Washington School Research Center

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The Influence of District Size, School Size and Socioeconomic Status on Student Achievement in Washington: A Replication Study Using Hierarchical Linear Modeling

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The Washington School Research Center (WSRC) is an independent research and data analysis center within Seattle Pacific University. The Center began in July 2000, funded through a gift from the Bill and Melinda Gates Foundation. Our mission is to conduct sound and objective research on student learning in the public schools, and to make the research findings available for educators, policy makers, and the general public for use in the improvement of schools. We believe that sound data and appropriate data analysis are vital components for the identification of school and classroom practices related to increased student academic achievement.

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A Technical Report For
The Washington School Research Center

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Foreword

In recent years there has been a growing interest in the role that school size plays in creating effective learning environments for students. Serious questions have been raised about the "bigger is better" approach to schools, and policy makers are asking researchers if there are research findings on this important topic. In fact, there have been numerous studies, both quantitative and qualitative, strongly suggesting students generally do better in smaller schools than larger schools.

Such a study published in the year 2000 on education in the state of Georgia caught the interest of the Urban Issues Committee of the Washington State School Directors' Association (WSSDA). Recognizing that such research findings have direct policy implications, the Association approached the Washington School Research Center (WSRC) about replicating the study in the state of Washington. Through the joint sponsorship of WSSDA and WSRC, this technical report is a replication of that study using achievement, poverty, school and district size data from Washington State.

The research findings on school size show that the question is a complex one, and that there are numerous factors that might interact with school size to account for variation in student and school performance. Using a statistical procedure called Hierarchical Linear Modeling, WSRC researchers Abbott, Joireman, and Stroh attempt to identify the ways in which district size, school size, and family income level interact to effect student achievement.

Replication research across states is difficult because of differing state tests, grade structures, data bases, and other factors. And, in fact, while this study replicates the general approach used in the Georgia study, it does differ in some significant ways. First, WASL scores were used for this study rather than the ITBS; second, because of questions about the reliability of the high school poverty data, 4^{th} and 7^{th} grade data were analyzed, while the Georgia study analyzed 8^{th} and 11^{th} grade data. Still, the results presented here complement the original findings and add to the body of research that strongly suggests that school size *and district size* do matter.

The WSRC researchers conclude: "We found that large district size is detrimental to achievement in Washington 4^{th} and 7^{th} grades in that it strengthens the negative relationship between school poverty and student achievement." Further, they state, "the negative relationship between school poverty and achievement is stronger in larger districts," and "small schools appear to have the greatest equity effects." In other words, when school poverty is high, children perform better in small districts, and the effect of school level poverty on achievement is smallest when both the district and school are small.

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The Influence of District Size, School Size and Socioeconomic Status on Student Achievement in Washington: A Replication Study using Hierarchical Linear Modeling

Introduction

New interest in the effects of school size on academic achievement has grown in recent years as nationwide school reform efforts have gained momentum. Policy makers and practitioners have suggested new models of schools based on the idea that smaller is better. As these models have gained currency, there is also a call for research to investigate the likely effects of creating smaller schools. Are smaller schools needed as a strategy to improve student academic performance?

Several studies have examined this question by employing single-level regression models to examine the influence of size (district and school) and low-income on academic achievement. A recent article by Robert Bickel and Craig Howley (2000), however, advanced the research in this area by introducing a multi-level approach to their analysis examining the joint influence of district and school size on academic performance in Georgia. Their research focuses on the "cross-level interaction" of district and school socioeconomic status and size through a single-equation relative-effects model.

The results of the Bickel and Howley study particularly highlight the sizeable influences of two such cross-level (i.e., district and school level) interactions: the product of district size and school socioeconomic status (SES), and the product of school size and district SES (especially at the 8th grade level). School-level academic performance is negatively affected both by the district poverty-school size cross-level interaction, and the school poverty-district size cross level interaction. (These findings are not as consistent at the 11th grade level.) Single level regression models cannot identify these important cross-level dynamics.

Another important contribution of the Bickel and Howley study is their "equity" analyses. According to the authors, "equity" refers to non-equivalence in the socioeconomic status-academic performance relationship as a function of size. In effect, this asks whether "the amount of variance in achievement associated with SES is substantially reduced in smaller units" (p. 5). The analysis is accomplished by examining the variance in school performance associated with low-income in four different configurations of school and district size (i.e., large school-large district, large school-small district, small school-large district, and small school-small district).

Literature Review

The issue of school and district size effects on student achievement is not new. Beginning in the 1920s schools and school districts grew larger as districts attempted to consolidate both administration and curriculum and instruction. Ellwood Cubberly, a former urban superintendent, advocated for the creation of large schools as immigrant populations in major cities grew. Meanwhile, Joseph Kennedy, dean of the school of education at North Dakota State University, was concerned about losing the participation and identity of local communities as rural schools consolidated (Robertson, 2001; Howley, 1996). The press for larger schools continued through the 1950s as U.S. educators felt the pressure of the "space race" and the need to provide a wider, more academically rigorous curriculum for future scientists.

Large schools, however, are not without fault. Bracey (2001) noted:

> …large schools, especially large high schools, produce their own set of problems, which a growing number of researchers and policy makers think can be solved by returning to small schools. Advocates for small schools have argued that they can
>
> - raise student achievement, especially for minority and low-income students;
> - reduce incidents of violence and disruptive behavior;
> - combat anonymity and isolation and, conversely, increase the sense of belonging;
> - increase attendance and graduation rates;
> - elevate teacher satisfaction;
> - improve school climate;
> - operate most cost-effectively;
> - increase parents and community involvement; and
> - reduce the amount of graffiti on school buildings. (p. 413)

Such arguments by advocates for small schools bear some merit, as research indicates that school (Lee & Loeb, 2000) and district (Bickel & Howley, 2000; Johnson, Howley, & Howley, 2002) size can impact student achievement. Lee and Loeb examined 264 Chicago elementary schools and found that school size influenced student achievement both directly and indirectly. They reported that teachers in small schools (less than 400 students) take more responsibility for students' academic and social development, and that this in turn enhances student achievement. They noted that small schools facilitate more intimate and personal relationships among both teachers and students, and that it is these relationships that impact student learning. Another study of Chicago's public schools found that small schools increase attendance, student persistence, performance, graduation rates, grades, course completion, and parent, teacher, student, and community satisfaction (Walsey, Fine, Gladden, Holland, King, Mosak, & Powell, 2000).

Other research on school size has found socioeconomic status to be the confounding variable in the size/achievement equation, noting that as school size increases, achievement levels for schools with less advantaged students decreases (Bickel, 1999; Howley & Bickel, 2000). Bickel, Howley, Williams, and Glascock (2000) confirmed these findings while controlling for ethnicity, language, size, cost, and curricular composition factors. Interestingly, Howley, Strange, and Bickel (2000) noted that "size exert[s] a negative influence on achievement in impoverished schools, but a positive influence on achievement in affluent schools. That is, all else being equal, larger school size benefits achievement in affluent communities, but it is detrimental in impoverished communities" (p. 4). Additionally, the authors' results indicated that "the relationship between achievement and SES is substantially weaker in the smaller schools than in the larger schools" (p. 5).

The authors also noted, however, that small size doesn't necessarily guarantee student success. "Small size is a necessary but insufficient condition for school improvement. . . . It is important to avoid seeing small schools as the sole solution to all that ails education. Rather, we would suggest that it is a key ingredient in a comprehensive plan to improve education" (p. 66).

District size may also moderate the effects of school size. Bickel and Howley (2000) found an interesting interaction between district and school size. The authors explained:

> Larger schools in larger districts seem to propagate inequality of outcomes by comparison to smaller schools and smaller districts. In fact, smaller schools in larger districts demonstrate a useful equity effect, as well. For large schools in smaller districts, however, the improvements in equity might be so slight as to be called negligible. (p. 21)

The authors (Bickel & Howley, 2000) found that in communities with high rates of poverty, small schools in small districts increase student achievement. Overall, "smaller districts and smaller schools demonstrate greater achievement equity" (Howley, 2000, p. 7).

Simply stated, current research indicates that the amount of impact socioeconomic status has on student achievement is dependent upon several factors, including the size of the school and the size of the district in which the school functions.

A Replication Study

The present study is a replication of the Bickel and Howley (2000) method to the Washington state academic performance of 4th and 7th grade students. While Bickel and Howley focused on the 8th grade Iowa Test of Basic Skills (ITBS) and the 11th grade Georgia High School Graduation Test, this study examines 4th and 7th grade academic performance on the Washington Assessment of Student Learning (WASL)[1] test that is mandated across the state. A great deal of attention in Washington has focused on the use of the WASL, which has replaced other tests (e.g., ITBS) for assessing statewide standards-based learning objectives.

Bickel and Howley's method is accomplished in this study by the use of Hierarchical Linear Modeling through the HLM software program (Raudenbush, S., Bryk, A., and Congdon, R., 2000). The two approaches attempt to specify the joint relationships and cross-level interactions of two structural levels (district and school) on school academic performance.

Nature of the Data

The data used for this replication study were provided by Washington State's Office of the Superintendent of Public Instruction, and are from the testing year 2001. The data consist of all 4th and 7th grade student WASL scale scores in reading and mathematics, aggregated to the school level.[2] Schools with less than ten students were excluded from the study, and, because there was a concern over the unique characteristics of some "types" of schools, those labeled "Alternative," "Institutional," and other "Unclassified" types were not included.

Table 1 indicates the descriptive data for the variables used in this study. Percent Free and Reduced (F/R) Lunch is used on both school and district levels as a measure of low socioeconomic status[3]. Spansize is the number of students per grade level and is used as our measure of school size, as it was by Bickel and Howley (2000). Enrollment is the total number of students per district.

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[1] For more information on administration of the WASL and ITBS in Washington, visit www.k12.wa.us/assessment/WASLintro.asp. For more technical information on the WASL, visit www.k12.wa.us/assessment/qawasl.asp. For more technical information on the ITBS, visit www.riverpub.com/products/group/itbs.htm.

[2] Grade 10 WASL scores were not used since, in our experience, the % Free/Reduced Lunch data are less reliable at that level.

[3] Bickel and Howley (2000) refer to free or reduced price meals as SES.

Table 1

Descriptive Statistics for 4th and 7th Grades

4th Grade			
School-Level	Mean	SD	N
Percent F/R Lunch	37.86	23.62	1035
Spansize	69.67	28.29	1035
Math Scale Score	392.83	14.79	1035
Reading Scale Score	405.45	7.07	1035
District-Level			
Percent F/R Lunch	37.92	18.84	251
Enrollment	3903.34	6089.11	250
7th Grade			
School-Level	Mean	SD	N
Percent F/R Lunch	33.27	21.33	417
Spansize	177.87	112.74	417
Math Scale Score	366.29	17.81	417
Reading Scale Score	393.79	6.81	417
District-Level			
Percent F/R Lunch	37.92	18.75	255
Enrollment	3924.40	6277.40	255

Joint Effects of School and District Variables Using Hierarchical Linear Modeling

Major Goal

As noted earlier, our major goal was to determine whether the cross-level interactions (school x district level) between size and socioeconomic status reported by Bickel and Howley (2000) would replicate within Washington. More specifically, we were interested in whether the data in Washington would replicate two major patterns reported by Bickel and Howley: (1) larger schools are beneficial within affluent communities, whereas smaller schools are more beneficial within less affluent districts; and (2) the “achievement cost” associated with less affluent schools is greater in large districts (i.e., the negative relationship between school-level poverty and achievement is stronger in larger districts). The first pattern would require an interaction between school size and district-level SES; the second pattern would require an interaction school-level SES and district size.

Hierarchical Linear Modeling (HLM)

To determine whether these two patterns (interactions) were present within the current Washington State data, we conducted a series of analyses using *hierarchical linear modeling* (*HLM*). HLM is a statistical technique that is appropriate for analyzing multi-level data (e.g., schools nested within districts). HLM has a number of advantages over other approaches to multi-level data, such as ignoring the nested nature of the data (which violates the assumption of non-independent errors) or pooling the data by, for example, aggregating across schools within a district (which results in a loss of data, and eliminates the possibility of examining cross-level interactions).[4] In each of the analyses, school level variables were group centered (district means) and district level variables were grand mean centered.

Overview of Models 1 and 2

Tables 2 and 3 summarize the results of two different models, respectively. Model 1 examines the influence of school size and district poverty (on math and reading at both the 4th and 7th grades), whereas Model 2 examines the influence of school poverty and district size (on math and reading at both the 4th and 7th grades).

Model 1 Summary – School Size and District Poverty

We begin by interpreting the results for Model 1, using the 4th grade, shown in the top half of Table 2. As can be seen, results for math and reading were quite similar. First, scores in math and reading each showed a highly significant negative relationship with district poverty (Bs = -47.10 and -24.10, ps < .0001). Second, math and reading showed no significant relationship with school size (ps > .35). Third, results did not reveal interactions between school size and district poverty, findings that were not consistent with Bickel and Howley's (2000) findings.

While the interactions were not significant, they were in the expected direction. To further examine the nature of the interactions, we plotted the relationship between school size and achievement for districts in the 25th (thin lines) and 75th (bold lines) percentiles on poverty, as shown in Figure 1. While the interaction was not significant in either case, there was a tendency for larger schools to be somewhat more beneficial in more affluent districts (25th percentile, thin line) than in less affluent districts (75th percentile, bold line).

[4] For more information on Hierarchical Linear Modeling, see Raudenbush and Bryk (2002).

We now turn to the results for the 7th grade, summarized in the bottom half of Table 2. As can be seen, the 7th grade results replicated the 4th grade results. First, both math and reading showed a significant negative relationship with district poverty ($Bs = -61.05$ and -23.41, $ps < .0001$). Second, math and reading showed no significant relationship with school size ($ps > .28$). Last, results at the 7th grade failed to reveal a significant interaction between school size and district poverty on either math or reading ($ps > .27$). For comparison with the 4th grade results, we present graphs of the relationship between school size and achievement at the 25th and 75th percentile on district poverty for the 7th grade (Figure 2). As can be seen, while the interaction was not significant in either case, there was a tendency for larger schools to be somewhat more beneficial in more affluent districts (25th percentile, thin line) than in less affluent districts (75th percentile, bold line).

Taken as a set, results for Model 1 do not replicate Bickel and Howley's (2000) findings concerning the interaction between school size and district poverty. As we explain in the next section, results did replicate Bickel and Howley's finding concerning the interaction between school poverty and district size.

Model 2 Summary – School Poverty and District Size

We now turn to the results for Model 2, in which we examine the influence of school poverty and district size on math and reading in the 4th and 7th grade, as summarized in Table 3. First, math and reading showed significant negative relationships with school level poverty in both grades ($ps < .001$). Second, math and reading showed a significant positive relationship with district size in the 4th grade ($ps < .004$), but showed no significant relationship with district size in the 7th grade ($ps > .09$). Finally, in each case, school poverty and district size showed a significant interaction ($ps < .001$). As we will explain, the nature of this interaction was consistent with Bickel and Howley's (2000) findings (for their 8th grade only – comparable 11th grade results were not significant).

To further examine the nature of this interaction, we plotted the relationship between school poverty and achievement for small districts (25th percentile, thin line) and large districts (75th percentile, bold line) at both the 4th and 7th grade. Figure 3 presents the results for 4th grade; Figure 4 presents the results for the 7th grade. As can be seen, in every case, the negative relationship between school poverty and achievement is stronger in large districts, thus replicating Bickel and Howley's (2000) findings (for the 8th grade only).

Table 2

Summary of HLM Runs – Model 1 – Effects of School Size and District Poverty on Math and Reading Achievement in 4th and 7th Grades.

4th Grade (Figure 1)

Math	B	SE	t	df	p-value
Intercept	389.99776	0.519294	751.015	246	0.000
School Size	0.03	0.031156	0.925	246	0.355
District Poverty	-47.10	2.843856	-16.562	246	0.000
SS x DP	-0.16	0.143109	-1.127	246	0.260

Reading	B	SE	t	df	p-value
Intercept	404.00	0.242452	1666.317	246	0.000
School Size	0.01	0.014902	0.574	246	0.566
District Poverty	-24.10	1.377889	-17.492	246	0.000
SS x DP	-0.087	0.073228	-1.191	246	0.234

7th Grade (Figure 2)

Math	B	SE	t	df	p-value
Intercept	364.36	0.708944	513.95	253	0.000
School Size	0.04	0.038757	0.95	253	0.343
District Poverty	-61.05	4.394758	-13.89	253	0.000
SS x DP	-0.25	0.229240	-1.09	253	0.275

Reading	B	SE	t	df	p-value
Intercept	393.02	0.277042	1418.64	253	0.000
School Size	0.01	0.011056	1.06	253	0.289
District Poverty	-23.41	1.776674	-13.18	253	0.000
SS x DP	-0.05	0.068546	-0.76	253	0.445

Note. *DP* = District Poverty (% of students in district on free or reduced lunch); *SS* = School Size (spansize).

Table 3

Summary of HLM Runs – Model 2 – Effects of School Poverty and District Size on Math and Reading Achievement in 4th and 7th Grades.

4th Grade (Figure 3)

Math	B	SE	t	df	p-value
Intercept	390.21	0.806115	484.062	247	0.000
School Poverty	-0.24	0.038737	-6.228	247	0.000
District Size	.000287	0.000107	2.682	247	0.008
SP x DS	-0.00001	0.000003	-3.809	247	0.000

Reading	B	SE	t	df	p-value
Intercept	404.075	0.397746	1015.914	247	0.000
School Poverty	-0.14	0.017709	-7.719	247	0.000
District Size	.000151	0.000052	2.907	247	0.004
SP x DS	-0.000005	0.000001	-4.497	247	0.000

7th Grade (Figure 4)

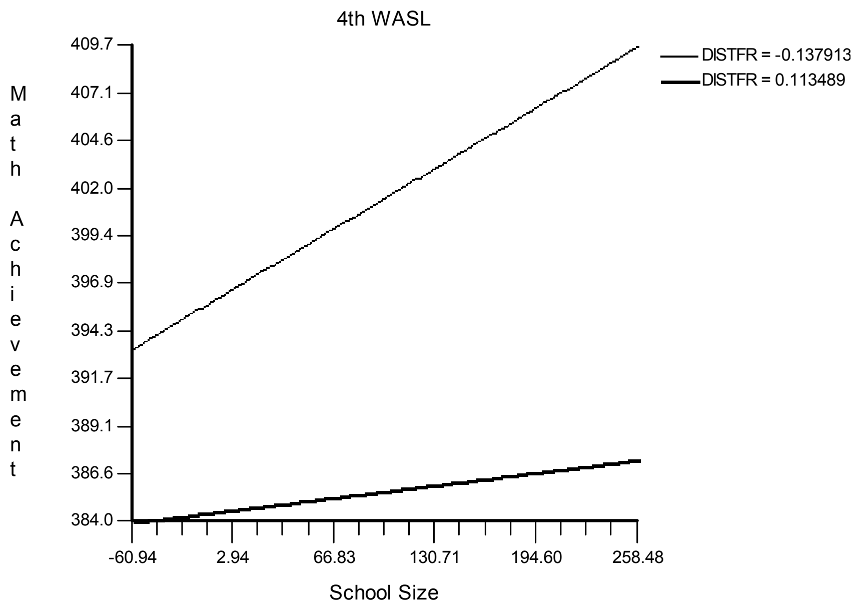
Math	B	SE	t	df	p-value
Intercept	364.83	1.020967	357.34	253	0.000
School Poverty	-0.40	0.120292	-3.29	253	0.001
District Size	.000250	0.000149	1.68	253	0.093
SP x DS	-0.00002	0.000006	-3.51	253	0.001

Reading	B	SE	t	df	p-value
Intercept	393.24	0.401891	978.48	253	0.000
School Poverty	-0.18	0.051623	-3.42	253	0.001
District Size	.000084	0.000052	1.60	253	0.108
SP x DS	-0.000008	0.000002	-3.51	253	0.001

Note. *DS* = District Size; *SP* = School Poverty (% students on free or reduced lunch).

Figure 1

Math and Reading Achievement as a Function of School Size (Spansize) and District Poverty (25th and 75th Percentiles) – 4th Grade.



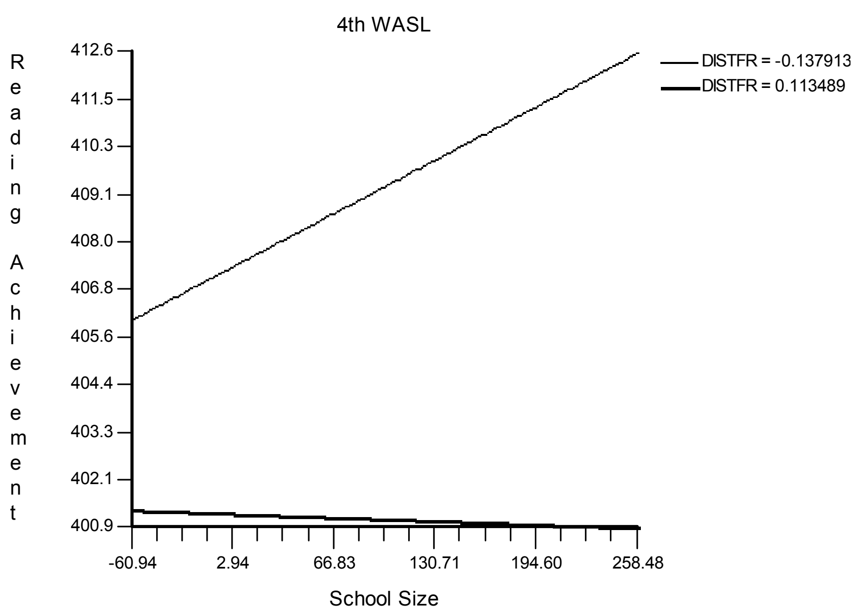
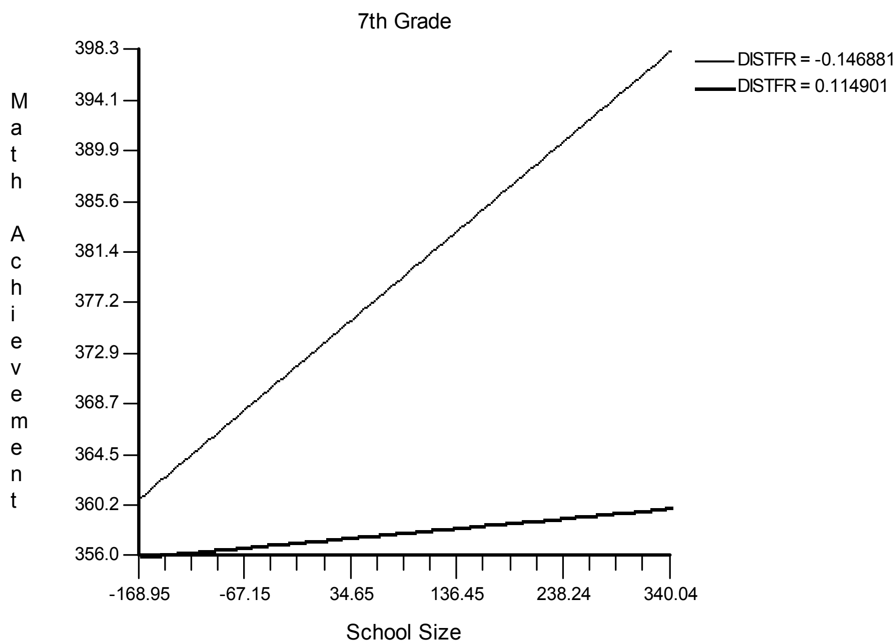


Figure 2

Math and Reading Achievement as a Function of School Size (Spansize) and District Poverty (25^{th} and 75^{th} Percentiles) -- 7^{th} Grade.



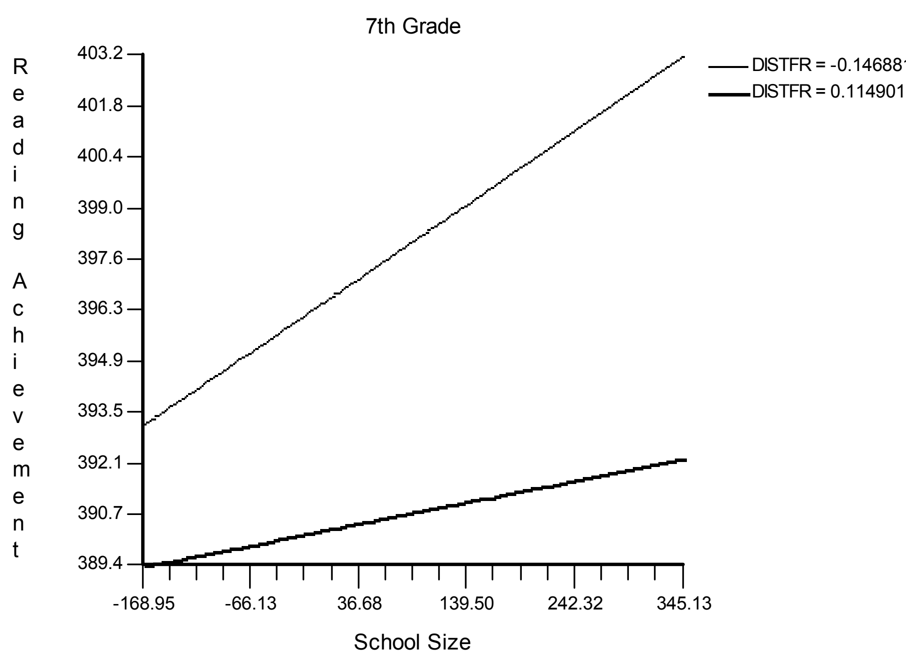
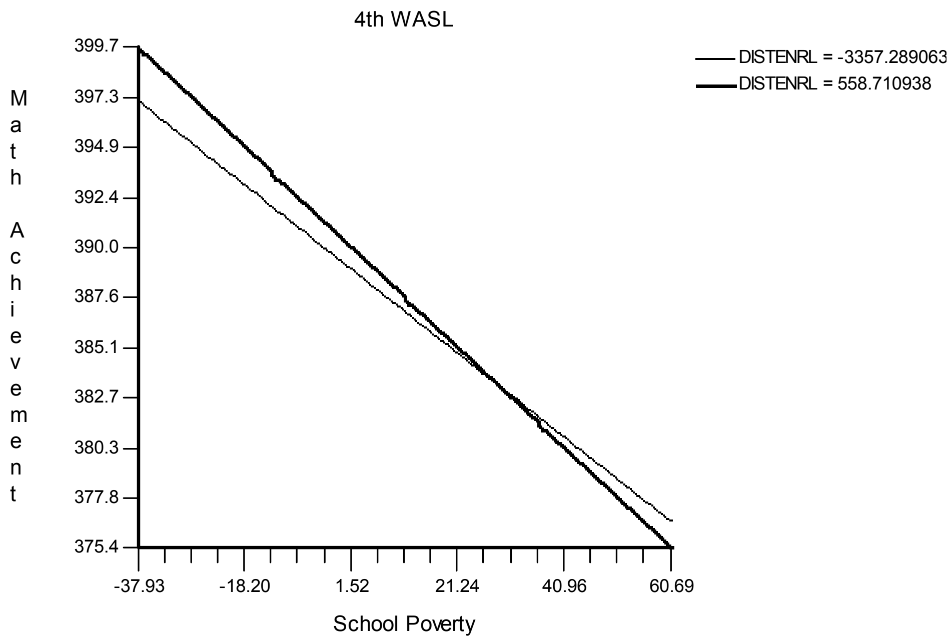


Figure 3

Math and Reading Achievement as a Function of School Poverty and District Size (25th and 75th Percentile) – 4th Grade



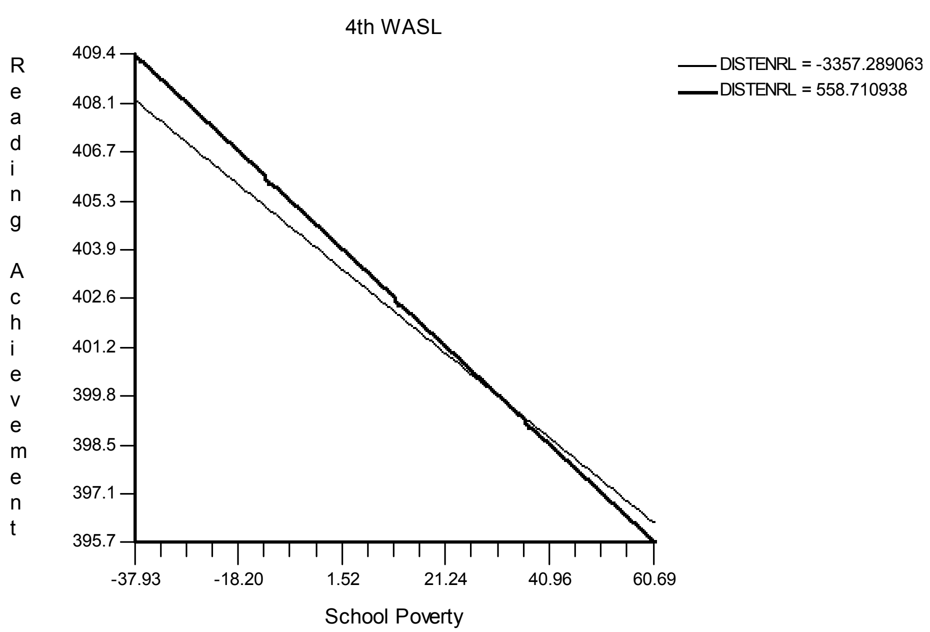
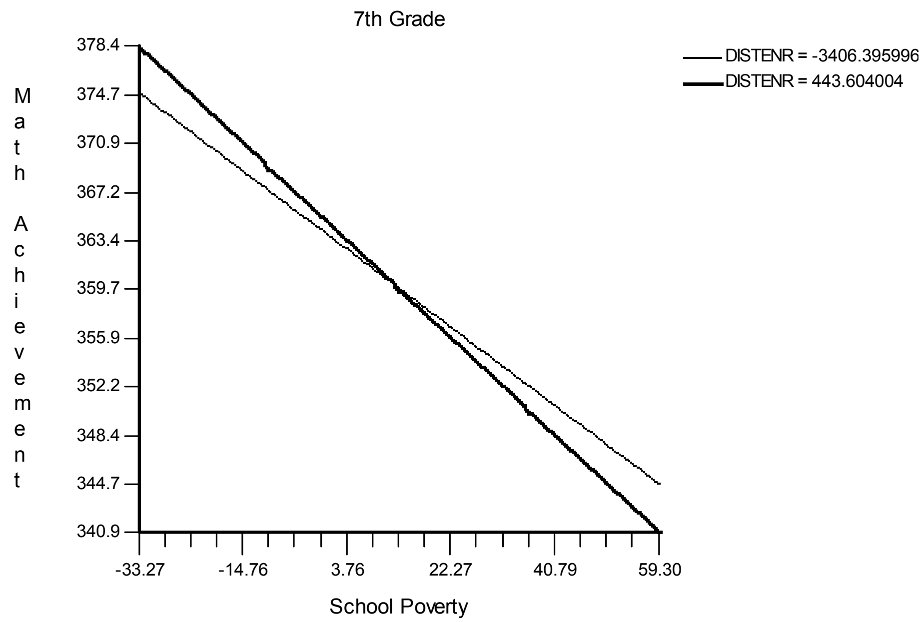
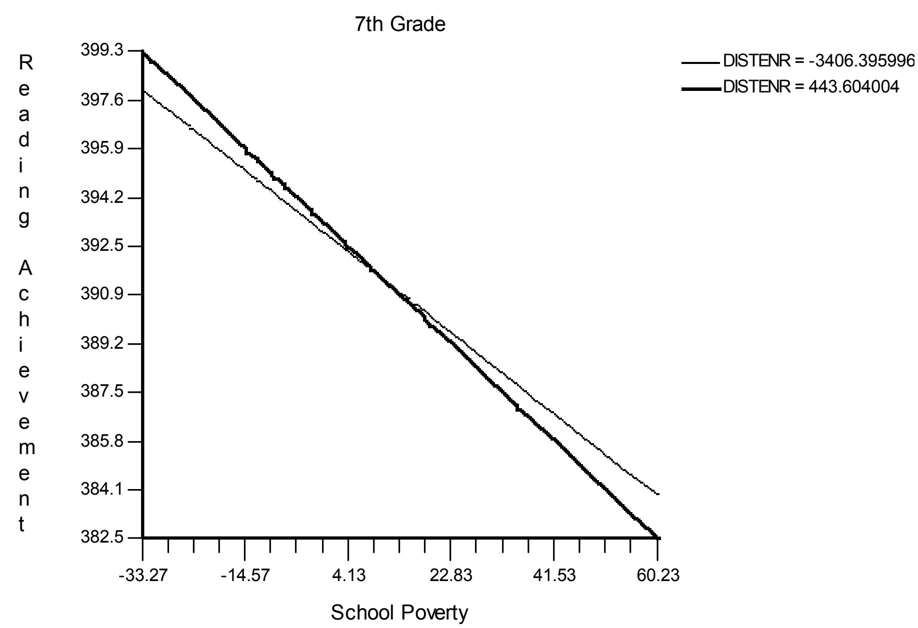


Figure 4

Reading Achievement as a Function of School Poverty and District Size (25th and 75th Percentile) for 4th and 7th Grade.





Fourth and Seventh Grade Equity Effects

In order to measure equity effects, Bickel and Howley (2000) used squared zero-order correlation values (r^2) between SES and achievement within four categories of district and school size (i.e., large school-large district, large school-small district, small school-large district, and small school-small district). They found that,

> the predicted equity effect of reducing district size but not school size would be practically significant; the predicted equity effect of reducing school size but not district size would also be practically significant and perhaps somewhat larger; and the combined strategy of reducing both school and district size would be predicted to yield substantial equity and excellence effects . . . (p. 20)

This study replicates Bickel and Howley's method by creating four categories of district and school size based on median split values: large school-large district, large school-small district, small school-large district, and small school-small district. Within each of these categories are the r^2 values between F/R lunch % and achievement (math and reading WASL scores) for 4th and 7th grades. Table 4 lists the results of these analyses.

Both 4th and 7th grade results reflect Bickel and Howley's (2000) results in that the data in this study show the small district-small school category shows the smallest proportion of variance in achievement associated with school poverty. Apart from this however, the results are different from Bickel and Howley in at least one major instance: the large district-large school category did not result in the greatest amount of variance explained across grade levels and subjects.

The overall results of both 4th and 7th grades reflect the school poverty – district size interaction results reported in Table 3: that the negative relationship between school poverty and achievement is stronger in larger districts. Small schools in small districts explain the least amount of variance (13% to 24% of the variance in achievement associated with poverty), but the largest amount of variance explained is in large districts irrespective of school size (41% to 54%).

This finding is consistent across grade levels and subjects despite large differences between 4th and 7th grade spansizes. The 4th grade spansize is approximately 2 ½ times smaller than the 7th grade spansize while the mean district enrollments are approximately equal. Therefore, small schools appear to have the greatest equity effects, while large districts are the most detrimental.

Table 4

Variance in Achievement Explained by School Poverty as a Function of District and School Size: Washington Multi-Level Equity Effects[1]

Large and Small Districts and Schools—4th, 7th WASL Scores

4th Grade Math Scale Scores

		Districts[2]			
		Large		Small	
		r^2	*n*	r^2	*n*
Grade Span Size[3]	Large	0.41	487	0.27	30
	Small	0.45	416	0.17	101

4th Grade Reading Scale Scores

		Districts[2]			
		Large		Small	
		r^2	*n*	r^2	*n*
Grade Span Size[3]	Large	0.47	487	0.46	30
	Small	0.54	416	0.13	101

7th Grade Math Scale Scores

		Districts[4]			
		Large		Small	
		r^2	*n*	r^2	*n*
Grade Span Size[5]	Large	0.48	208	-	0
	Small	0.46	80	0.24	129

7th Grade Reading Scale Scores

		Districts[4]			
		Large		Small	
		r^2	*n*	r^2	*n*
Grade Span Size[5]	Large	0.53	208	-	0
	Small	0.51	80	0.20	129

[1] Variance (r^2) in Scale Scores attributable to % Free/Reduced Lunch
[2] Median Split = 1,514.5
[3] Median Split = 68.9
[4] Median Split = 1,411
[5] Median Split = 186

Conclusions

Our study replicated the method of Bickel and Howley (2000) for understanding the influence of district size, school size and socioeconomic status on student achievement in Washington. We found that large district size is detrimental to achievement in Washington 4th and 7th grades in that it strengthens the negative relationship between school poverty and student achievement. This finding replicated that of the Bickel and Howley (2000) study.

We did not replicate another of Bickel and Howley's (2000) findings, however. In our study, district affluence did not have a significant impact over the school size – student achievement relationship. The tendency for larger schools to be somewhat more beneficial in more affluent districts (and, equivalently, for smaller schools to be more beneficial in less affluent districts) is shown in the analyses, but was not found to be statistically significant.

The nature and configuration of Washington schools may partially explain the discrepancy between the findings of the two studies with respect to district affluence. First, the majority of districts (for both 4th and 7th grades) in Washington are single-school districts that tend to be smaller, poorer, and more rural than multi-school districts.[5] Second, our study used the WASL as the measure of student achievement (both 4th and 7th grades) in contrast to Bickel and Howley's use of the ITBS (8th grade) and the Georgia High School Graduation Test (11th grade). Preliminary analyses in Washington indicate that the WASL and the ITBS have different correlations with school poverty, especially in math.[6] Third, there are a number of other variables not addressed in either study that may exert important influences on student achievement.

Taken together, the method used by Bickel and Howley (2000) and that of this study were useful for explaining relationships in multi-level data that could not be explained by more traditional (single-level) analyses. School and district size are often assumed to be primary, independent influences on student achievement. In fact, this is a commonly expressed sentiment even among practitioners and policy makers. However, based on this study, it appears that size is a more complex matter, and needs to be viewed in the context of other influences in order to determine its contribution to school-level achievement.

Certainly, the multi-level findings of our study argue against the simplistic conclusion that reducing school and/or district size will automatically improve student achievement, or be more equitable. We are in complete agreement with Bickel and Howley (2000) in their comment that, "the conclusions of this study would seem to require rather wide debate and reconsideration of the size issue,

[5] We use "single-school districts" to indicate districts with a school containing one (4th and 7th) grade level.
[6] For a comparison of the WASL and ITBS in Washington, see Joireman and Abbott (2001)

across the spectrum of poverty and wealth, and not just in the case of impoverished communities” (p. 21).

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