synthesis, evaluation or the application of abstract ideas to practical problems. Instead, we would argue 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 the mean achievement level on tests of higher order thinking skills will be greater in large schools than in small ones.

While it is the case that larger urban schools, on average, offer more advanced courses than do smaller 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, 1991). 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 and rurality and higher order skills will depend on the presence of advanced courses and student course taking patterns. Finally, any relation between school size and these skills may depend on the socioeconomic level of the school's clientele. Friedkin & Necochea's (1988) finding that size and SES interact in affecting the more usual measures of academic achievement may also hold in regard to high order skills.

Based on these considerations, we hypothesize that there will be a positive zero-order relation between high school size and location in an urban or suburban area and the average level of achievement of students on tests of higher order thinking skills. This relation may depend on the SES of the schools' clientele. In either case, we hypothesize 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.

Methods

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 and high school science and mathematics education. The collection began in the fall of 1987 and is ongoing. The results we report 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 consisted of 2,829 students who were enrolled in the 10th grade in the fall of 1987.[2] These students were drawn from 51 schools around the nation. The sample consisted entirely of public schools, which were 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 drawn into 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 utilized items developed by the National Assessment of Educational Progress (NAEP). The NAEP items permit an assessment of students' capabilities along several dimensions of achievement, including certain higher order cognitive skills.

In science, the measure of higher order skills pertained to the integration of science knowledge (*SCIENCE*). This involved the student's ability to "organize information more generally for problem solving, often involving use of scientific concepts and principles, drawing proper conclusions, and employing higher-order

[2] The base year sample also includes 3,116 students who were in the 7th grade in 1987, but these data were not used in this study.

thinking skills in reaching a solution to a problem" (Miller, Suchner, Hoffer & Brown, 1990). In mathematics, the measure of higher order skills was also focused on problem solving. This scale (*MATH*) measured a student's ability to interpret underlying concepts, assumptions, and relationships and their use in solving non-routine, often multi-step problems (Miller, *et al.*, 1990).[3] Tests administered during the Fall of 1989, when students were in the twelfth grade, provided the data for our measures. The within-school means of both achievement scores were calculated and taken as the dependent variables of this study.

We took as a measure of a school's size (*SIZE*) its 10th grade enrollment as reported by a school administrator. The socioeconomic level of the school (*SES*) was indexed by taking the average of the educational level of each student's parents and calculating the mean of this for each school. Our measure of a school's location was based on administrators' responses to a question asking them to characterize their schools as urban, suburban or rural. These responses were coded as a dummy variable with urban and suburban as the reference category.

Our measure of a school's course offerings as well as of students' course-taking patterns were based on teachers' responses to questions concerning the classes taken by LSAY students. In each semester the math and science courses

[3] The scores we used were estimated by Item Response Theory methods which recognizes that some items are more difficult than others. Students' response patterns were adjusted in light of these variable difficulty levels. The reliability coefficient for the science integration scale is .59; for mathematics problem solving, .84.

taken by each student were identified. If any of the sampled students in a school was reported as having taken, while a sophomore, junior or senior, an honors math course (e.g., "Honors Geometry"), or a course in geometry, algebra 2, 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 schools' course offerings in advanced mathematics (*CRSOFF(M)*). A similar procedure was followed for science course offerings: all honors courses, second year biology, anatomy/physiology, chemistry and physics were counted as advanced science course offerings (*CRSOFF(S)*).[4]

The extent to which students took the advanced courses offered by a school was computed by first counting the number of these advanced math and science courses taken by each student. Then, the mean of each of these numbers was then calculated for each school (*CRSTAKE(M)*) and (*CRSTAKE(S)*).

We used ordinary least squares regression analyses to examine the effects of size and rurality on higher-order thinking skills. In order to test the hypothesis that higher order thinking skills are positively related to school size and rurality, we regressed *SCIENCE* and *MATH* separately on each of those variables, with *SES* and a product term for the interaction of *SIZE* and *SES* in the equation. Next, to test the idea that the effect of school size and rurality on higher order skills is due to the ability of large urban schools to offer advanced courses in

[4] See Haller et al. (1990) for a full discussion of the rationale for this coding scheme.

science and mathematics, we entered *CRSOFF(M)* and *CRSTAKE(M)* or *CRSOFF(S)* and *CRSTAKE(S)* into the appropriate equation. If we are correct, we should expect to see the regression weights for school size and rurality decrease significantly in magnitude.

Results

Table 1 provides descriptive information for the variables used in this study as well as a zero-order correlation matrix. With listwise deletion of missing cases in effect, 47 schools remained for analysis. It is obvious from Table 1 that, unless there is a substantial interaction between school size and socioeconomic status, school size has no effect on higher order skills in either science or mathematics. The correlations hover about zero. Similarly, there is no association between a school's rurality and its students scores on test of higher order thinking skills.

(TABLE 1 HERE)

There are a few other points worth noting in Table 1. Empirically, there is little to distinguish the measures of science and mathematics achievement. The correlation of .87 suggests that the tests developed by NAEP are measuring the same construct. Notice also 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, our measure of students' willingness to enroll in advanced courses does seem to be 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.

SES has a significant zero-order relation with both measures of higher order skills. The magnitude of its correlation with these variables is typical of its relation with more usual measures of achievement. School socioeconomic status is also related positively to school size and negatively to location in a rural area. Further, it is significantly correlated with the number of advanced science and mathematics courses these schools offer. Finally, students attending higher SES schools tend to take more advanced mathematics courses than their peers in lower status institutions, though this may not be true of science.

On average, these schools offer about 6 advanced math courses, one more than the number of advanced science courses they offer. Students are also more likely to take advanced math courses than they are science, though in neither case does course taking seem high. That is, in the typical school students take, on average, 1.6 semesters of advanced math and 1.1 of advanced science. Notice that 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. Large high schools offer more advanced mathematics and science courses than do small ones, while the curriculum of rural schools is more restricted than urban and suburban ones, at least in the case of math. Rural students also appear to take fewer advanced mathematics courses than do their urban contemporaries.

Table 2 reports the results of our regression analyses. We first ran these regressions with a product term for a *SIZE x SES* interaction in the equation to test for the possibility that the any relation between school size and higher order skills is dependent upon the SES level of the school. This interaction term was not significant in any regression, and Table 2 reports our results after we dropped it from the analysis. (We also tested for the possibility of a *RURAL x SES* interaction and found none.) We ran the a pair of regressions for each dependent variable. First we entered school size, rurality and SES in the equation (columns 1 and 3 of the Table), and then added our measures of course offerings in math and science (*CRSOFF*) and of student course-taking in those subjects (*CRSTAKE*).

Table 2 Here

Table 2 makes it abundantly clear that school size is unrelated to students' performance on the LSAY measures of higher order cognitive skills. The only variable significantly related to either outcome is school socioeconomic status. Student course taking, significant at the zero-order level, is not significant here, undoubtedly because of the intercorrelations among course taking, course offerings and school ses. Thus, our hypothesis that the benefits of larger school size accrue in the form of students' acquisition of higher order cognitive skills in science and mathematics was refuted.

Discussion

We began this study by suggesting that a positive relationship 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 size has no influence. Thus, this study joins the numerous others that suggest 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 the tests of math and science higher order skills is consonant with this suggestion. If either of these conditions 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.

It would be possible to continue spinning explanations for our non-findings. The fact remains that this study joins the host of others which suggests little advantage to large schools, at least insofar as student achievement is concerned. More to the point, 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 student achievement.

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TABLE 1

CORRELATIONS, MEANS, AND STANDARD DEVIATIONS
N=47

	1	2	3	4	5	6	7	8	MEAN	SD
MATH									62.54	5.80
SCIENCE	-.87**								61.26	5.07
SIZE	-.10	.00							331.21	201.27
RURAL	.05	.07	-.36**						.34	.48
SES	.38**	.37**	.43**	-.42**					2.51	.37
CRSOFF(M)	.05	-.02	.39**	-.45**	.42**				5.68	1.82
CRSOFF(S)	.12	.10	.38**	-.24	.48**	.44**			4.72	1.84
CRSTAKE(M)	.38**	.32*	.15	-.31*	.56**	.27*	.46**		1.56	.41
CRSTAKE(S)	.37**	.28*	-.10	-.02	.21	.10	.44**	.59**	1.11	.41

One-tail Significance:
** $p < .01$
* $p < .05$

TABLE 2

REGRESSION RESULTS

	MATH		SCIENCE	
	1	2	3	4
SIZE	-.008	-.007	-.003	-.001
RURAL	2.375	2.682	2.585	2.493
SES	9.180**	7.221*	7.252**	7.151**
CRSOFF		-.044		-.519
CRSTAKE		3.207		3.026
Intercept	41.41	41.15	43.33	41.91
R^2	.264	.299	.213	.259