

IX. The Cost Effectiveness of Reducing Class Size or Adding Aides

1. Introduction

The cost of making a change is always a consideration in deciding whether it will be possible or desirable to make the change. Costs should be examined in relation to the benefits; a costly program that brings large benefits will be a better bargain than an inexpensive program that does nothing for the students.

Since a substantial reduction in class size is costly, the legislation establishing Project STAR directed that estimates of the cost of reducing class size be made. The estimates of cost are related to the benefits in increased student achievement, to produce a cost effectiveness ratio that estimates the amount of benefit per unit of cost increase.

The estimation of costs is usually straightforward, but the estimates of benefits is more complex. Class-size reduction, for example, produces immediate benefits for teachers and immediate benefits for student learning, but it may also have other longer-term or indirect effects that are much harder to identify and measure. These estimates of Project STAR costs and benefits concentrate on immediate benefits to student achievement. This allows these estimates to be compared with any other program or treatment that is also aimed at increased student performance. Levin, Glass and Meister (1984) used this methodology to estimate costs and benefits of four different educational interventions, including reductions in class size. Project STAR estimates are calculated for both class-size reduction and the full-time aide, and these cost benefit ratios can be compared with estimates for any other intervention.

2. Estimating the Cost

The additional costs can be estimated on both a total basis for Tennessee (if kindergarten through grade three had class size reduced 15 to 1 statewide) and on a per-pupil basis, which would be applicable to whatever population of students was to be included in the policy (for example, if class-size reduction were targeted in schools with low-achieving students). If class-size reduction were implemented only for kindergarten and grade one, the two grades where the class-size effect is greatest, per-pupil estimates could be multiplied by the number of students involved to get an estimate of the total costs. Per-pupil cost additions can be expressed in both dollar and percentage terms. The percentages can be applied to the average cost per pupil in whatever future year the policy is implemented; this adjusts the dollar costs for effects of inflation in future years.

Estimating the cost of each individual student reduction in class size can also be done with this methodology, so the cost of reducing class size from 23:1 to 20:1 or 18:1 can be estimated. Project STAR has evidence on the benefits of an average of 15 to 1 as compared with an average of 23 to 1; the cost/effectiveness ratios are calculated for those class sizes. The cost estimates can be calculated for any class size. The effectiveness estimates can also be calculated on a proportional basis, although the study design does not allow us to say that a reduction from 23 to 19 would have half the effect of a reduction from 23 to 15.

3. Teacher Aides

Estimating the additional costs of a teacher aide is straightforward. If the salary cost of an aide is \$8,000 and the benefits (social security, insurance) are 12 percent, the total cost of an aide is \$8,960. Systems pay aides at different rates. The actual Project Star salaries were a little less than \$8,000 in the base year 1987-88. The year 1987-88 was chosen as the base year because state comparative cost data was available, and this was a middle year in the project. Adding an aide does not increase capital or other operating costs appreciably. The aide's salary is the primary factor.

The operating cost per pupil in Tennessee in 1987-88 was \$2,842. The average class size was 23 in the first three grades in Tennessee that year. The aide cost (\$8,960) divided by 23 is \$390 per pupil, which represents the additional cost per student from adding an aide. The additional per-pupil cost is \$390 divided by \$2,842, or 13.7 percent.

If better qualified aides were to be employed, requiring higher salaries, the percentage increase would be larger. If an aide were shared between two teachers, the percentage increase and cost per student would be cut in half.

4. Small Classes

Estimating the additional costs per student of small classes is more complex, because both increased operating costs, and the capital costs for additional classrooms must be taken into account. The data necessary to estimate the total capital costs are not available for Tennessee, because there is not a statewide space inventory that identifies how many additional classrooms are available in schools now and how many would have to be added. Project STAR data are not useful for making a statewide estimate, because the schools that participated either had to have the necessary space to accommodate any extra classes or they had to supply the space. Only two schools that participated had to add classrooms. Project STAR required smaller classes for only one grade per year. If the program were implemented in three or four grades at the same time, most schools would need extra classrooms. There probably is some available space in many schools across the state but we do not have a good estimate of how much.

Per-student cost estimates for reduction to 15 to 1 are made on two different bases: one, that an additional classroom would have to be added; or two, just the additional operating costs would be required. The primary additional operating costs would be for the additional classroom teachers and the additional cost of maintaining the space. Teacher salaries in 1988 averaged \$23,300. When fringe benefits are added, the average total cost of adding one teacher would be about \$28,500. Operation and maintenance of the physical plant is about 10 percent of the total budget. In 1988 in Tennessee, this averaged about \$6,500 per classroom, making the total additional operating cost \$35,000 per added classroom.

When translated to additional per pupil costs, teacher salaries would add 23.3 percent to per-pupil costs, and operating expense would add 5.3 percent, for a total additional cost of 28.6 percent. These are not precise estimates of actual salaries and additional maintenance costs because they will vary in different systems and at different times. A reasonable range would be between 27 percent and 30 percent. A one-third reduction in class size would not increase operating costs by one third, because the reduction would not affect transportation costs, supplies, or administrative costs.

5. Capital Cost

The cost per classroom added would be \$60,000 to \$70,000 (this assumes that no land purchase is required). If this is amortized over 30 years, the additional cost per year per classroom would be (assuming a 7 percent interest rate) \$4,800 to \$5,600. This would add an additional 4.0 to 4.6 percent per year to the costs per student. Thus in a school that had to add all the space, total costs per classroom would be \$39,800 to \$40,600 and additional costs per student would be \$1,023 (1987-88 prices), or 32 to 33 percent higher, with a range of 31 to 34 percent.

Another approach to providing the additional classrooms would be to adopt a year-round school calendar which would provide the required 180 instructional days, staggered vacation times, and use of the buildings for 12 months.

6. Tennessee's Costs of Reducing Class Size or Adding an Aide

In kindergarten through grade 3 in 1989 there were about 11,410 classroom teachers (this excludes special education, Chapter One teachers, art, music, and P.E. teachers who do not have a regular class). There was an average daily attendance of 22.16 per classroom teacher, which works out to an average daily membership of about 23.5 to 1. To provide a full time aide for every teacher would require the addition of about 8,440 aides to the 2,970 that are currently employed as Basic Skills First aides. The cost of these additional aides, at \$8,900 each, would be approximately 75 million dollars (1988 prices).

If class size were reduced to an average daily attendance of 15 students per teacher (an average membership of about 16 to 1), an additional 5,447 teachers would be needed. At an average cost of \$28,500 (salary and benefits) per teacher plus an additional \$6,500 per classroom in maintenance and operating expense (1988 prices), this would require about 191 million additional dollars.

table (IX-1) below shows the total costs for Tennessee of class-size reductions of various amounts at various costs per classroom.

Table IX-1

**Additional Costs of Reducing Class Size
to Specified ADA Levels for Different Levels of
Teacher Salary (in millions)**

Costs per Classroom	ADA Per Teacher		
	20 to 1	17 to 1	15 to 1
\$35,000 (1987-88 costs)	44	121	191
38,500 (1988-89 costs)	47	133	210
44,000 (1988-89 costs & capital outlay)	54	152	240

7. Benefits

The benefits of a smaller class, or of a teacher aide can be estimated from the difference between achievement scores in small classes and regular classes (or between regular and regular/aide classes). These differences can be expressed as effect sizes. Project STAR effect sizes for reading and math scores (Stanford Achievement Test) are shown below for each year of the project¹ in Table IX-2.

Table IX-2
Effect Size by Grade for Small and Regular/Aides
in Reading and Math

Test and Comparison	Kindergarten	Grade 1	Grade 2	Grade 3	Average of All Grades
Small and Regular					
Total Reading	.21*	.34*	.26*	.24*	.26
Total Math	.17*	.33*	.23*	.21*	.23
Regular/Aide and Regular					
Total Reading	.05	.15*	.11	.05	.09
Total Math	.02	.11*	.05	.03	.05

*Significant at $p < .01$

Another approach to calculating the benefits is to compare the average gains students make each year in small as compared with regular classes (or regular/aide compared to regular). Since there was no pretest for kindergarten entry, gain scores are available for only grades one through three. (The end of kindergarten test score is the pretest for grade one, etc.) The effect of small classes or of using teacher aides is their gain divided by the gain in the regular class. The result is expressed as a percent which indicates the percentage that small-class gain is greater than regular-class gain (see Table IX-3). A figure of less than 100 indicates that the regular (control) group had a larger gain score than the experimental group (either small or regular/aide). Gains in small classes in the first grade were about 15 percent greater than in the regular classes, while in the second grade, the small class had about 2 percent smaller gain in reading than the regular class. This table shows that the gains of a small class or a class with an aide are concentrated primarily in the first grade (and in kindergarten for small classes), and that gains in subsequent years are small or slightly negative (as compared with the regular class). The differences (effect sizes) are about the same from year-to-year because the gains obtained in kindergarten and grade one are maintained.

¹Effect size is the difference between the treatment group mean (the small class or the regular-aide class) and the control group mean (regular class) divided by the standard deviation of the control group. This expresses the experimental effect in standard deviation units. An effect size of less than .25 is considered small, an effect size of .25 to .5 is considered moderate, and an effect size of greater than .5 is considered large.

Table IX-3
Comparative Gain Scores

Comparison Group and Test	Grade 1	Grade 2	Grade 3
Small and Regular			
Total Reading	115.4*	97.6	94.3
Total Math	115.0*	102.5	95.9
Regular/Aide and Regular			
Total Reading	112.1*	101.7	96.1
Total Math	112.7*	106.6	102.6

*Gain Score Significant @ $p < .01$

8. Cost Benefit Comparisons

Cost benefit ratios can be calculated which show, for every \$100 of additional cost, how many effect size points or gain percent points would be obtained. Total costs can be allocated among the different outcomes (reading and math) or a composite outcome can be estimated by averaging the two outcomes. In kindergarten through grade two, the greatest amount of time is spent on reading and language arts, and math is the second largest. Together, these two subjects take up about two-thirds of instructional time with one-third devoted to all other subjects (music, science, art, etc.). In third grade the emphasis on other subjects increases to about 50 percent of the total instructional time.

It is also possible to break down the math and reading time by the percent of time spent on each (based on teacher logs and observed lesson time in grades two and three). In the first two grades, almost twice as much time is devoted to reading as to math (65 percent versus 35 percent). In the third grade the ratio is 60 percent reading and 40 percent math. Calculations which weigh the costs of reading and math equally, and also which weigh the costs proportional to the average of time spent in each subject are presented in Table IX-4.

Table IX-4 indicates that small classes, either with or without capital costs included, are more cost effective than aides in kindergarten and third grade. In first grade small classes and aide classes have similar cost effectiveness when capital costs for small classes are included. In second grade, small classes are more cost effective for math than aide classes, but the two are similar in cost effectiveness for reading.

Table IX-4

**Cost Effectiveness Ratios for Small and Regular/Aide Classes
in Reading and Math, 1987-88
(Effectiveness measured by Effect Size)**

Comparison Group, Subject and Weighting of Cost Allocation	Kindergarten	Grade 1	Grade 2	Grade 3
Math and reading equally weighted				
Small - Regular (without capital costs)				
Reading	.078	.126	.096	.120
Math	.063	.122	.085	.105
Small - Regular (with capital costs)				
Reading	.062	.100	.076	.096
Math	.050	.097	.068	.084
Regular/Aide - Regular				
Reading	.038	.115	.085	.050
Math	.015	.085	.038	.030
Math and reading proportionately weighted				
Small - Regular (without capital costs)				
Reading	.060	.097	.074	.100
Math	.089	.174	.121	.131
Small - Regular (with capital costs)				
Reading	.048	.077	.059	.080
Math	.071	.137	.096	.105
Regular/Aide - Regular				
Reading	.029	.088	.065	.042
Math	.022	.122	.055	.037

Effect size points per \$100 per pupil of additional cost.

9. Discussion

Many research studies estimate benefits by effect sizes, and the cost effectiveness estimates in Table IX-4 can be compared with other interventions that have presented effect sizes and cost. The Levin, Glass and Meister (LGM) study (1984) provides the most direct comparisons since we used their methodology to compute cost effectiveness estimate. The LGM cost figures have to be adjusted for inflation from 1980 to 1988. When costs are expressed in percentage increases, they are quite comparable to those of Project STAR. Their effect sizes were based on a reanalysis of the Glass (1980) meta analysis data for class-size reductions from 35 to 20, which is a 43 percent reduction in size, as compared with a 33 percent average reduction in Project STAR. The LGM cost estimates include capital costs, and their estimate of cost increases is 43 percent for a reduction from 35 to 20.

The difference in estimates of cost effectiveness between Project STAR and LGM is primarily on the effect side. For a 43 percent reduction in class size, LGM estimated an effect of .11 for reading and .22 for math. Project STAR estimates (average of all four years) are .26 for reading, more than twice as high, and .23 for math, quite comparable. Project STAR was only in the early elementary grades, while the LGM covered all grades. Other summaries (Robinson & Wittbols, 1986) of research have indicated that the early elementary grades are the ones most likely to provide advantages for small classes. Another reason is that a reduction from 35 to 20 may not have a proportional effect to a reduction from 23 to 15.

LGM came up with an overall cost-effective ratio of about .09 for reading and math combined to a STAR cost-effective estimate of about .12, about one-third larger.

LGM compare cost-effectiveness for three other interventions: tutoring, lengthening the school day by one hour, and computer aided instruction (CAI). Lengthening the school day had a cost effectiveness ratio of .09, CAI had a ratio of .15, and cross-age tutoring had an effect of .22. The comparisons with Project STAR are shown in Table IX-5, with Project STAR cost-effectiveness ratios of Table IX-4 adjusted for comparability with the LGM estimate.

Table IX-5

Comparison of Cost-Effectiveness Ratios for Different Interventions

Project STAR, full-time aide	.09
Project STAR class size reduction from 23 to 15	.12
LGM class size reduction from 35 to 20	.09
LGM increasing instructional time one hour per day	.09
LGM computer aided instruction	.15
LGM cross age tutoring	.22
LGM peer component	.34
LGM adult component	.07

Source: Levin-Glass Meister Cost Effectiveness of Four Educational Interventions, Center for Educational Research, Stanford University, Project Report 84 A11 (1984) Table 4. Project STAR cost effectiveness ratios adjusted for inflation and averaged across reading and math for all four years.