

Daylighting in Schools

Energy Costs Reduced... Student Performance Improved

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Editor's Note. Ordinarily, architectural-engineering firms are only indirectly concerned with psychological and physical benefits to the occupants of the buildings they design. However, a firm in North Carolina, Innovative Design, is not ordinary. Their use of daylighting in schools yields considerable economic benefits: energy costs reduced up to 64 percent, cooling and electrical equipment costs reduced, long-term mechanical and lighting equipment maintenance costs reduced.

But equally impressive are the benefits of daylighting on student performance. Students in schools using daylighting have higher achievement scores in reading and math tests. Further, as shown in a related study, because of additional vitamin D received by students via daylighting, they will have less dental decay—and grow taller!

In the two performance reports which follow, authors Nicklas and Bailey analyze specific “win-win” benefits of daylighting. Their findings are startling.

The following study analyzes the energy performance and cost of daylit schools designed by Innovative Design in Johnston County, North Carolina. The analysis compares the first-year energy performances of three daylit schools with similar but non-daylit schools in the county. The two daylit middle schools (Selma, Clayton) were completed in the spring of 1993 and the comparison year was July of 1993 through June of 1994. The other school (Four Oaks) was completed in August of 1990 and the first year of collected data was 1991-92.

In addition to the three daylit schools listed above, cost information is also provided on two other daylit schools in the same area.

The Four Oaks School was constructed on an existing campus when the majority of the old school burned.

The two daylit middle schools are very similar in design, both based on a prototype design that incorporates extensive south-facing roof monitors. However, the Selma Middle School is approximately 22,000 square feet smaller and houses 150 less students. The Durant Road Middle School, although much larger, also includes many of the same design features incorporated in the Clayton and Selma Middle Schools. However, Durant utilizes both north and south facing roof monitors. The Clayton Elementary School is considerably different in design but also utilizes south-facing roof monitors as the major daylighting strategy.

In all cases, translucent fabric baffles are suspended in the lightwells to eliminate any direct beam radiation from entering into the work area below. Light sensors are used at each of the schools to stage the backup lighting. All of the schools are designed to achieve in excess of 70 footcandles, through daylighting, over two-thirds of the time the schools are occupied. Each classroom is also equipped with shades that can be used to darken the spaces and override switches to increase lighting levels. Although the shades and lighting override switches provide occasional functional benefits for individual classrooms, they are also the source of reduced daylighting benefit in certain classrooms.

The schools used in the comparison had, at the time of the analysis, the following characteristics:

- a. the majority of space at each school was air conditioned;
- b. the schools were within the same county (a several county region was used in comparing cost of construction);
- c. the majority of the space within the school was being utilized; and
- d. the grade levels were similar.

CHARACTERISTICS OF THE DAYLIT MIDDLE SCHOOLS AND COMPARISONS TO NON-DAYLIT SCHOOLS

Although attempts were made to compare the daylit schools to similar schools within the county, there were several significant energy related differences. Although the daylit schools performed extremely

well, the following factors significantly increased the energy consumption and made the comparisons closer than otherwise would have been the case. Energy consumption in the daylit schools was abnormally high because:

- a. the Clayton and Selma schools were the newest (and daylit) and they were utilized much more for extracurricular activities and community events, accounting for considerably more night-time and weekend use;
- b. the gymnasiums were extensively used during the summer and at night;
- c. the schools were equipped with individual classroom TV/video monitors and communication systems;
- d. more electrical equipment and computer technology was incorporated into the schools;
- e. in the Four Oaks case, the gymnasium and cafeteria were shared with a middle school; and
- f. the newer schools required considerably more fresh air make-up.

Both Clayton and Selma had central, natural gas boilers for heating and Four Oaks heating was with oil.

In all cases it appears that, even though the schools were not designed as year-around schools, they were occupied (at least by staff) most of the year.

THE COST OF DAYLIGHTING

The following lists both new daylit schools and non-daylit schools constructed in the immediate, several-county region of North Carolina during the time frame of our study. Taking into account the general trend of greatly escalating school construction costs, the daylit schools are very comparable. The highlighted schools indicate daylit schools designed by Innovative Design since 1990. In addition to the Clayton and

Selma Middle Schools and the K-5 Four Oaks School, we have also included cost data on the Durant Road Middle School for Wake County and the Clayton Elementary School for Johnston County.

In all of these schools the cost of the daylighting components have added little to the first-cost of the projects. In the Durant Road Middle School the owner was particularly interested in calculating the energy cost versus savings attributed to the daylighting schemes employed. Through extensive cost estimating by an independent construction cost estimating firm, it was determined that the added cost of the daylighting features totalled \$230,000. However, when one accounts for the \$115,000 in mechanical equipment and electrical system downsizing possible because of the cooling and lighting load reductions, the net additional cost to the project was \$115,000—less than 1% of the total construction budget. The overall project, when completed, was 5% under budget and the daylighting/energy investment (when compared to typical new middle schools in the area) will be returned to the school system in less than a year.

<u>Middle/High</u>	<u>Bid</u>	<u>Sq. Ft.</u>	<u>\$/Sq. Ft.</u>
Clayton	91	120,000	\$65.26
Selma	92	98,000	\$71.89
Carrboro	92	136,266	\$81.17
Davis Drive	93	132,000	\$70.79
Durham	93	290,046	\$72.35
Durant Road	94	148,500	\$83.04
Chapel Hill	94	191,569	\$107.19

<u>Elementary</u>	<u>Bid</u>	<u>Sq. Ft.</u>	<u>\$/Sq. Ft.</u>
Four Oaks	90	120,000	\$55.02
Cleveland	93	103,079	\$71.93
Davis Drive	93	76,000	\$72.57
Eastway	93	78,000	\$83.22
Oak Grove	94	77,586	\$90.95
Hodge Road	94	75,070	\$89.37
Weatherstone	94	75,070	\$93.18
Clayton	95	96,800	\$90.75

In our latest school—the Clayton Elementary School—the daylighting components were bid as an alternate in order to clearly iden-

tify the actual costs associated with the daylighting. This was done at the request of the North Carolina Division of School Planning that was, at the time, very critical of daylighting. The total daylighting investment, based upon a simple payback, will be recouped in under three years.

In the Four Oaks, Clayton and Selma schools built earlier, estimates indicated the investments in daylighting could be recaptured within three to nine years. Since these earlier projects, the improvements in cost-effectiveness can be mostly attributed to 1) the downsizing of conservatively sized mechanical and electrical equipment, 2) improvements in the roof framing design, and 3) improved lighting controls.

DOLLAR SAVINGS FROM DAYLIGHTING

The first year following the construction of the new Clayton and Selma Middle Schools the following energy consumption data was compiled between the daylit schools and several comparable, non-daylit schools. The school year starting in July 93 and ending June 94 had the following weather conditions:

- a. Cooling Degree-Days were 12.3% above the norm
- b. Heating Degree-Days were 5.1% above the norm
- c. % Sunshine during the Cooling Season was 4.7% above the norm
- d. % Sunshine during the Heating Season was 6.8% below the norm

These conditions would indicate an abnormally high energy bill for all the schools being compared but particularly the daylit schools which are impacted more by reduced sunshine in the heating season.

Energy Costs of Daylit Middle Schools in Johnston County (July 93-June 94)

The following costs reflect:

- (a) actual cost per square foot with all exterior lighting included
- (b) cost if each school had same electrical rate of \$.09/kWh
- (c) cost with same electrical rates and exterior lighting loads subtracted

<u>Daylit Schools</u>	<u>\$/Square Feet</u>			
	(a)	(b)	(c)	(*)
Clayton Middle	.90	.90	.84	(.71)
Selma Middle	.97	.92	.90	(.77)
Average Daylit	.94	.91	.87	(.74)

*In typical climatic years Clayton's cost would drop to \$0.71/sq.ft. and Selma's cost would be \$0.77/sq.ft., averaging \$0.74/sq.ft. for the daylit schools.

<u>Non-Daylit Schools</u>	(a)	(b)	(c)
North Middle	1.00	1.03	1.00
Smithfield Middle	1.42	1.17	1.14
Smithfield-Selma HS	1.43	1.22	1.12
South HS	1.20	1.29	1.23
Average Non-Daylit	1.26	1.18	1.12
Savings/Sq.Ft.	.32	.27	.25

It is our conclusion that the measured energy savings between average daylit and non-daylit schools of \$.32/square foot (or \$.25 per square foot discounting utility price differences and exterior lighting) should be viewed as a minimum benefit since there are numerous factors relating to additional use which, if all accounted for, would increase the benefit.

Lack of data and the existence of other elementary schools that are similar (i.e., other elementary schools did not have air-conditioning), prohibit an accurate comparison to other elementary schools in this first year of recorded data, but the following consumption data for Four Oaks was recorded during the 91-92 time frame. During this time frame the following weather conditions were experienced:

- a. Cooling Degree-Days were 11.7% above the norm
- b. Heating Degree-Days were 5.1% below the norm
- c. % Sunshine during the Cooling Season was 6.1% below the norm
- d. % Sunshine during the Heating Season was 6.5% below the norm

It should be noted that despite the higher than normal cooling degree-days, the facilities appeared to not be used as much during the summer months as they are in later years when summer use more than doubled. 1990-91 had 5.1% lower heating degree-days but also had 6.5% less winter sunshine.

Energy Costs of Daylit Four Oaks K-5 School (May 91-April 92)

Four energy cost scenarios, in energy \$/square foot/year, reflect different ways of viewing the energy usage. The range between "C" and "D" represents the best estimate of the "building" energy cost associated with the K-5 component of the campus.

- (a) Reflects actual bills which included all of the gymnasium, cafeteria, and exterior lighting
- (b) Proportions gymnasium and cafeteria energy use between the middle school and the K-5
- (c) Proportions gymnasium and cafeteria-energy use and subtracts exterior lighting
- (d) Same as (c) except estimated use of gymnasium and cafeteria reflects a high 75/25 split to account for additional middle school, community use and athletic events

Scenario \$/Sq.Ft./Year

- (a) \$.53
- (b) \$.46
- (c) **\$.44**
- (d) **\$.40**

The energy costs at Four Oaks are less than 40% of those experienced in other elementary schools (when air conditioning was added in later years). For example, in 1993/94 (with similar energy costs for electricity and oil) the Clayton Primary School consumed \$1.03/square foot and Benson Elementary used \$1.11/square foot.

TRACKING THE BTUs

At Four Oaks School the energy consumption in Btus/square foot per year for the same four scenarios are listed below.

Energy Consumption of Daylit Four Oaks K-5 School (May 91-April 92)

<u>Level of Inclusion</u>	<u>Btu/Sq.Ft./Year</u>
(a)	36,952
(b)	31,779
(c)	30,984
(d)	28,396
objective:	36,000

The objective of Innovative Design was to achieve, for the Four Oaks School, 36,000 Btus/square foot per year. The 28,396 to 30,984 Btu/square foot range represents a 14% to 21% reduction from the objective. In an adjacent county, 87 separately monitored schools, during the same time frame, consumed between 30,900 and 126,300 Btus/square foot/year. This range covered a wide variety of new and existing buildings with numerous mechanical, electrical and build shell differences.

At Clayton and Selma Middle Schools, like other middle schools, energy consumption would logically be greater. At Clayton the energy objective was to achieve 41,400 Btus per square foot, based upon 9 months occupancy and normal nighttime and weekend use. As previously pointed out this did not turn out to be the case for either Clayton or Selma as utilization of the facilities was greater than anticipated.

The following reflects the actual energy consumed as well as different estimates of the effects of abnormal conditions and the impact of additional use. The 1993-94 year had 12% more cooling degree-days, 5% more heating degree-days, and 7% less sunshine during the heating season.

Energy Consumption of Daylit Clayton and Selma Middle Schools (July 93-June 94)

- (a) Reflects total energy use for campus including exterior lighting
- (b) Same as (a) except exterior lighting is subtracted to reflect only the building load

- (c) Same as (b) except this reflects a correction to account for typical heating and cooling degree days as well as percent sunshine
- (d) Same as (c) except consumption attempts to account for a 50% reduction in summertime energy use, more closely reflecting a typical 9-month school schedule

<u>Scenario</u>	<u>Btu/Sq.Ft./Year</u>	
	Clayton	Selma
(a)	53,443	53,114
(b)	51,168	50,502
(c)	47,315	47,486
(d)	43,731	44,282
objective:	41,400	

CONCLUSIONS

The most obvious conclusion is that daylighting, even excluding all of the productivity and health benefits, makes sense from a financial investment standpoint. The daylit schools in the study indicated energy cost reductions of between 22% to 64% over typical schools. With paybacks on all the new daylit schools below three years, the long term benefits to a school system are enormous. In North Carolina, a 125,000 square foot middle school that incorporates a well integrated daylighting scheme is likely to save \$40,000 per year over what is typically constructed. And, if energy costs go up by 5% per year, the savings on just this one school, over the next ten years, would exceed \$500,000.

From an analytical standpoint, it also appears wise to assume that:

- a. even though the school program calls for a nine month schedule, anticipate the school will be occupied for 12 months;
- b. public spaces (i e., gymnasiums, cafeterias and libraries) will be utilized considerably more than is needed to fulfill just the students' class needs;

- c. internal loads due to computers and other electrical equipment will greatly exceed amounts typical of previous years;
- d. new requirements for fresh air make-up will drastically impact energy consumption;
- e. indoor temperatures, if individual room controls are provided, will routinely exceed 70°F in the winter and 76°F in the warmer months; and
- f. that the daylighting performance, even though controlled by light and motion sensors, will ultimately be determined by the teachers and, in particular, the schools' principals that greatly influence attitudes.

References

Johnston County Energy Consumption Data
Johnston County Schools' Maintenance Department, January, 1996.

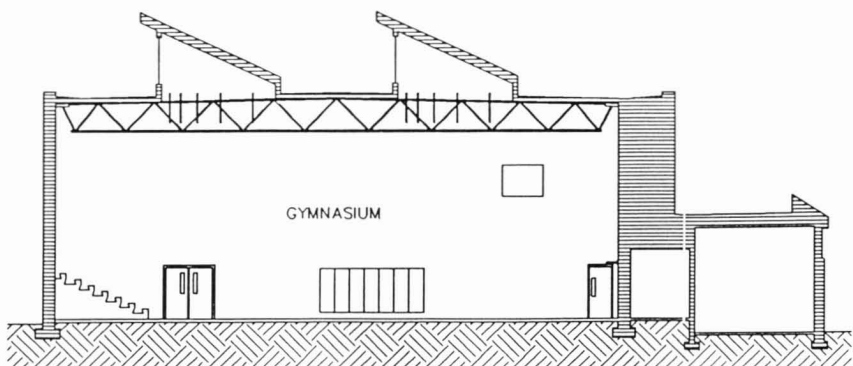
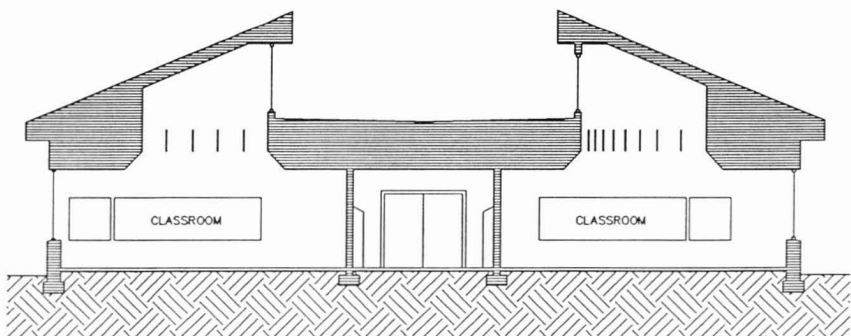
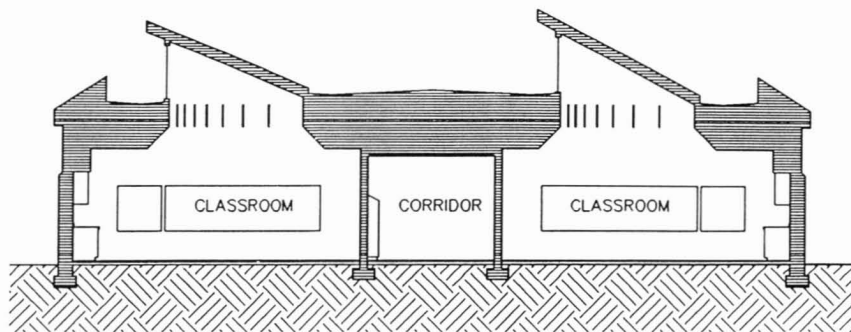
STUDENT PERFORMANCE IN DAYLIT SCHOOLS

The conclusions of a recent research project on the impacts of full-spectrum light on student performance and health prompted us to investigate the performance of students attending three daylit schools that were designed by our firm. The "Study into the Effects of Light on Children of Elementary School Age: A Case of Daylight Robbery" was conducted in Alberta, Canada, by the Policy and Planning Branch of Alberta Education. Over a 2-year period, the study compared children attending elementary schools with full-spectrum light versus children attending similar schools with normal lighting conditions.

The most striking conclusions of this study were:

- a. the students in full-spectrum light were healthier and attended school 3.2 to 3.8 days more per year;
- b. libraries with superior light resulted in significantly lower noise levels;

Three Typical Daylit School Sections



- c. full-spectrum lighting induced more positive moods in students; and
- d. because of the additional vitamin D received by the students in full-spectrum light, they had 9 times less dental decay and grew in height an average of 2.1 cm more (over the 2-year period) than students attending schools with average light.

The following analysis investigates the relationships between elementary and middle school student performance and natural daylighting. The performance of students attending three daylit schools designed by Innovative Design for Johnston County Schools (described in the preceding section) was analyzed and compared to the county school system as a whole and other new schools within the same county. The first daylit school, completed in August of 1990, was the Four Oaks Elementary School. The Clayton Middle School and the Selma Middle School were very similar in design; both were developed around a daylit prototype design and constructed in the spring of 1993.

EVALUATION AND COMPARISON OF TESTING PERFORMANCE

To compare the performance of the students, the test results from both the California Achievement Tests (1987/88-1991/92) and the End-Of-Grade Tests (1992/93-1994/95) were compiled for every school (16 elementary and 8 middle schools) within Johnston County. The test result summaries were provided by the Johnston County School System. From 1987/88 through 1991/92 the average total battery scores of the California Achievement Tests were compared for 3rd, 4th and 5th grade students. First and second grades were not tested. After 1991/92 the average of the reading and math components of the End-Of-Grade Tests are used to compare performance.

The California Achievement Tests were given each year through the 1991/92 school year. The tests were administered in March or April of the school year. After the 1991/92 school year, the evaluation testing was switched to End-Of-Grade Testing and was given in May of each year. Because of the differences in the tests, it has been recommended by both Johnston County Schools and State Department of Public Instruction that we do not compare scores between the two types of tests.

The analysis consisted of reviewing:

- a. improvement in performance within each school from year to year;
- b. relative improvement in performance between Innovative Design's three daylight schools and the improvement in the county-wide average for similar grade levels;
- c. first year student performance at a fourth daylight school (designed by another firm); and
- d. relative improvement in performance of a new, non-daylit middle school constructed in the county during the same time frame.

Because significant differences existed between the student and teacher make-up at each school, the comparisons we have made do not attempt to draw conclusions regarding the average scores between the various schools. To help minimize this problem of false comparisons, the relative improvement within each school is viewed as the more significant comparison. For example, if the CAT score average at one school increases from 60 to 70, this 17% improvement is compared to another school whose grade average may have risen from 50 to 55, or a 10% improvement. But, the average CAT score of 60 versus 50 was not considered important.

All three of Innovative Design's schools incorporated designs which maximized daylighting through the use of south-facing roof monitors and allowed controlled sunlight to enter into all major occupied spaces within the schools. The roof monitors were designed to provide superior lighting (in excess of 70 footcandles) two-thirds of the time during which the spaces were to be utilized. In all cases the roof monitors were equipped with baffles which eliminate glare into the rooms and with light sensors which control the artificial lighting. Smaller windows were also incorporated for view but were not a significant element in the daylighting strategies.

FOUR OAKS ELEMENTARY SCHOOL

The Four Oaks School situation is unique because we were able to trace the progression of a rather homogeneous group of students through various classroom environments. In December of 1988 the ma-

majority of the old Four Oaks School burned to the ground and the facilities were replaced by a new, daylit school. During the 1988/89 and 1989/90 school years the students were placed in mobile units/temporary facilities. In August of 1990 the new daylit K-5 School was completed and the first CAT's were taken by students in the new daylit school during 1990/91. The last year that CAT's were given was the 1991/92 school year.

From a case study standpoint, the Four Oaks situation reflects a good comparison because we are able to track a student population from 1) a condition where the same group of students was in a typical Johnston County school setting, to 2) a situation where they were relocated to mobile classrooms, to 3) where the students were in daylit school facilities.

Table 1 shows the results of the CAT scores for the students at the Four Oaks School and the averages for all Johnston County School (including the daylit schools) during the same time frame. The scores reflect the averages of the total battery of reading, language, and math.

Table 1. Four Oaks Elementary Daylit School (1987/88 - 1991/92 California Achievement Tests

<u>Grade</u>	<u>Four Oaks/County</u>	<u>87/88</u>	<u>88/89</u>	<u>89/90</u>	<u>90/91</u>	<u>91/92</u>
3rd	Four Oaks	67	61	67	79	76
	County Average	63	70	68	66	65
4th	Four Oaks	70	55	65	70	72
	County Average	57	58	64	62	65
5th	Four Oaks	52	61	56	66	69
	County Average	56	68	63	67	67
Ave.	Four Oaks 3-5	63.0	59.0	62.1	71.7	72.3
	County Average	58.7	65.3	65.0	65.0	65.7
CAT Score						
relative to norm		+4.3	-6.3	-2.3	+6.7	+6.6
% above/below norm		+7%	-10%	4%	+10%	+10%

Four Oaks Conclusions

Before the school was destroyed by fire in 1988, the students at Four Oaks had CAT's 7% higher than the norm within Johnston County. As students were relocated and placed in mobile classrooms, their performance dropped dramatically. The following year the student's grades went from 7% above to 10% below the norm—a 17% decrease in performance.

The first year the CAT's were given, after the new daylit K-5 school was complete, the students' performance increased, equally dramatically, to 9% above the norm. The next year, the last that the California Achievement Tests were given, the student performance leveled off and was again 9% above the norm for the county.

In comparing the relative increase in performance between the 1988 (the testing year before the fire) and 1992 (the last year of comparable data), the county-wide average scores increased from 58.7 to 65.7, or by 12%. However, the students' performance at Four Oaks, during the same time frame, increased at a 3% higher rate of 15%, going from 63 to 72.3. Figure 1 shows this comparison.

DAYLIT CLAYTON AND SELMA MIDDLE SCHOOLS

Comparisons were made between the End-Of-Grade Testing results at the new daylit Clayton and Selma Middle Schools to the other new middle school in the county, North Johnston Middle. These same schools were then compared to the county-wide averages (which included the daylit schools).

Because of changing student body make-ups, it is difficult to accurately compare the students that attended other schools, prior to 1992/93, with those that attended the new Clayton or Selma schools. Because the California Achievement Tests were stopped in 1991/92 and the End-Of-Grade Tests were started in 1992/93, it is even more difficult to accurately track the past progression. Because of this, no attempt has been made to make any comparisons between later years and years prior to 1992/93. However, since the Clayton and Selma students were at the new schools for only a couple of months prior to the first year of the End-Of-Grade testing, this was logically established as the base year. It is assumed that because of the very short time period at the new school during the base year, little impact would have occurred.

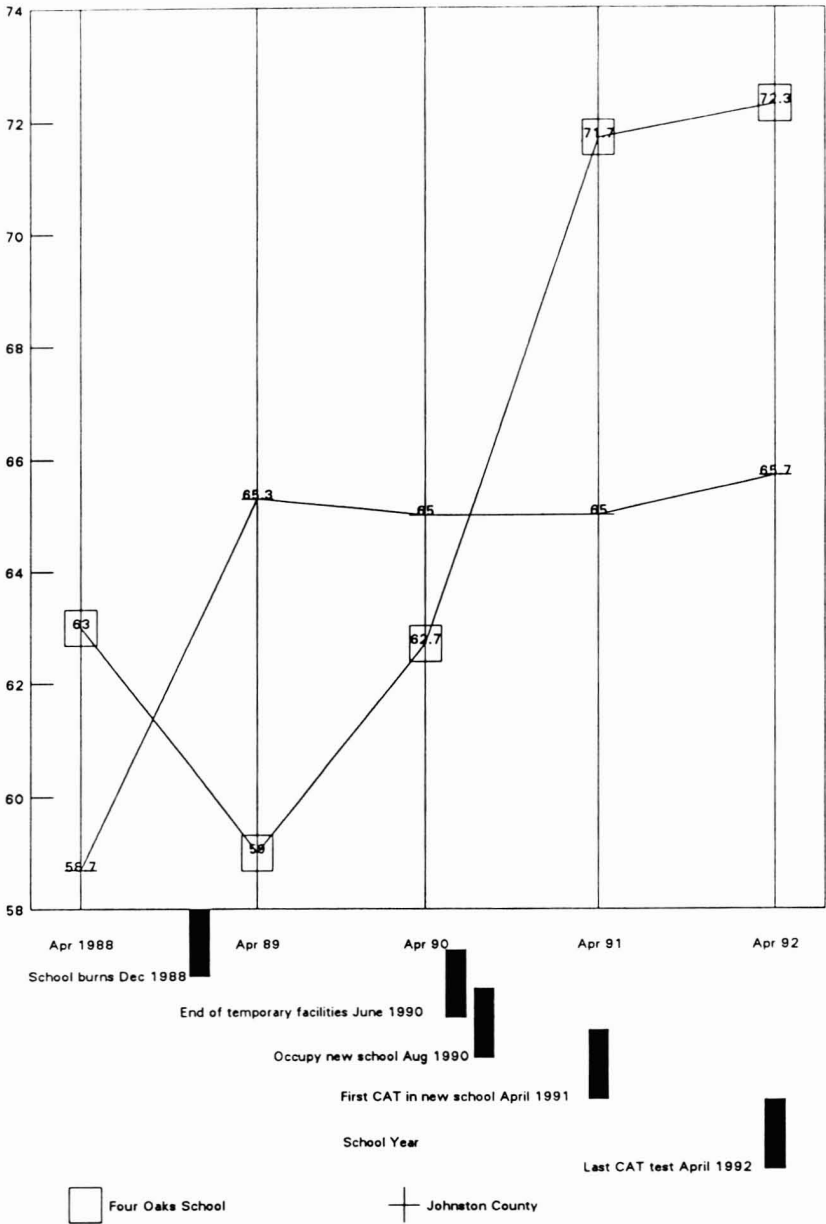


Figure 1. California Achievement Test Score
Four Oaks School vs. Johnston County

These 1992/93 scores were then compared to the results of the next two years to see the relative improvement. To help eliminate as many variables from the comparisons as possible, the test results between 1994 and 1995 were averaged. Between 1993 (base year) and the average of 1994 and 1995, the county-wide improvement was 5%. Because testing was not conducted for the Selma 8th grade in 1992/93, the comparisons made for Selma reflect only the 6th and 7th grades.

To better evaluate the impact of multiple years of being in the daylight schools, the scores associated with only the final grade level at each of the schools were also compared (i.e., 8th grade at Clayton and North Johnston and 7th grade at Selma).

End-Of-Grade testing, by law, is given in May of each year. Both Clayton and Selma Middle Schools were opened in March of 1993, just two months prior to the first End-Of-Grade testing.

Average of Reading/Math for all Grades

	1992/93 Base Year	Average 1993-95	% Improvement Base-Average
Average Score			
Clayton 6-8	68.4	73.2	+7%
Selma 6-7	46.3	54.8	+18%
N. Johnston 6-8	62.5	64.2	+5%
County Aver 6-8	62.1	65.4	+5%
County Aver 6-7	61.3	64.6	+5%
EOG Score relative to norm			
Clayton	+6.3	+7.8	+1.5
Selma	-15.0	-9.8	+5.2
N. Johnston	+4	-1.2	-1.6

Average of Reading/Math for Last Grade Only

	1992/93	1993/94	1994/95	%Improvement Base 1994/95
Average Score				
Clayton 8th	69.2	67.8	83.8	+21%
Selma 7th	45.6	51.8	60.3	+32%
N Johnston 8th	69.9	58.9	68.6	-2%
County Aver 8th	63.8	64.3	70.2	+10%
County Aver 7th	61.4	59.7	70.4	+15%

Non-Daylit North Johnston Middle School

California Achievement Test data is also available for the non-daylit North Johnston Middle School for the time period of 1987/88 to 1988/89 when the students were in the old North Johnston Middle School, and from 1989/90 to 1991/92 after they moved to the new school. Although test results can't be compared before and after 1992, (because one being the CAT and the other being End of Grade) it is interesting to see if there was a positive trend after the students moved into the new school and to see if this trend followed in subsequent years. North Johnston Middle School was opened in August of 1989.

It would be logical to assume that any new school would have a positive impact. This didn't prove to be the case.

Non-Daylit North Johnston Middle School
(1987/88-1991/92 California Achievement Tests)

		Old North Johnston		New North Johnston		
<u>Grade</u>	<u>N Johnston/County</u>	<u>87/88</u>	<u>88/89</u>	<u>89/90</u>	<u>90/91</u>	<u>91/92</u>
6th	North Johnston	52	53	59	56	49
	County Average	54	56	63	65	65
7th	North Johnston	58	54	54	57	61
	County Average	53	53	55	58	60
8th	North Johnston	59	55	61	52	53
	County Average	56	55	56	54	53
Aver	North Johnston	56.3	54.0	58.0	55.0	54.3
	County Average	54.3	54.7	58.0	59.0	59.3
CAT Score relative to norm		+2.0	-.7	0.0	4.0	-5.0
% above/below norm		4%	-1%	0%	-7%	-8%

Clayton, Selma, and North Middle Conclusions

The fact that a school is new doesn't guarantee that grades improve. Between 1988 and 1992, the average CAT results in Johnston County (for the same 6-8 grade levels) increased 9%. To the contrary, the

new North Johnston Middle School (non-daylit) experienced a 4% decrease in test results. This comparison seems reasonable since there was a very high correlation between the students that attended the old North Middle and those that attended the new North Middle. However, if you look at just the progress from the first year in the new school (1989/90) to 1991/92 the results are similar. The county-wide average improved 2% while North Johnston decreased in performance by 6%—a net 8% drop in student performance.

In tracking North Johnston Middle even farther, when the End-Of-Grade Testing started in 1993, one sees no improvement as the school closely tracks the county-wide averages.

The daylit schools performed much better. In comparing the scores in 1992/93 (two months after opening operations for both Clayton and Selma) with the average scores between 1993/94 and 1994/95, the improvement is significant. While the county-wide improvement in test results improved 5%, Clayton improved 7% and Selma rose by 18%. North Johnston's students tracked the county-wide 5% improvement.

However, if you compare only the older students, reflecting those who attended the daylit school for three years (two for Selma) from 1992/93 to 1994/95, one sees even more notable improvement. This analysis attempts to determine the impact of multiple years in a daylit school. For example, in 1992/92, the Clayton eighth graders were in the daylit school for only a couple of months. At the time of the 1993/94 testing, the eighth graders had been there two years and by 1994/95—three years. At the daylit Clayton Middle, the 8th graders improved by 21% from the base year, while the other 8th graders in the county improved by 10%. At North Johnston Middle the students' performance actually decreased by 2%. Selma Middle, the other daylit school, showed even greater improvement with test results rising by 32% (versus norm of 15%) over those in 1992. This would indicate the longer-term impact by attending a daylit school could result in a 14% ($11\% + 17\%/2$) increase in student performance.

CONCLUSIONS

Although there are many variables that can alter student performance, it appears that the students attending daylit schools clearly benefit by being in the superior, daylit learning environments.

- 1) The students who attended daylit schools outperformed the students who were attending non-daylit schools by 5 to 14 percent, depending upon whether you consider short or long-term impacts. When analyzing the improvement experienced by all the reference classes at Four Oaks, Clayton, and Selma, the average improvement was 4.7%.

School	Comparison Yrs	Net Change in Student Performance	Percent Improvement
Four Oaks K-5	87/88-91/92	+4.3 Above norm to +6.6 = +2.3	107% above norm to 110% = +3%
Clayton	92/93-93/95	+6.3 above norm to +7.8 = +1.5	110% above norm to 112% = +2%
Selma	92/93-93/95	-15.0 below norm to -9.8 = +5.2	24% below norm to 15% = +9%

Average CAT Grade = +3.0 Ave % Improvement = +4.7%

When you consider the impact on student performance resulting from being within a daylit facility for multiple years, the impact is even greater. During the same time frame, Clayton’s 8th graders showed a 21% improvement versus the norm improvement of 10%. The Selma Middle School 7th graders showed a 32% gain versus the norm of 15%. This equates to an average increase of 14% better performance by the students in daylit schools.

- 2) “New” does not necessarily translate into better performance. The new, non-daylit North Johnston Middle School actually showed a negative impact on the students’ performance.
- 3) It is quite clear that placing students in temporary, mobile classroom units had a very significant and negative impact on the performance of students. The year following the Four Oaks School destruction and the subsequent students relocation, the average CAT scores went from 7% above the norm to 10% below the norm for the county—a 17% decrease in student performance.

References

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