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AUTHOR	Huang, Gary; Howley, Craig
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ABSTRACT

This paper examines the hypothesis that school size mediates the effect of disadvantaged status on the achievement of individual students. A previous study using national data from the High School and Beyond data set failed to confirm the hypothesis. This study sought to test the hypothesis further by limiting the analysis to students in a single state, using multiple indicators of educational disadvantage, and applying more rigorous control over background variables known to affect academic achievement. The group studied included all (13,553) students in Grades 4, 6, and 8 who had attended the same school since first grade and who had participated in the fall 1989 Alaska Statewide Student Testing Program. The disadvantaged status of students was rated on a scale of 0-4, with 1 point each given for minority ethnic status, migrant education status, Chapter 1 status, and handicapped status. Data were analyzed with multiple regression analysis, controlling for school resources, school climate, and student academic background. While the overall average achievement score was lower for students in small schools than in large schools, results indicated that: (1) the negative effect of disadvantaged background on student achievement is significantly less in small than in medium or large schools; and (2) the interaction of disadvantaged status and school size explains an additional, significant amount of variance in student achievement. (Author/SV)

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Mitigating Disadvantage: Effects of Small-Scale Schooling on Student Achievement in Alaska

by

Gary Huang & Craig Howley

ERIC Clearinghouse on Rural Education and Small Schools
Appalachia Educational Laboratory
P.O. Box 1348
Charleston, WV 25325

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Abstract

Controlling for three domains of background variables (school resources, school climate, and student academic background), this study investigated the hypothesis that school size mediates the effect of disadvantaged status on the achievement of individual students. The group studied included all students in grades 4, 6, and 8 who had attended the same school since first grade and who participated in the fall 1989 Alaska Statewide Student Testing Program (n=5,589, n=3,930, and n=4,034, respectively for each grade). Data were analyzed with multiple regression analysis with the three domains of background variables controlled. Results indicated that while the average achievement score was lower for students in small schools than in large schools, (1) the negative effect of disadvantaged background on student achievement is significantly less in small than in medium or large schools and (2) the interaction of disadvantaged status and school size explains an additional, statistically significant amount of variance in student achievement.

Mitigating Disadvantage: Effects of Small-Scale Schooling on Student Achievement in Alaska

With increasing frequency, the "crisis of risk" in U.S. education is being interpreted as the predicament of impoverished, minority, and handicapped children in schools (e.g., Bull & Garrett, 1989; Oakes, 1990; Taylor & Piché, 1990). Indeed, the proportion of minority children in the nation's schools will increase substantially in the coming decades (Natriello, McDill, & Pallas, 1990) and the depth and extent of poverty among children is growing (Shapiro & Greenstein, 1991).

The need to address this predicament seems pressing. One of the strategies considered by some policymakers and investigated by some researchers is small-scale schooling (e.g., Cross, 1990; Fowler & Walberg, 1991; Friedkin & Necochea, 1988; Plecki, 1991). Available research suggests that disadvantaged students perform better in small than in large schools (Fowler & Walberg, 1991; Howley, 1989). The underlying theoretical rationale is that small schooling provides a setting in which instructionally effective contact among students and teachers is more likely than in large schools, and in which social differentiation among students and teachers is less likely than in large schools. As a result, small schools may better facilitate learning of disadvantaged students than large schools, if other conditions are equal (Howley and Huang, forthcoming).

One shortcoming of available analyses, however, is that they have employed data sets from the nation's two <u>most urbanized</u> states, New Jersey and

California (Howley & Huang, forthcoming). Most small-scale schooling, by contrast, takes place in rural states (Stephens, 1991). Further, most recent studies have used schools or districts, rather than individual students, as the unit of analysis for the dependent variable (Howley & Huang, forthcoming).

In order to test the hypothesis of the differential effect of small school size with students as the unit of analysis in a national sampling frame, Howley and Huang (forthcoming) conducted a study that used the High School and Beyond dataset. Little evidence in support of the hypothesis was found. The present study again tests the hypothesis with individual student achievement as the dependent variable, but this time using a dataset from a rural state (Alaska).

Hypothesis

Hypothetically, small schooling reduces the negative influences of low SES on student academic achievement, while large schooling expands such negative impacts. One might further hypothesize that school size alters only the extent of the influences of educational disadvantage on school performance, but does not reverse the direction of the effects. In other words, ascribed disadvantage will always exert a negative influence on achievement, regardless of school size; however, small school size may diminish such negative effects, whereas large schooling may magnify them.

In statistical terms, this interaction effect would be ordinal (as contrary to disordinal) in nature (Aiken & West 1991). That is, when regressing disadvantage on achievement separately for students in small schools and students in large schools, while the slopes (b weights) of the two regression lines for small schools and large schools should hypothetically differ, the two lines would not be expected to intersect within the range of measured the independent variable (i.e., measured disadvantage). Thus, though scale of schooling has hypothetically differential effects in mediating the detrimental consequences of being disadvantaged, the main effect of disadvantage persists. To put it still another way, the hypothesis implies that, despite the possibility that the average achievement of students in large schools is higher than that of students in small schools, such discrepancy is smaller among the more disadvantaged students and larger among the more advantaged students (see Figure 1).

Previous Research

Our prior study based on the national sample of the High School and Beyond Survey failed to find a clear pattern in which school size mediates the effect of student socioeconomic background on academic achievement (Howley & Huang, forthcoming). It was reasoned that the failure to identify such a nationwide pattern might have been due to the diverse conditions in which schools operate within states. Distinct contexts of education at the state level may alter the meaning of school size, and, further, introduce many complexities to the analysis. The national data set, we reasoned, might obscure these meanings and increase these complexities. The earlier study faced a dilemma: while excluding these influences from analysis might blur the picture, yet to consider them would have demanded information that was not available in the High School and Beyond dataset.

Inadequate conceptualization and measurement of student SES background in the study may also have been responsible for the comparatively weak relationship between SES measures and academic achievement for individual students. The notion of SES influence essentially refers to the structurally imposed advantages or disadvantages impinging on individual students. These disadvantages generate student learning difficulties and academic failure, among others negative outcomes.

In this study, our concern for "at-risk" students leads us to focus on mechanisms to reduce the effects of disadvantages. In the prior study, the student self-report of father's educational attainment was used as the indicator of student socioeconomic status. As a one-dimensional variable, this measure probably failed to capture salient features of the construct of disadvantage. For example, ethnic, linguistic, and physical disadvantages ought reasonably to be considered in conceptualizing the notion of educational disadvantage.

In addition to conceptual shortcomings, lack of systematic control for other variables affecting school performance might also have contributed to the inconclusive results of the earlier study. School organization and student behavior are evident factors that affect academic outcomes. On the school or district level, characteristics such as financial resources, community support, and school leadership or school climate are known to be important (e.g., Eberts, Kehoe, & Stone, 1984; Mirochnik & McCaul, 1990; Stockord & Mayberry, 1986; Turner, Camilli, Kroc, & Hoover, 1986). On the individual level, student educational background such as early childhood education, academic attitudes, and study strategies are potentially influential (e.g., Barnett & Escobar, 1987; Mullis & Jenkins, 1990). Only when such conditions can be assumed to be similar, would it be meaningful to compare the intermediate impacts of small schooling and large schooling in changing the effects of educational disadvantage on school outcomes.

The present study is intended to address the shortcomings of the previous analysis and to test the hypothesis further by (1) limiting the analysis to the student population of a single state; (2) using multiple indicators to reflect educational disadvantage; and (3) applying more rigorous statistical control of confounding factors associated with academic achievement.

Data and Measurement

Data collected by the Alaska Statewide Student Testing Program in fall, 1989 were used (Stofflet, Fenton, & Silverman, 1990). The Iowa Tests of Basic Skills (ITBS)[1], Form G, was administered to over 23,000 students in grades 4, 6, and 8 of the state--more than 95 percent of the state population enrolled in these three grades. We selected for study, however, only those students who reported that they had attended the same school districts since first grade. This criterion ensures that the school outcomes are clearly associated with the student's continuous experience in a single district, thus eliminating the error that would otherwise be introduced by enrollment in a

[1]The objection may be raised that a standardized, norm-referenced test such as the ITBS yields results that are inherently biased against culturally-different minority students. Kleinfield's (1991) assessment of this objection is that it is unfounded. Kleinfeld (1991, p. 4) first observes that "it makes no sense...to say that the ITBS is 'biased' simply because it measures general knowledge and academic skills." Kleinfeld further reports that item analysis carried out for the Alaska Department of Education investigated differences in the performance of Alaska Native and white students based on data from the ITBS administration used in this study: "When Native students and white students of similar ability levels were compared...[the study] found that seven percent of the test items statistically favored white students and six percent...favored Native students.... In a technical sense, the ITBS is not particularly biased against either Native or white students of similar levels of competence" (Kleinfeld, 1991, p. 8).

number of different schools. The resulting sample includes 5,589 4th graders, 3,930 6th graders, and 4,034 8th graders.

Besides the ITBS test scores in reading, writing, and mathematics, the program also collected information on (1) students' background as reported by teachers; (2) students' academic attitudes and study habits reported by students; and (3) school climate as reported by principals. Investigators also incorporated into the dataset information about school districts from state government reports, including student-teacher ratio per classroom, community size, and various measures of educational costs. (For original measures and questions, see Stofflet, Fenton, & Silverman, 1990).

We used the normalized composite test score of the ITBS to represent the dependent variable, academic achievement. School size was estimated by the average number of students per tested grade level. Schools were categorized as small if this average number was less than 20; schools with the average number greater than 60 were classified as large; and the schools between these extremes considered as medium. Though not ideal, this estimate of school size is believed to be reasonably valid since it is based on the size of three grades that are evenly distributed across the academic levels of school (Stofflet, Fenton, & Silverman, 1990).

We used four variables of student status to operationalize the disadvantaged status of students, including: (1) ethnic status (Native Alaskan and American Indians, Hispanics, and Blacks); (2) migrant education status; (3) Chapter 1 status; and (4) handicapped status. The resulting 5-scale measure was coded zero through four, with zero indicating no disadvantage suffered by the respondent and four reflecting all counts of disadvantage. Oneway analysis of variance demonstrated a significant linear pattern in achievement score differentiated by the 5-count disadvantagedness measure: the higher the counts of disadvantage, the lower the test score.

Three conceptual domains are typically involved in models that explain academic achievement. Variables in these domains serve only as controlled predictors of academic achievement in the study.

First, the school resources, largely represented by information the state government reported, include total cost per pupil, adjusted cost by areas, instructional cost, student-teacher ratio, and community size. Average class size as estimated by the principal can also be considered as a measure of school resources since it is known that small class size requires greater resources to support the operation. Including this variable also allows us to disentangle the presumably related effects of small class size versus small school size.

We refer to the second conceptual domain as "school climate." This domain, which represents an assessment of process variables, is derived from principals' reports on three multi-item scales. A set of questions asking whether seven administrative strategies were used in school generated a 7-count variable based on the dummy-coded responses to the questions. Another set of questions asking the extent to which 12 instructional strategies were used in teaching produced a 12-count scale based on counting the number of those strategies that were reportedly used "a lot." Finally, a group of questions asking the extent to which 12 problems existed in school resulted in a 12-count scale by counting the number of problems that were admitted to be "serious."

Student academic background variables constitute the third domain. With the available data, this concept includes four measures, namely, (1) attendance in a kindergarten or preschool program (a dummy variable); (2) student's perceived importance of three academic subjects (counts of "very important" for reading, writing, and mathematics); (3) the extent of liking these three academic subjects (counts of "like a lot" for each subject); and (4) frequency of out-of-school reading (a dummy variable with daily reading versus monthly reading or less)[1].

Analysis Strategy

To focus on the interaction effect of size of schooling and educational disadvantage on academic achievement, we attempted to exclude as thoroughly as possible the compounding effects of other factors related to achievement. This was done by statistical control in multiple regression analysis. The controlled variables are conceptualized within the three domains (school resources, school climate, and student academic background) discussed in the preceding section.

To examine the hypothesized interaction effect, two approaches were involved. First, within each of the three categories of school size, and controlling for all the other outcome-related variables, educational disadvantage was regressed on achievement. The resultant magnitudes of the raw regression coefficients from the three equations were then compared.[1]

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[1]Three questions on frequency of out-of-school reading were asked to the 4th graders (reading, silent reading, and being read to); two questions (reading and silent reading) were asked to the 6th and 8th graders. Based on these questions, we created a dummy variable, which was coded 1 if the responses included "most every day" to one or more questions and "1-2 times a week" to others; and 0 if otherwise.

[1]Unstandardized regression coefficients (b weights), rather than standardized regression coefficients (beta weights), should be used for legitimate comparison of the strength of the effects of the same independent variable across different equations. Unstandardized regression weights

The hypothetical interaction effect should manifest itself in increasingly greater magnitude of these raw regression coefficients across the three size categories.

Second, cross-product variables indicating the interaction effect were analyzed in multiple regression (Aiken & West, 1991). The 3-category variable of school size was re-coded into two dummy variables. One is small size (1) versus others (0) and the other is large size (1) versus others (0). Such a dummy coding system takes the medium size as the comparison group. The coefficients of the two dummy variables in the model can be straightforwardly interpreted as the effects of small and large school size on achievement in contrast to the medium-size school. Two cross-product vectors were generated by multiplying the disadvantage score with the two dummy variables of size. The statistical significance of the interaction effect is indicated by the F ratio associated with the R^2 change due to the entrance of the two cross-product vectors into the equations. The magnitude and significance of the cross-product vectors are also interpretable. They can be seen as the effects of disadvantage on achievement differentiated by small and large size so that the disadvantage effect specified by medium size is modified.

Findings

On the three grade levels, Table 1 describes the major characteristics of focal variables for this study, namely, normalized composite test score,

indicate changes in the dependent variable associated with a unit change of the independent variable in raw score and are fixed across equations, whereas standardized regression weights vary with sample size and standard deviation in order to provide comparison with other regression weights within a given equation (Pedhazur 1982).

educational disadvantage, and school size. The three subsamples appear to be quite similar on this basis.

Table 2 presents the zero-order correlation coefficients of academic achievement and presumably related variables, by grade levels. A unique feature of Alaska emerges in this analysis. The relationships between the three measures of costs (total cost, adjusted cost, and instructional cost) and achievement are consistently negative in zero-order correlations. This negative relation may be understood by considering the remote and rural environment of Alaska, where small, rural schools serve a large portion of Native Alaskan or American Indian students. Higher educational costs result from the disadvantaged ecological and social conditions under which students experience difficulty in achieving at high level. The zero-order negative correlation between costs and outcomes should thus be considered spurious; both high costs and low achievement are related to the "detrimental" rural environment. In fact, in multiple analysis, the adjusted cost was found to be positively related to achievement.

As expected, the zero-order effects of community size and class size on achievement are positive, as the measures reflect the scale of settlement and operation, and hence, the resources potentially available. The student-teacher ratio per classroom is also positively associated with performance. This may be a spurious finding however, as rural, remote schools often have a low student-teacher ratio due to the very nature of small schooling. Again, in multiple analysis, this variable was found to be negatively (for grade 4 and 8) or insignificantly (grade 6) related to achievement.

Measures of "school climate" also relate to academic achievement in the expected manner. The more administration and instructional strategies reportedly used, the higher the achievement outcome; the more serious problems admitted, the lower the achievement outcome. Also as expected, student academic background (preschool attendance, liking of academic subjects, perceived importance of academic subjects, and frequency of out-of-school study) are positively associated with achievement. Note that educational disadvantage has the greatest zero-order coefficient among all variables and that it is negatively related to achievement across all three grade levels.

With multiple regression analysis, on each grade level, three equations were generated for the three categories of school size. We controlled for the variables of school resources, school climate, and student academic background.

The resulting regression coefficients of disadvantage on achievement are presented in Table 3. A stable pattern appears in all three grade levels: the increase of magnitude of the raw coefficients of disadvantage is related to school size. While the effect of disadvantage on achievement is negative in every category of size, small size is associated with the smallest effect of disadvantage and large size is associated with the largest effect of disadvantage. This finding matches the hypothesized pattern of the interaction.

In order to determinate whether the interaction between educational disadvantage and school size is significant, we test whether the increment in the proportion of variance of the dependent variable (academic achievement) accounted for by the interaction vector (i.e., the R^2 increment associated with the entrance of the cross-product vectors into the equation) is significant.

Table 4 shows that the increment of R^2's caused by entering the interaction vectors is significant in the three equations based on the three grade levels. In addition, as indicated by the raw regression coefficients of the interaction vectors, all coefficients except the interaction between large size and disadvantage for the 8th grade subsample are significant.[4]

The pattern of the interaction effects revealed here is consistent with the findings from prior models separately built in the three school size categories.[5] On all three grade levels, the interaction vector of small size

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[4]To assure that the significance of R^2 increments derived from analyses of the full samples was not due to the large sample size, we applied the following procedure at each grade level: repeated random sampling from the total sample to generate three to five subsamples sized at 10 percent of the original sample (with the safeguard that there were more than 20 cases per independent variable so that the regression would not be biased) and running the same test of the interaction effect on each subsample. Results indicate that for grades 4 and 6, the size and significance level of R^2 increments are close to that found in analyses based on the total samples and that the statistics are reasonably consistent. For grade 8, however, the results are satisfactorily stable only when the subsample is as large as 40 percent of the total sample. These findings are consistent with our preliminary tests of the interaction by analysis of variance, taking the background variables as covariates.

A unique pattern found in ANOVA analysis for the 8th graders may account for the less clear interaction pattern in this group. While all other cell means were similar to those found among the 4th and 6th graders, among the 8th graders who were in large schools, a heavily disadvantaged group (3 counts) had the <u>highest</u> mean achievement score (even higher than that of the students who were not disadvantaged). Evidently, this peculiar distribution of cell means acts to blur the picture of our multivariate analysis.

[5]Intercepts and coefficients of disadvantage yielded from the analysis with product vectors and the analyses separated by school size categories, however, are not identical. This may be due to the interactions between controlled variables and school size on achievement since the different correlations between these variables and achievement across school size change the coefficient matrix (personal communication with Leona Aiken, 1991). Close examination of the coefficients of controlled variables across school size indicates that such interactions do exist. The overall pattern in which school size and educational disadvantage interact is nevertheless consistent,

and disadvantage has positive regression coefficients, whereas the interaction vector of large size and disadvantages has negative coefficients.

To further examine the hypothesized ordinal nature of the interaction, the intersection point of the two linear regression lines for small schools and large schools needs to be located. Assuming other factors identical (as the result of being statistically controlled), we may use b weights of disadvantage and intercept values to calculate the point on disadvantage where the two lines intersect (Aiken & West, 1991)[6]. If the point locates within the range of disadvantage, the interaction is considered to disordinal, otherwise it is ordinal. The results indicate that the interaction is disordinal. Our assumption about the ordinal interaction of educational disadvantage and school size is not supported by the data. The disordinal effect suggests that among students who were identified with one or more disadvantages, those who were in small schools had <u>even higher</u> average achievement than equally disadvantaged students in large schools, holding other conditions constant.

Note, however, that the <u>average</u> achievement score seems different across categories of school size. The average achievement score of large schools is higher than that of medium-size schools, and the average achievement score of

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as evidenced in the two analytic approaches used in the study.

[6]Since at the point of intersection, the predicted Y's are equal for the two groups, to find the intersection point, we simply solve the equation:

$$a_s+b_sX=a_l+b_lX$$

where a_s and b_s denote intercept and b weight for the small school group, and a_l and b_l are the same items for the large school group. X is the independent variable, disadvantage. Note that controlled variables are identical on the two sides of the equation and thus canceled each other. Resultant intersection points are approximately 1 for the three grades.

small schools is lower than that of medium-size schools. This pattern is revealed in the values of intercept (the mean of achievement for medium-size schools) modified by the school size effects (see Table 4). For example, at the 4th grade level, small schools have an achievement mean of 76.000 (by subtracting -6.754 from the intercept 82.574, the mean of medium-size schools); and large schools have a mean of 84.907 (by adding 2.333 to the intercept 82.574). Such a pattern is not, however, significant among 8th graders.

The findings suggest that, given similar school resources, school climate, and individual academic background, while the average achievement is higher in large schools than that in small schools, educationally disadvantaged students generally tend to do better in small schools than they do in medium-size schools (ranging from of 2.738 to 4.279 normalized composite score gains associated with every count in disadvantage) and that given the same conditions, they tend to do less well in large schools than they do in medium-size schools (ranging from a nonsignificant loss on grade 8 to -5.962 in normalized composite score on grade 6 associated with every count in disadvantage). For students suffering no disadvantages, no such differential effect exists across the categories of school size (because these students scored zero on the scale of disadvantage, which renders a zero value to the interaction vectors).[7]

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[7]Such effects might exist in reality, but investigation of the hypothesis that <u>advantage</u> interacts with school size was not the focus of this study.

Figure 1. Interaction between school size and educational disadvantage on academic achievement

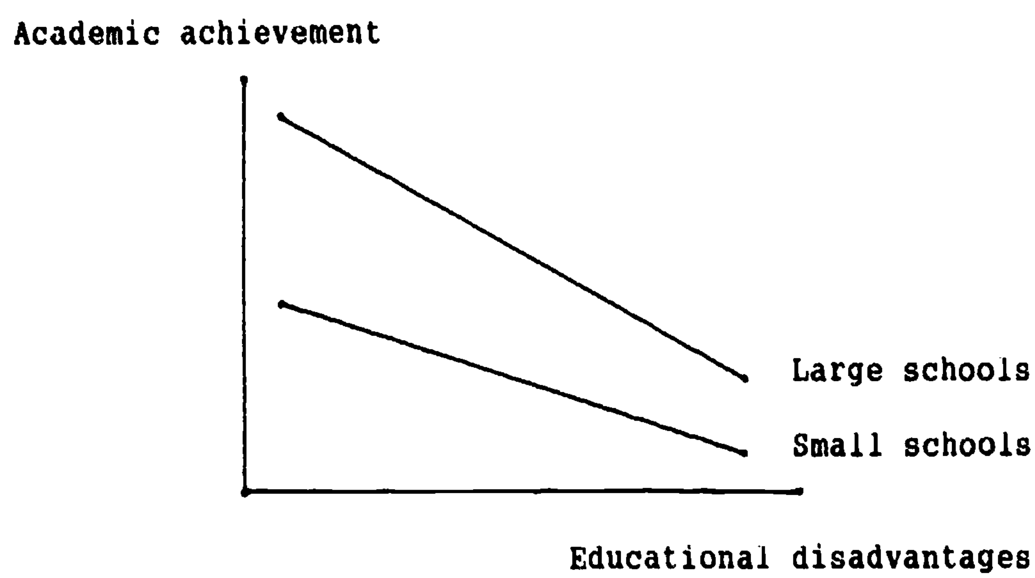

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Table 1. Descriptive statistics for focal variables on the three grade levels.

Variables	Grade 4	Grade 6	Grade 8
Normalized composite test score			
mean	51.10	52.87	54.93
s.d.	22.78	23.42	21.50
N	5,589	3,930	3,897
Educational disadvantage			
mean	.48	.48	.42
s.d.	.79	.79	.75
N	5,589	3,930	4,034
School size (frequencies)			
small	971	881	648
medium	1,580	1,000	386
large	3,038	2,119	3,000

Table 2. Zero-order correlation coefficients of academic achievement relating to school resources, school climate, student academic background, and the two focal variables.

Variables	Grade 4	Grade 6	Grade 8
School resources			
Total cost per pupil	-.33	-.40	-.40
Adjusted cost	-.29	-.38	-.39
Instruction cost	-.32	-.39	-.39
Community size	.31	.39	.40
Student teacher ratio	.28	.38	.37
Class size	.21	.25	.34
School climate			
Administ. strategies	.05	.09	.11
Instruct. strategies	.07	.16	.09
Serious Problems	-.22	-.27	-.16
Student academic background			
Liking subjects	.09	.16	.25
Perceived importance	.23	.24	.22
Home study every day	.14	.31	.17
Preschool attendance	.09	.09	.12
Focal variables			
School size	.32	.37	.40
Disadvantage	-.45	-.49	-.38
minimum pairwise N	4876	3860	3500

Note: All coefficients are significant at .001 level with 2-tailed T test.

Table 3. Regression coefficients of educational disadvantage on academic achievement in small, medium, and large schools, controlling for school resources, school climate, and student academic background.

	Small Schools	Medium Schools	Large Schools
Grade 4			
b	-4.788	-11.798	-14.762
s.e	.731	.798	.794
Intercept	62.352	115.134	160.829
Adjusted R^2	.299	.196	.191
N	786	1321	2769
Grade 6			
b	-5.683	-9.877	-14.881
s.e.	.668	1.032	.891
Intercept	21.698	-1.494	26.593
Adjusted R^2	.359	.224	.244
N	810	1000	2118
Grade 8			
b	-4.904	-8.506	-9.591
s.e.	.833	1.729	.695
Intercept	38.263	83.7453	90.515
Adjusted R^2	.299	.334	.176
N	507	272	2721

Note: All coefficients and adjusted R^2's are significant at .001 level.

Table 4. Regression coefficients of school size, educational disadvantage, and cross-product vectors (school size and educational disadvantage) on academic achievement, intercepts, and R^2 increments due to entrance of the cross-product vectors into the equations, controlling for school resources, school climate, and student academic background.

Focal vectors	Grade 4	Grade 6	Grade 8
Intercept	82.574***	37.497***	55.496***
Small size	-6.574***	-2.868	-3.727
Large size	2.333**	3.146***	-1.658
Educational disadvantage	-10.645***	-8.899***	-8.741***
Small size*disadvantage	4.279***	2.738*	3.404*
Large size*disadvantage	-4.065***	-5.962***	-.372
R^2 increment	.010***	.010***	.003**

* $p<.05$ ** $p<.01$ *** $p<.001$

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