PLANNING EDUCATIONAL SERVICES*

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A school system can be visualized as a firm utilizing capital and labor to produce its output. It must compete with other firms in purchasing its inputs. It is broadly concerned with efficient use of resources to produce its product. However, there is no well-defined product nor a price that can be attached to its product, and most of its product is not directly sold. Users (students) exert little pressure to increase efficiency, not only because they lack mature judgment and are unaware of input-output relationships (often inputs as well as outputs are ill-defined and uncertain), but also because efficiency gains are not passed to users. Furthermore, factors outside the school system influence output throughout the long production process. Even if the price mechanism does not work, economic principles can still be used in education to improve decision making.

Economic analysis is applied to education in a manner similar to any other activity which uses scarce resources. This type of analysis encompasses the allocation of a community's scarce resources so as to satisfy wants or objectives. It requires adequate information on (1) educational objectives, (2) performance of various educational methods or inputs in attaining these objectives, and (3) costs associated with these educational methods or inputs.

This paper identifies educational inputs and outputs and relates their use to relevant economic principles which can be followed to improve a school system's efficiency of operation. It discusses production functions for educational output and cost relationships which allow for factor substitution and control for quality. These costs and production functions are then combined to find the most efficient method of producing a given output. The study simultaneously determines the optimum organization of resources within a school district, as well as the optimum school district size.

EDUCATIONAL PRODUCTION FUNCTIONS

Input-output relationships can be used to determine the consequences of changing input combinations. Output variables ideally should represent what the school system is trying to do. Input variables ideally should include all factors which influence output of the school system .

Educational output

The output of a school's program is measured by the number of students in the program and the quality of schooling. Quality of the schooling program is ultimately measured by the behavior it produces in the students who pass through it. Since the many dimensions of lifetime behavior are difficult to assess, variables such as achievement test scores, dropout rates and absentee rates (which are known to be related to subsequent behavior) were used herein to measure schooling quality.

Educational input

Three general factors determine the output of an educational system–student input, educational process, and environment. Student input variables are defined as the characteristics and level of attainment of students at the beginning of an educational program. Educational process variables are all the activities in a school that are designed to raise students' level of attainment. Environmental or background variables are circumstances in the community and the home that facilitate or impede the educational process.

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These factors of production were specified as a hierarchy of inputs based on how their values were determined. First, the school board has at its disposal an array of policy or instrumental variables which it can use to reach certain objectives. There are, however, a large number of factors whose values are determined outside the school system; these factors are control variables.

Instrumental variables. The educational process variables are the focal point of the allocative analysis and are placed in the first echelon. These educational process variables include program offerings, teaching innovations, instructional materials, and teacher characteristics. Teacher characteristics which affect student performance include workloads, qualifications and salaries. The scope of the program is based on the number and type of course offerings and special services provided by the school. Capital services–plant, grounds, equipment and instructional materials–are an important factor in an educational system. The volume of capital services actually used is difficult to measure, but the inclusion of approximate measures of capital services in the model appears desirable.

Control variables. The second echelon of inputs into the educational system include those control variables--student input and environmental variables–which at least in the short run must be considered fixed. The student input and environmental variables are interrelated, making it difficult to distinguish their separate effects on output.

The output of the educational program depends heavily on the quality of students that enter the program. Students' educational potential and commitment to education are important determinants of student performance. Environmental variables which affect student performance include parents' education, occupation, income, residence and interest in their children's education.

Regression results

Data from a random sample of Oklahoma school districts were used to estimate the effect of various inputs on educational output in grades 4, 8, and 11 [2, pp. 51-77]. In a stratified sample, the population of school districts in Oklahoma was divided into sub-populations according to geographic location and size of school district. The sample was designed to be proportional, sampling five percent of the districts in each stratum.

Regression analysis was used to estimate the net relationship between educational process variables and educational output, while holding the control variables constant. In this analysis, the achievement scores, absentee rates and dropout rates are termed the dependent variables. The educational process, student input and environmental variables are the independent or explanatory variables. The regression equation is essentially a formula for predicting the value of the dependent variable.

Significant variables.[1] The students intelligence quotient (IQ), representing ability, was positively related to educational output in elementary. junior high and high schools. Time spent studying and number of books read outside of school, as measures of educational effort, were also positively related to output. Parents' education, occupation and income were directly related to student attainment. Parents' plans for their children's continuing education and number of times that parents talk to their children about schoolwork, representing parents' interest in their children's education, were positively related to student attainment.

Of the educational process variables, those variables associated with teacher performance had the greatest impact on educational output. Teachers workloads, measured by pupil-teacher ratios and percentage of teachers with a planning period, were especially important in the lower grades; lighter workloads were associated with higher output levels. Teacher education (percentage of teachers with a masters degree) was positively related to output in high school. Higher teacher salaries, standardized for experience and education, improve all dimensions of educational output. The level of teacher experience was also important. Teacher experience was more important in lower grades than in high school and was more important in reducing absentee and dropout rates than in raising achievement.

As measures of the program, availability of kindergarten was positively related to elementary achievement and number of nonvocational units were positively related to high school achievement. Instructional materials–periodicals, printed volumes and audiovisual material–were positively related to output in lower grades. Availability of facilities was positively related to high school achievement; and school district size was negatively related to all dimensions of educational output, other variables held constant.

Nonsignificant variables. Identification of variables which did not have a significant effect on student attainment can also be an important part of evaluation. Ability groupings, special education and accelerated classes appeared to have little effect on

[1] Coefficients of the variables included in the stepwise regression equations were significant at the .10 level.

elementary student performance. Teacher education and facilities also showed no significant effect on elementary student performance. Variables related to teaching workload had no significant effect on student performance in high school. Of course, it is possible that some of these variables may have been important but did not show significance because of limited data in the sample or because they were closely correlated with other variables which were included in the equation.

Input-output limitations. The input-output relationships discussed above can be used to improve the quality of educational output by changing factor inputs. Policy decisions should not be based solely on the significance of a factor's effect on educational output, but should be based on the impact of a factor on output in relation to its cost relative to other factors. Consequently, analysis of schooling cost is also needed.

EDUCATIONAL COSTS AND COST FUNCTIONS

A thorough analysis of a rural school district's operation requires cost data on transportation as well as education. The problem of providing high-quality education at a reasonable cost in rural areas is intensified by the high cost of transportation. The large variation among schools in the quality of educational programs must also be accounted for in estimating cost functions. Measures of quality used to derive the cost relationships include achievement scores as well as the number and type of credit units offered.

In planning for educational services, it is useful to know how costs of education vary with the number of students in a school district. This paper is concerned with a long-run period, a time interval of sufficient duration to allow a school district to vary in size. The long-run average cost curve shows the minimum cost of producing various outputs. In other words, a school district can operate on the long-run average cost curve only if resources are combined efficiently for each level of output. Much concern over school district size relates to per-unit costs associated with educating students in school districts of different sizes. The long-run average cost curve for school districts is thought to exhibit both economies and diseconomies of size.

Internal economies of large-scale production are primarily a long-run phenomenon, dependent upon appropriate adjustment of plant scale to each successive output [1, p. 213]. An illustration of technical internal economies would be the savings in teacher requirements per student made possible by a larger scale of operation. Average cost curves derived from the random sample of Oklahoma school districts are presented in Figure 1 [2, pp. 78-112]. Educational costs considered here include expenditures for administration, instruction, plant operation and maintenance, buildings and equipment. The average educational cost curve, adjusted to a standard quality of output per student ADA, exhibits significant economies of size to 800 ADA.

On the other hand, major diseconomies of size accrue from transportation costs. Such costs are particularly prominent in sparsely populated areas. All costs of operating school buses were combined to derive the average cost of transporting students by various student densities and district sizes. Students were assumed to be evenly dispersed. The average transportation cost curve for a student density of 1.8 transported students per square mile, typical for rural areas, is presented in Figure 1. This analysis assumes there were 265 nontransported students, the sample average.

An examination of a school district's long-run average cost curve provides some insight into how large the school district should be. The optimum size of school district is defined as that which has minimum long-run average costs with resources combined in a least-cost manner. For this analysis the average transportation and educational cost curves were added together to get the average cost of all the school district's functions (Figure 1). The curve's minimum occurs at 675 ADA. However, the curve is very flat between 400 and 1,100 ADA. School districts can operate anywhere within this range without significant differences in per-unit costs.

LEAST-COST COMBINATION

The school district can combine factor inputs in varying proportions to produce its output. The problem facing the school district is to use factor inputs in such a way that, whatever the output produced, the cost will be a minimum. In mathematical terms, the problem is one of constrained cost minimization in which the restrictions on output are the constraints.

A separable programming model used data on cost and production functions to find the minimum cost of a given quality of education. Activities affecting both costs and production included teacher qualifications and workloads and instructional materials. For example, lowering the pupil-teacher ratio increases student performance, as shown by the estimated production functions, but increases cost. This trade-off is taken into consideration to determine the optimum pupil-teacher ratio for a given quality of output. Costs of administration, buildings and equipment were linked directly to ADA or school district size. This model provides information on

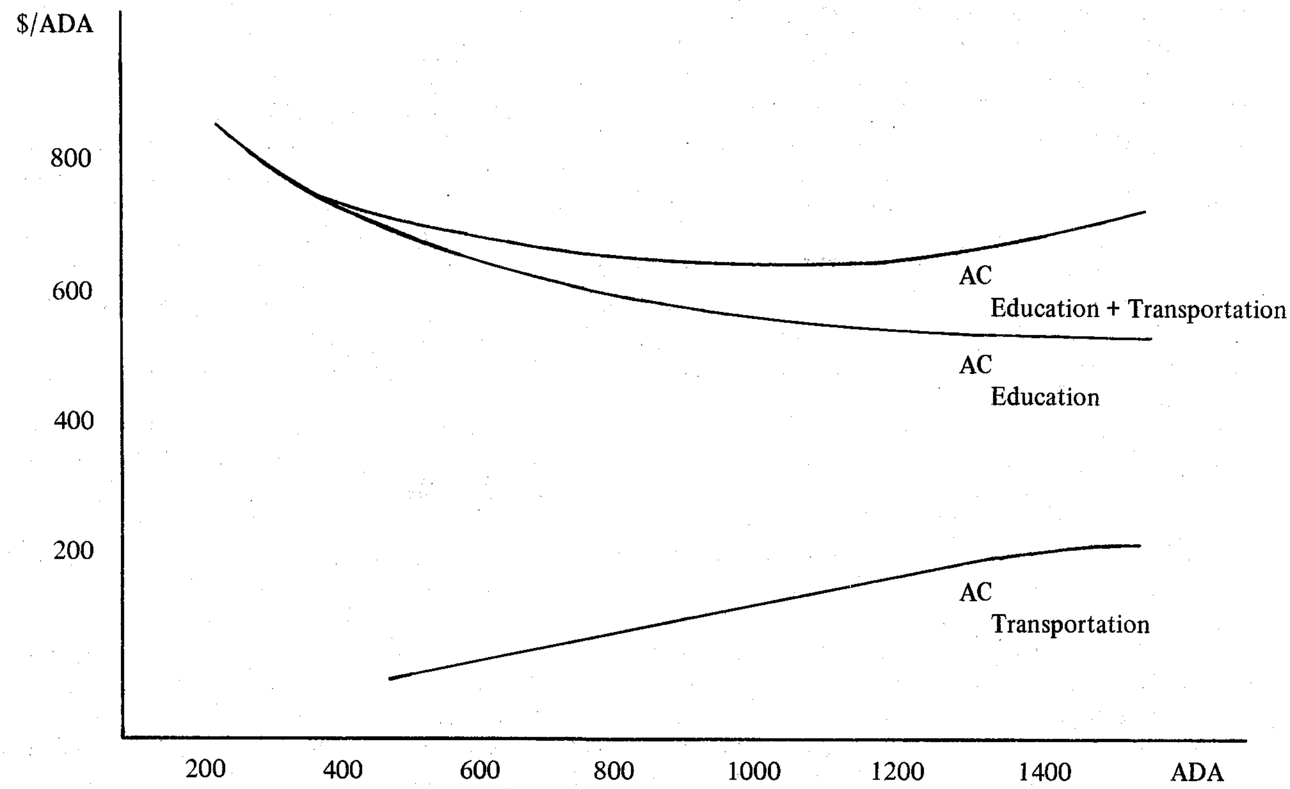

FIGURE 1. AVERAGE COST OF EDUCATION AND TRANSPORTATION PER ADA FOR A SCHOOL DISTRICT WITH A STUDENT DENSITY OF 1.8 TRANSPORTED STUDENTS PER SQUARE MILE

efficient resource allocation and school district organization for given student and community characteristics, as well as school district goals. The basic model was specified to reflect average levels of output, student background, salary and curriculum.

High transportation costs in rural areas have a major influence on school district organization and size. Student performance deteriorates slightly with increases in district size per se, causing minor adjustments in other educational process variables to maintain the level of educational output. Table 1 shows the optimum resource combination of educational process variables for various student densities. The optimum pupil-teacher ratio is 28:1 in high school; 30:1 in junior high and 26:1 in elementary education. The optimum average teacher experience is less in higher grades.

Differences in student densities cause significant differences in optimum school district size and average cost as shown in Table 1. Average cost with optimum organization was $744.27 for a student density of 0.6 transported ADA per square mile and $660.68 for a 3.0 student density. The optimum school district size ranged from 300 ADA with the light density to 1,075 with a heavy density.

CONCLUSIONS

This study has presented a framework to efficiently organize educational resources. The applicability of its results are restricted to schools operating under circumstances similar to the sampled schools. Continuation of this line of research using data gathered for more schools and students and for more years will provide further insight into schooling efficiency. The schools being considered could be categorized by similar characteristics. Although the school district appeared to be the obvious unit of analysis in rural areas, similar analysis could be applied to just elementary, junior high, or high schools.

TABLE 1 SEPARABLE PROGRAMMING RESULTS OF OPTIMUM RESOURCE COMBINATION BY STUDENT DENSITY

Resources	Student Densities in Transported ADA per Square Mile .6	1.2	1.8	2.4	3.0
Elementary and Secondary ADA	300.00	550.00	675.00	900.00	1075.00
Pupil-teacher ratio					
High School	28.00	28.00	28.00	28.00	28.00
Junior High	30.00	30.00	30.00	30.00	30.00
Elementary	26.00	26.00	26.00	26.00	26.00
Percentage of teachers with three to nine years of experience (percent)					
High School	69.88	66.33	65.48	64.14	63.21
Junior High	23.36	31.24	33.10	36.07	38.13
Elementary	20.56	20.56	20.56	20.56	20.56
Percentage of teachers with ten or more years of experience (percent)					
High School	30.12	33.67	34.51	35.86	36.79
Junior High	76.64	68.76	66.89	63.93	61.87
Elementary	79.44	79.44	79.44	79.44	79.44
Average teacher experience (years)					
High School	8.51	9.32	9.51	9.81	10.02
Junior High	19.01	17.23	16.81	16.14	15.68
Elementary	19.64	19.64	19.64	19.64	19.64
Percentage of teachers with a planning period (percent)					
Junior High	3.18	21.52	25.88	32.79	37.59
Elementary	-0-	-0-	-0-	-0-	-0-
Value of audiovisual material per ADA (dollars)					
High School	8.70[a]	8.70	8.70	8.70	8.70
Junior High	8.70	8.70	8.70	8.70	8.70
Elementary	59.85	92.23	99.70	112.11	120.58
Average Cost per ADA (dollars)	744.27	728.83	691.85	674.82	660.68

[a]All underlined values have entered the solution at their lowest limit.

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