DOCUMENT RESUME

ED 090 937 IR 000 547

AUTHOR	Klees, Steven J.
TITLE	Television and Other Determinants of Scholastic Achievement in Mexican Secondary Education.
INSTITUTION	Stanford Univ., Calif. Inst. for Communication Research.
SPONS AGENCY	Agency for International Development (Dept. of State), Washington, D.C.; Educational Testing Service, Princeton, N.J.
PUB DATE	Apr 74
NOTE	64p.; Paper presented at the Annual Meeting of the American Educational Research Association (59th, Chicago, Illinois, April 1974)
EDRS PRICE	MF-$0.75 HC-$3.15 PLUS POSTAGE
DESCRIPTORS	*Academic Achievement; Comparative Analysis; Conventional Instruction; Costs; Developing Nations; Educational Research; Grade 9; *Instructional Television; Language Arts; School Community Relationship; *Secondary Education; Secondary School Mathematics; Spanish; Student Characteristics; Teacher Characteristics
IDENTIFIERS	Ensenanza Directa; *Mexico; Telesecundaria

ABSTRACT

Research was conducted to compare the efficacy of the Mexican Telesecundaria (TS) system, which used instructional television (ITV), with that of the Ensenanza Directa (ED), which employed traditional instructional techniques. Information on the following four dimensions of the two systems at the ninth-grade level was collected: (1) student characteristics, (2) teacher traits, (3) school and community factors, and (4) costs. The dependent variable was student cognitive achievement in language and math. Results obtained by multiple regression analysis indicated that ITV had a significant positive effect on achievement; this effect was sufficiently strong to overcome other disadvantages associated with the TS system, such as larger class size and adverse student background factors. In addition, the costs of the TS system were 25% lower than those of the ED. It was concluded that it was technically and economically feasible to implement the TS system, and it was recommended that the national policymakers weigh the social costs and benefits of so doing prior to wide-scale implementation. (PB)

TELEVISION AND OTHER DETERMINANTS OF SCHOLASTIC ACHIEVEMENT IN MEXICAN SECONDARY EDUCATION

by

Steven J. Klees
Cornell University

Paper prepared for the
American Educational Research Association
April, 1974

Note: Work on this paper has been supported by the Educational Testing Service, Princeton, New Jersey. The data for this study were gathered by Stanford Institute for Communication Research (under contract with the U.S. Agency for International Development - contract no. AID/csd 3284) and the Audiovisual Department of the Mexican Secretariat of Public Education. Any errors of omission or commission are, of course, solely the responsibility of the author.

TELEVISION AND OTHER DETERMINANTS OF SCHOLASTIC ACHIEVEMENT IN MEXICAN SECONDARY EDUCATION

As many nations' school systems begin to feel the dual pressure of increased enrollment demand and a scarcity of available funds and/or critical resources for their educational system, there develops growing interest in the possibility of finding more efficient educational techniques. Among developing nations, where these pressures have been rising for as long as two decades, a number of countries have been expressing their concern, in part, by experimenting with the relatively new educational media of radio and television. This study attempts to evaluate some of the results of one such experiment in Mexico. The primary focus here will be on the ability of the media to increase student language and mathematical achievement. Secondarily we will look at the effect of other school system and student inputs to the learning process. Examination of this system's costs and other possible system outputs have been treated elsewhere,[1] but will be discussed briefly at the conclusion.

The Telesecundaria System[2/]

In 1965 the number of primary school graduates unable to enter secondary school in Mexico is over 180,000, or approximately 37 percent of the previous year's sixth grade graduates. The lack of opportunity at the secondary level was most acute in the rural areas where there have not been sufficient funds to provide either traditional secondary schools (Ensenanza Directa-(ED)) or qualified teaching personnel. In answer to this problem, the Telesecundaria (TS) system was developed, beginning open circuit instructional television broadcasts to approximately 6500 seventh graders in 1968, and expanding to cover almost 30,000 students in all three grades by 1973. The system covers an eight state, 100,000 square mile region around Mexico City, with its 30,000 students representing about 5 percent of the total secondary student enrollment in the region. Television carries the primary instructional burden of the system in all subjects (about 10 subjects per grade) by delivering one twenty-minute program every hour to each classroom at all three grade levels. Each student therefore receives about 360 hours of televised instruction a year, which is one-third of his or her time spent in school. The telesecundaria curriculum is designed to parallel and replicate that of the traditional secondary system.

Primary school teachers,[3/] initially called monitors, and now referred to as coordinators, are supplied by the federal government to prepare the students for the televised lessons and provide review after a broadcast. Over time it appears that the televised lessons and the accompanying teacher guides have enabled many of these coordinators to sufficiently master the subject matters to encourage them to break away from the traditional drill and repetition practice they were intitially conceived of as performing (see Mayo, McAnany, and Klees (1973) and Mayo (1973))

School buildings and facilities (including television reception equipment) are supplied by the locality (unlike the traditional system in which such facilities are provided by the government), which requests the initiation of a tele-school in its community. These facilities usually provide inferior instructional resources (excluding the television receiver) to those provided in the traditional secondary school system. Generally, Telesecundaria serves more rural areas than the traditional system, although a number of urban areas that already have secondary schools have opened tele-schools to meet the burgeoning demand for more educational opportunities. At present, the future of the telesecundaria system - whether it will be expanded, dropped, or radically changed - is open to question; hopefully, this research can contribute to the formation of an answer by Mexican educational policy makers, as well as contribute to other researchers and policy makers investigating possible uses of educational technology.

Methodology

The primary goal of this study is an attempt to examine the comparative efficacy of instructional television (ITV) with that of traditional instruction (TI) in the Mexican secondary school system. Secondarily, we are interested in the relative efficacy of other school resources. The measure of objectives used will be cognitive achievement in language and mathematics. The use of these outputs as principal measures of system effectiveness, is directly in line with the expressed goals of Telesecundaria policy makers (from conversations and documents).

During the last fifteen years, a great many studies have been done comparing the use of various instructional media with traditional face-to-face instruction in a variety of educational evironments. There have been a number of relatively recent and thorough reviews of the literature comparing the effectiveness of televised instruction and traditional instruction with regard to student achievement (and other output variables as well), so we will not attempt to repeat the process here (see Jamison, Suppes, and Wells (1974), Schramm (1973, Chapter 3), Dubin and Hedley (1969), Chu and Schramm (1967), and Stickell (1963)).[4/] Briefly, while some studies show an advantage for ITV, and other for TI, by and large the general finding has been that no significant statistical difference exists in measured effectiveness. The conclusion reached by Jamison, et. al. (1974, p 38) that "ITV can teach all grade levels and subject matters about as effectively as TI" [5/] seems well documented. However, the crucial word is "can"; that is, although we are pretty certain ITV and TI are substitutable in a variety of situations, the question in the minds of Mexican educators was 'is it working here?' Further doubts were added by the fact that most of the comparative studies have been carried out in the United States and other industrialized mass-media cultures, and there are obvious questions as to their transferability. Relatively little careful work has been done examing the comparative effectiveness of ITV with TI in developing countries, although the media is widely used in a variety of educational settings in many of these countries. The evidence that we do have, is reviewed in Schramm (1973) and for an excellent longitudinal analysis of the effectiveness of ITV in secondary schooling in El Salvador (perhaps one of the projects most similar to Mexico's) the reader is referred to Hornik, et. al. (1973).

The studies reviewed in most of the sources cited above were controlled experiments (although Stickell (1963) questioned the rigor of the designs of many); therefore the method of comparative analysis was usually a t-test of the significance of differences in mean outcomes. The results of such a comparison between the ITV and TI systems will be discussed in the following section, but the reliability of a simple comparison of mean outcomes in a field study situation, as opposed to an experimentally controlled one, are extremely questionable. Even in an experimental comparison, it is difficult to control the treatment so as to eliminate all possible confounding variables, and to do so in the field is next to impossible. The next best solution in the latter situation is to attempt to control for likely confounding variables in the data analysis by appropriate choices of statistical procedures. A number of related statistical methods are possible - analysis of variance, partial correlation analysis, path analysis, multiple regression analysis - depending on the type of output measure desired and the type of assumptions the analyst is willing to make about the structure of the system.

Given the goals of this study, multiple regression analysis was selected as the most appropriate statistical technique. We will attempt to estimate the production function for the secondary schooling process and in so doing, to see if television and other selected variables contribute significantly to the acquisition of language and mathematics achievement and, additionally, try to gain some understanding of the education process itself.

Educational Production Function Analysis

A production function is a technical relationship that describes the transformation process by which system outputs are produced from system inputs, usually applied by economists to private market firms or industries. Application of production function analysis to educational systems is a relatively recent phenomenon, stemming perhaps largely from the interest generated and the data made available by the U.S. Office of Education's survey on equality of educational opportunity (see Coleman et. al. (1966)). In a number of respects, the utilization of production functions in educational system analysis has problems present that are not usually encountered in firm analysis, although Bowles (1970) is probably correct when he points out that the data base available for schools is somewhat better than that for firms:

> [W]e have data at the "firm" [school] level and therefore avoid the problem of making "technological" inferences based on industrial, state, or national averages; most of our input data are measured directly, rather than in monetary aggregates; and we have ample data on the quality of the factors of production - e.g. teachers, principals, and other school personnel. [p. 13]

However, there are both conceptual and measurement problems related to the description of educational system outputs and inputs.[6] On the output side, a school may be considered a multi-product firm with inputs that are sometimes indivisible among outputs. For example, a teacher with certain characteristics may be instructing students in the elements of the Spanish language and at the same time conveying certain ideas and attitudes about discipline, authority, motivation, social customs, culture, and history. If one only examines the effectiveness of various teacher characteristics on Spanish language performance, then resulting resource allocation recommendations may be dysfunctional with respect to the other unmeasured outputs. This problem is compounded by uncertainty as to what outputs schools are producing, what outputs they are supposed to produce, and how to reasonably measure any of them.

Keeping in mind the limitations above, we will still confine ourselves to language and mathematics achievement as the output measures examined in this study (other outcomes of the Mexican TI and ITV secondary system are examined elsewhere - see footnote 1). The multiple output problem is considerably less serious at the secondary level, where teachers are subject specific, than at the primary level where the same teacher may give instruction in a large number of subject areas.

Perhaps the most serious difficulty with educational production function analysis is the lack of a theory of learning and instruction that is sufficiently developed to enable us to identify both the relevant inputs and the structural form of the input-output transformation.[7] Given this lack of knowledge of the educational process, combined with the lack of incentives administrators have to even attempt to maximally produce specified outputs, it is unlikely that any estimated function will truly represent the production frontier. The theory of production assumes firm profit maximazation, which implies that a production function is a frontier function in the sense that it represents the maximum output that can be produced by the firm with alternative sets of given inputs. A firm that produces on its frontier is said to be technically efficient; schools are usually seen as technically inefficient.[8]

Efficiency. At this point, it seems important to digress for a few moments and briefly look into the oft-times confused notion of efficiency. Traditional economics is often considered the science of efficiency;[9] unfortunately, the literature abounds with different and sometimes contradictory conceptions of efficiency. The most agreed upon is allocative efficiency which refers to choosing the optimum input structure, given the specific input-output relationship and input prices; in a firm this is defined by the marginal conditions necessary for profit maximization.[10]

Leibenstein (1966) introduced the concept of X-efficiency, which is commonly used interchangably with technical efficiency as defined above.

Technical efficiency is often considered a technical or engineering problem as opposed to an economic one (see Henderson and Quandt (1958), Levin and Muller (1974)) in that it pertains to knowledge of the input-output structure. Technical inefficiency is usually seen to come about through ignorance of the correct production function or through organizational and motivational deficiencies, that is, the inputs are there, they are just not put together correctly, in contrast to allocative inefficiency whereby the wrong inputs are purchased.[11]

Allocative and technical efficiency are necessary (and sufficient) conditions for a firm to be profit maximizing, sometimes referred to as economic efficiency. Regarding economic efficiency as discretionary (i.e. management can decide whether a firm will profit maximize), a somewhat different concept of efficiency is added by Wells (1974) and Jamison and Suppes (1972), termed technological efficiency, to get at the differences in ability to profit-maximize (or alternatively, differences in the production possibilities) between firms. One firm is considered more technologically efficient than another (usually in the context of the firms being in the same industry) if it has the ability to produce more profits (or output) given a set of inputs.

Technological efficiency can be viewed as the inter-firm extension of technical efficiency (the latter as defined above, applies within the firm). Lau and Yotopoulos (1971), Timmer (1970), Massell (1967), Brown (1966), and others have pointed out that firms may differ in their production abilities due to factors outside management's control - patent rights, location, climate, technology used, etcetera; these would be the assumed basis for differences in technological efficiency.[12]

Production function analysis generally assumes firms are technically efficient and that there is no difference in technological efficiency between firms.[13] This allows the analyst to make recommendations specific to allocative efficiency. When firms are not equally technologically efficient, it is not acceptable to use one production function specification across firms for different firms may well have different input-output relationships. When firms are not technically efficient, the options open to management can be much greater than those implied by production function analysis. For example, although the production function analysis might imply a school should hire more experienced teachers as opposed to more educated teachers, if the school was technically inefficient, it might be more productive to attempt to give stronger motivation to teachers already on the staff. This latter recommendation would not usually be discernible from production function analysis.[14]

To isolate differences in technical efficiency (and perhaps technological efficiency as well) a common practice is to estimate a separate production function for "best practice" firms; that is, those firms that seem to be operating closer to the production frontier (see Aigner and Chu (1968), Salter (1960)). Levin (1974) shows that not doing so may yield resource allocation recommendations that might actually reduce the productivity of some firms (schools).[15] However, it would seem that Michaelson (1970) is correct when he argues that although average production function relationships (based on the total data set) may not be too useful to firm managers (e.g. school principals and superintendants), they can be quite useful to a body that determines system policy. The practical point is that although system -

wide policies may be dysfunctional in some individual cases, average relationships do provide a reasonable indication of the probable results of implementing system-wide changes.[16] It is certainly true that educational policy that takes account of local conditions can yield more effective results than uniform policy, but very often in developing countries uniform policy is the practical rule and it seems valid to be concerned with improving it. Furthermore, it is possible that the additional costs of information and administration necessary to make and administer local-varient policies could make this endeavor less cost-effective than uniform policy-making.

In summary, one has to be careful in making efficiency recommendations based on average production function estimation. However, there does seem to be reasonable expectations that significant system policy insights can emerge. Therefore this procedure is attempted below, although caution should be taken in interpreting the results.

The Model. As we previously mentioned, the theory of how knowledge and attitudes are tranferred, has not developed far enough to provide any clear specification for a model of classroom instruction. Attempts to model the education production process have relied on a combination of common sense and the conventional wisdom of educators. Perhaps the most sophisticated, general model that implicitly or explicitly has been the basis for much of the most recent educational production function work, is the one developed by Hanushek (1968)[17]. In essence it is a capital embodiment approach in that a "child's achievement performance is determined by the cumulative amounts of "capital" [achievement] embodied in him by his family, his school, his community, and peers as well as his innate traits" (Levin (1970, p.61)). The mathematical formulation is as follows:

$$(1) \quad A_{it} = g\left[F_{i(t)}, S_{i(t)}, P_{i(t)}, O_{i(t)}, I_{it}\right]$$

where the i subscript refers to the ith student, the t subscript refers to time period t, and the t subscript in parentheses (t) refers to being cumulative to time period t. Thus:

A_{it} = a vector of educational outcomes for the jth student at time t;

$F_{i(t)}$ = a vector of individual and family background characteristics cumulative to time t.

$S_{i(t)}$ = a vector of school inputs relevant to the ith student cumulative to time t.

$P_{i(t)}$ = a vector of peer or fellow student characteristics cumulative to t.

$O_{i(t)}$ = a vector of other external influences (community, etc.) relevant to the ith student cumulative to t.

$I_{i(t)}$ = a vector of initial or innate endowment of the ith student at t.

(Levin (1970, p. 61))

It is generally further assumed that all first partial derivatives (marginal products) are positive; that is, additions to the quantity or quality of any of these resources will increase student performance.

The logic of the model seems reasonable enough (see Levin (1970) for details), but unfortunately its generality precludes its being too informative. The primary problems are to determine which specific measurable input variables are relevant to the output(s) under scrutiny and what specific functional form to estimate.

The outputs examined will be measures of cognitive achievement in mathematics and language. Since we are interested in the role of schooling in developing these cognitive outcomes, we would like to focus our attention on the value added to these two dimensions of achievement by the school process. Therefore it is more appropriate to consider changes in achievement over time than the student's absolute level of achievement. However, due to greater reliability problems in the use of change scores, we will follow the advice of Cronbach and Furby (1970) who suggest that one better approach is to still use achievement level, that is, post-test scores, as the dependent variable of analysis and control for the initially different starting positions by using pre-test scores as an independent variable.

The inputs considered will be a range of individual, family, community, and school characteristics that one would expect, both logically and on the basis of previous studies, to influence the formation of these cognitive outputs (see Table 2 in the following section for specifics). However, it must be remembered that the input measures used are very often proxy measures of the underlying attributes of the input variables which affect changes in achievement level. For example, an input measure that has shown a relatively high degree of effect on student outcomes in many studies is the teacher's score on a verbal test (see Jamison, Suppes, and Wells (1974) for a review). It is quite likely though that teacher verbal score itself is not the influential factor, but that it is a proxy for certain teacher characteristics, such as general intelligence perhaps, that influence student outcomes. In these circumstances, allocative efficiency recommendations to hire teachers with higher verbal scores may be misleading; prospective teachers could study to increase their verbal score and not change the underlying attribute (e.g. general intelligence) from which student improvement is generated. Despite this, it is still informative to examine the effects of the proxy input variable measures on student outcomes, from the standpoint of increasing our knowledge about the schooling process, but perhaps even more from the realization that decisions to utilize certain inputs are themselves currently based on the proxy of the true input attributes. For example, teachers are very often hired and paid according to their experience and degree level, both of which are tacitly assumed proxies for their underlying teaching ability. It is useful to discover whether these proxy variables actually have a positive effect on student outcomes.

Choosing an appropriate functional form for equation (1) is difficult. The lack of an adequate macro theory of instruction has encouraged most educational researchers analyzing school production relationships to utilize a linear formulation, described mathematically as follows:

(2) $Y = \sum_{i=o}^{n} b_i X_i$ where Y represents the output under study, X_i reprsents the n inputs, i=1,...n, and $X_o = 1$

Although the linear model has the advantage of being easily interpretable - the estimated coefficients are input marginal products - it does have serious logical shortcomings. Primarily it assumes the marginal product of any output is constant and consequently, that the elasticity of substitution among inputs is infinite.[18] Therefore, technically the linear model would advise the decision maker to buy only that input with the highest marginal product per dollar cost (of the input) and abandon the use of all other inputs. Although these implications are logically untenable, most users of the linear formulation would counter that the model probably shows the directional effect of changes in inputs on output and possibly gives reasonable results on the magnitude of that change for marginal (i.e. small) changes in input variables.

A multiplicative model, in some senses, is more intuitively appealing. It allows for diminishing marginal products and interactions among inputs. It may be represented mathematically as follows:

(3) $Y = \prod_{i=1}^{n} aX_i^{b_i}$ where Y represents the output under study and X_i represents the n inputs, $i=1,\ldots,n$.

The parameters of the model are easily estimatable by conventional least squares techniques since the equation is linear in logarithmic form. Although marginal products are not directly discernible[19], the estimated coefficients are conveniently interpretable as elasticities of output; that is, the per cent change in the dependent variable resulting from a one per cent change in an independent variable.[20]

Unfortunately, the multiplicative model also has some logical difficulties. Although marginal products vary, elasticity of output is constant, so that regardless of the level of an input, let's say teacher experience, a 10% increase in that input would increase output by 10%. This assumption may be somewhat more tenable than that of constant marginal products, but it is still restrictive. Furthermore, positive values of <u>all</u> inputs are necessary to sustain a non-zero output; that is, all inputs are considered essential by the nature of the formulation. For many analyses this may not be a serious practical problem since the relevant ranges of the data are usually positive for all variables. However, it does sometimes necessitate rescaling of survey response items or in the case of employing a dummy (a zero or one value) variable, the form may be modified as follows:

(4) $Y = ae^{b_j X_j} \prod_{\substack{i=1 \\ i \neq j}}^{n} X_i^{b_i}$ where Y represents the output under study, X_i represents the n-1 inputs, $i=1,\ldots, j-1, j+1,\ldots,n$, and X_j represents the dummy variable

By taking the logarithm of both sides of equation (4), we can use standard least squares procedure to estimate (4) in the following form:

$$(5) \quad \ln Y = \ln a + b_j X_j + \sum_{i=1}^{n} b_i \ln X_i.$$[21]

Of course there are an infinite number of different possible functional forms which may be utilized. Forms other than the linear and multiplicative have been tried rarely in educational settings, due primarily to complexities of estimation and the lack of theory to guide in making a reasonable choice.[22] Given the considerations above, the multiplicative model seems somewhat more appealing than the linear model; however, without a theoretical model of instruction to guide us, it may be better procedure to choose on the basis of goodness of fit to the data. Rao and Miller (1971) describe a method for comparing linear and log linear models on the basis of the residual sum of squares, after an appropriate standardization transformation of the dependent variable in the latter model; this test was performed on several subsets of the data and the resultant variance explained of the two models were reasonably close. Therefore the multiplicative model was chosen as most appropriate based on the considerations above and the results reported will be estimations of the parameters of equation (4) (estimated in the form of (5)).[23]

The Data

The data available was collected as a part of a collaborative evaluation effort on the part of the Audiovisual Department of the Mexican Secretariat of Public Education and the Institute for Communication Research at Stanford University.[24] Information was gathered on four dimensions of the television and traditional systems: student characteristics, teacher characteristics, school and community characteristics, and costs.

Table 1[a]

Student Samples by Area and Instructional System

	Distrito Federal		Valle de Mexico		Hidalgo		Morelos	
	TS	ED	TS	ED	TS	ED	TS	ED
No. of Classes	15	10	15	4	15	4	13	5
No. of Students	384	462	313	208	252	183	287	248
Average Class Size	26	46	21	52	17	45	22	49

Totals	Telesecundaria	Enseñanza Directa
	58 classes	23 classes
	1236 students	1101 students
	21 average class size	47 average class size

[a]The four sampled states were chosen from among the eight in which TS exists. This was done after an analysis of test scores indicated that these four adequately represented the range of achievement in all TS classes. The ED sample, although random, is not representative of all ED schools throughout Mexico. However, since ED and TS classes were sampled randomly from the same states, comparisons within the four state region are valid.

The data, as is shown in Table 1, was based on random samples of ninth grade classes, stratified by four geographical regions: the Federal District of Mexico and the states of Mexico, Hidalgo, and Morelos. Only one grade level was sampled due to resource limitations of the study; ninth grade was chosen so as to reduce the chances of Hawthorne effects. The specific geographical regions sampled were chosen because: 1) they were large and diverse enough in economic as well as geographical terms; and 2) they were all close enough to Mexico City to facilitate classroom observations as well as test and survey questionnaire administration. The sampling strategy was intended to provide a minimum of 1000 students from each system, and because traditional system classes are on the average larger than television system classes, fewer of the former were needed to obtain the desired number of subjects.

Cognitive achievement tests in mathematics, spanish, and chemistry were given at two points in time over a one semester period (February and June 1972). Due to resource limitations, this study will only examine achievement output in mathematics and spanish. A general ability test was also planned, to be used as a control factor, but administrative difficulties prevented it from being given to students in the traditional system. Attitudinal data was collected at only one point in time as it was felt that the time period under study was too short to encompass significant changes in attitudes. One of the greatest strengths of this data sample over that of similar surveys is the detailed observation data that was gathered on classroom interactions and teaching methods (see Mayo (1973) for details). A listing and explanation of the variables used in this study is provided in Table 2.

Insert Table 2 about here

RESULTS

The results of the before and after achievement testing for Telesecundaria and Ensenanza Directa indicate that over the semester period, TS students gained

TABLE 2

VARIABLE LIST[a]

Variable Name	Variable Description
Student Outcomes	
POST-TEST	Raw score on mathematics or spanish post-test
Student Previous Learning	
PRE-TEST	Raw score on mathematics or spanish pre-test
Community Variables	
STATE -1, -2, -3	Dummy variables for the regions of the Federal District, Valle de Mexico, and Hidalgo respecitively
COMMINC	Average monthly family income in the community on a seven-point scale - from less than 500 pesos to greater than 3000 pesos, in increments of 500 peso ranges
Student Background Variables	
SES	Socio-economic status index based on father's education and occupation for mathematics achievement; index based on home possessions (magazines, newspaper, books, radio, TV) for spanish achievement
SEX	Student sex; F=0, M=1
SELFEX	Student self-efficacy index based on student's surety of belief that he/she will reach her/his educational and career goals (NOTE: high index value = low self-efficacy)
ASP	Student educational and career aspirations index

Variable Name	Variable Description
ATSECUR	Student desire for financial and occupational security index
MATNEED	Student desire for material success index
INTWORLD	Student belief in the importance of being acquainted with international news and affairs index (NOTE: high index value = low importance)
Teacher Variables	
TEASEX	Teacher sex; F=0, M=1
TEAED	Teacher general education and teacher training preparation index
TEAEXP	Teaching experience index in the primary and secondary school system
TEAGE	Teacher age index
TATED	Teacher attitude toward his/her job and profession in general
TEAOBS	Teacher method index, based on classroom observation variables; different sets of variables compose the index for math and spanish, and TS and ED, see text and Appendix A for discussion.
Classroom Variables	
CLSIZE	Class size
GROUP	Television versus non-television; TS=0, ED=1

[a]School facility variables were available, but did not have a significant effect on either student mathematics or spanish achievement.

more in mathematics, spanish, and chemistry than those students in the ED system, as shown in Table 3. Given the relatively impoverished home and school background of the TS students, it is somewhat surprising to note that pre-test scores were quite similar between the two groups, although whether this reflects equal inital ignorance about the semester's subject matter or the effects of previous learning is impossible to determine from the data.

Insert Table 3 About Here

A t-test shows the differences in given scores for the two groups on all three tests to be significant at the .01 level; if the two student groups had been identical except for instructional treatment, it would be possible to attribute the difference to the relative effectiveness of the television system.[25] However, because the TS and ED students differ systematically along a number of dimensions, further analysis is needed.[26] One important difference which lends <u>greater</u> strength to the test results is that TS students on the average come from more educationally and economically impoverished school and home environments than ED students - the TS group generally lives in more rural areas where school resources are fewer, rural elementary school teachers generally have less education and teacher training than the more urban teachers, families of TS students generally earn less than their ED counterparts, and parents of TS students have quite a bit less formal schooling than parents of ED students.

On the other hand, there are a number of factors, other than the television system - traditional system difference, that might also plausibly account for differences in learning gains. One rather simple factor is that the TS system has a higher percentage of male students than the ED system (the male-female ratio in the TS system is almost 3:1 as opposed to less than 2:1 in ED)

Table 3

Results of Before and After Achievement Testing for

Telesecundaria and Ensenanza Directa[a]

Telesecundaria (TS)

Subject Matter	Means	Std. Dev.	Gain Score	No. of Students
Math 1 (Feb.)	20.24	4.84		1,151
Math 2 (June)	25.92	6.74	+5.68	
Spanish 1 (Feb.)	26.39	6.62		1,110
Spanish 2 (June)	31.50	8.44	+5.11	
Chemistry 1(Feb.)	18.06	4.25		1,132
Chemistry 2(June)	24.31	6.15	+6.25	

Ensenanza Directa (ED)

Subject Matter	Means	Std. Dev.	Gain Score	No. of Students
Math 1 (Feb.)	20.15	5.02		836
Math 2 (June)	22.76	5.86	+2.61	
Spanish 1 (Feb.)	24.54	6.72		781
Spanish 2 (June)	27.19	6.84	+2.65	
Chemistry 1(Feb.)	18.49	5.02		713
Chemistry 2(June)	22.70	6.27	+4.21	

[a]From Mayo, McAnany, and Klees (1973, p. 58)

and males may simply outperform females. A direct examination of this hypothesis indicates that although males gain more than females in mathematics, females do equally well in spanish. Furthermore, TS males achieve more than ED males and TS females achieve more than ED females (see Klees(1974) for details). However, it may be that this simple comparison is not sufficient in that the education production relationship may differ for males and females; this will be examined later in this section.

Another hypothesis that might be used to explain the differences in learning gains between the TS and ED student groups is that TS students may be more able or more motivated to work and achieve than their ED counterparts. The a priori reasoning behind this hypothesis would say that it is more difficult for students in rural areas or from disadvantaged backgrounds to succeed in school or to continue in school, and that those who do succeed and continue are likely to have stronger than average motivation and/or ability.[27] Unfortunately, general numerical and language ability test results were only obtained for the TS students (due to administrative problems). However, indirect evidence indicates that ED students would have performed better on general ability tests than TS students - TS results were well below technical secondary school student norms (who are given these same ability tests), and technical school students are generally thought to be lower-ability students than those in the general secondary school (ED) system. (See Mayo, McAnany, and Klees (1973) for further details.) The motivation factor is still a problem, though, and will be treated in the production function discussion that follows, by examining and controlling for the effect of student attitudinal variables that may to some extent serve as proxy measures for student motivation. Ability differences will be examined in more detail by sample stratification.

A final alternative hypothesis to explain the learning gain differences is more difficult to examine - the average class size in the ED system is twice as large as in the TS system. However, although smaller classes are generally considered a 'better educational environment' according to traditional wisdom, the research on the relationship between class size and achievement does not give any clear indication that such is the case.[28] Jamison, Suppes, and Wells (1974) survey the substantial amount of research done in the United States on this question and find the relationship "generally weak", although a few studies report that small class sizes may be significant for young children. Husen (1967) reports on the results of an extensive international survey, which generally suggests there is no significant difference in achievement between classes of different size. Despite the above research evidence to the contrary, we will attempt to examine the possible effects of class size in the production function estimations below.

Secondary School Production Relationships

The production function estimated, as discussed earlier, is a multiplicative model in the form of equation (4) (estimated in the log linear form of equation (5)) with mathematics and spanish achievement post-test score as the dependent variable. Table 4 gives the resultant regression coefficients estimated on the total ED-TS student data set; both ordinary and standardized regression coefficients are reported.[29]

Insert Table 4 about here

The variable we are most interested in is the GROUP variable; examining it we find that even after controlling for sex, motivation (as represented by

TABLE 4

PRODUCTION FUNCTION FOR MATHEMATICS AND SPANISH ACHIEVEMENT:

All Students - TS and ED[a]

VARIABLE	MATH	SPANISH	VARIABLE	MATH	SPANISH
PRETEST	0.3850***	0.5258***	MATNEED	0.0859***	0.0292
	(.0187)	(.0197)		(.0186)	(.0205)
	0.3510	0.5062		0.0765	0.0247
STATE-1	0.1137***	0.0703***	INTWORLD	-0.0336***	-0.0023
	(0.160)	(.0177)		(.0089)	(.0098)
	0.1944	0.1143		-0.0668	-0.0044
STATE-2	0.0992***	0.0927***	TEASEX	-0.1025***	0.0143
	(.0159)	(.0181)		(.0126)	(.0132)
	0.1454	0.1292		-0.1592	0.0236
STATE-3	0.1362***	0.0484***	TEAED	0.3337***	0.0434**
	(.0153)	(.0161)		(.0166)	(.0167)
	0.1968	0.0665		0.4705	0.0508
COMMINC	-0.0924***	0.0095	TEAEXP	-0.1554***	-0.0880***
	(.0155)	(.0175)		(.0219)	(.0265)
	-0.1549	0.0151		-0.1836	-0.0944
SES	0.0020	-0.0177	TEAGE	0.0820***	0.0339*
	(.0173)	(.0170)		(.0166)	(.0209)
	0.0023	-0.0197		0.1080	0.0405
SEX	0.0067	-0.0067	TATED	0.0486***	0.1063***
	(.0100)	(.0109)		(.0135)	(.0156)
	0.0116	-0.0011		0.0702	0.1267
SELFEX	-0.0333***	-0.0446***	TEAOBS	0.0510***	0.0571***
	(.0097)	(.0106)		(.0089)	(.0134)
	-0.0588	-0.0748		0.1163	0.0895
ASP	0.0837***	0.0369*	CLSIZE	0.2167***	0.1388***
	(.0187)	(.0206)		(.0193)	(.0200)
	0.0851	0.0356		0.3637	0.2214
ATSECUR	-0.0666***	-0.0541***	GROUP	-0.4011***	-0.1856***
	(.0107)	(.0117)		(.0211)	(.0218)
	-0.1132	-0.0873		-0.7130	-0.3136
			R^2	0.4780	0.4318
			CONSTANT	1.2782	1.1441
			N	1976	1891

[a] The first number for each variable represents the estimation of the ordinary regression coefficient. The number below in parentheses represents the standard error of the estimated coefficient. The third number represents the standardized regression coefficient. Level of significance is indicated as follows:

* = significant at 85% ($t \geq 1.5$)

** = significant at 95% ($t \geq 2.0$)

*** = significant at 99% ($t \geq 2.8$)

attitudinal variables), class size, teacher differences, and other variables, the television system makes a statistically significant contribution (at the .001 level) to student achievement in both mathematics and spanish. The standardized coefficient for GROUP indicates that the contribution of the television system to achievement is large relative to that of other variables, although this is more true in mathematics than in spanish. It is worthwhile to examine the influence of other variable groups as well, although multicollinearity problems may lead us to reject variables that are in actuality significant.[30]

The effects of regional and community variables are somewhat difficult to interpret. The shift in the function between states is possibly a result of differences in urbanization (a separate urbanization variable was included in the original sample, but difficulties in coding made its reliability doubtful; additionally all ED schools are in relatively urban areas). However, if this were the case, we might expect the more urbanized regions, the Federal District and the state of Mexico (STATE-1 and STATE-2), to show the strongest influence. This is true for spanish achievement, but for mathematics the more rural state of Hidalgo (STATE-3) appears to have the strongest effect.[31] The negative effect of higher community income on mathematics achievement is impossible to explain (there is evidence that the effect of COMMINC changes if we stratify by state which indicates some type of interactive effect between income and region).

Somewhat surprisingly, student socio-economic status[32] and sex do not appear to make a significant difference in achievement, although a number of student attitudes do. Low self-expectations (SELFEX) detract from achievement while relatively high educational and occupational aspirations (ASP) and material desires (MATNEED) contribute to achievement, the latter effect probably a result of increasing student motivation. It was also found that the higher a student's need for occupational and financial security (ATSECUR), the lower the student's achievement and the smaller the student's interest in the international world (INTWORLD), the less is his or her mathematics achievement. More detailed analysis of student background and attitudinal variables, especially in terms of differences between TS and ED students, is presented in Mayo, McAnany, and Klees (1973), although the correlation approach used there sometimes show significant effects that do not appear above where co-linear factors are controlled for; their results are summarized in Appendix B.

A number of teacher-related variables exhibit significant effects on student achievement, although not always in the direction that might be expected. Male teachers (TEASEX) seem to do significantly better than females in mathematics instruction. For both mathematics and spanish, additional teacher education and training (TEAED) result in higher student achievement scores. The effects of additional teacher experience (TEAEXP) are negative however, even after controlling for teacher age (TEAGE) which has a positive effect. This finding has been reported in other studies of secondary schooling in developing countries (see Carnoy (1973)) and perhaps indicates a decline in teacher motivation and/or morale as their experience in the system lengthens. The repercussions of this result are especially strong when one realizes that salary scales are such that teachers receive income increments for more experience. One effect of teacher characteristics specific to Telesecundaria, not examined in the reported regressions, was that favorable teacher attitudes toward the television programs had a significant positive effect on student achievement in both mathematics and spanish (although student attitudes toward the TS programs did not make a difference).

Classroom observation data on teaching method and types of teacher-student interactions provided too many variables to include each individually in this analysis. Instead, a weighted index of selected observation variables was designed and used. The index was designed to test Mayo's (1973) interpretation of Beeby's (1966) theory of the positive effect of teacher modernization on student performance. More modern teachers, according to this interpretation, are ones that, for example, rely less heavily on lecture and dictation, ask relatively more thought and opinion questions, and tend to move towards more individualized types of instruction (see Mayo (1973) for details). An index based on this construct proved to be a significant factor affecting mathematics achievement and is shown in the mathematics production function as TEAOBS. For spanish, a number of classroom variables that we had expected to influence achievement appeared to have no significant effect or an affect in a direction opposite to the direction expected; therefore TEAOBS for spanish represents a post-hoc index based on the few variables that had significant simple correlations with post-test achievement.

The problems in interpreting the classroom observation data are quite complicated and beyond the scope of this study. Although Mayo (1973) concludes that teaching styles are quite similar for TS and ED teachers[33], preliminary indications suggest that the <u>effectiveness</u> of these styles appear to be quite different in the two systems. More analysis is needed in this area; Appendix A gives the results of a simple correlation analysis for achievement and classroom observation variables.

Perhaps the most puzzling finding is the highly significant, <u>positive</u> effect of increasing class size on achievement. At first glance it might seem that this would totally disprove the alternative hypothesis that class size, not television treatment, is responsible for the different performance of the TS and ED students. However, if we separately examine the production reltionships for the TS and ED systems (not shown in the tables) we find that although class size does continue to have a positive significant effect for TS students,[34] its effect on the achievement of ED students is insignificant for mathematics and significant and <u>negative</u> for spanish. These latter results tend to lessen our certainty in rejecting the alternative class size explanatory hypotheses, although the evidence still appears to be on the side of the difference in instructional treatment (television vs traditional); a comparative analysis of achievement is large size TS classes with all ED classes reveals that TS students still gain more both in mathematics and spanish. One final point that is worth noting is that contrary to recent sentiments toward, and analysis of, student achievement in the United States (see Jencks (1972) and Coleman et.al. (1966)), instructional treatment does seem to contribute to the students' achievement gain during the year. Although resources did not permit a full "commonality" analysis of the explanatory power of each variable group (see Mayeske et.al. (1969) for methodological details), the stepwise regression technique employed permitted us to examine the <u>minimum</u> amount of unique variance contributed by instructional variables to post-test achievement, after controlling for initial position (pre-test score).

Table 5

Change In R^2 As Variable Groups Are Added

Variable Group[a]	Mathematics	Spanish
Previous Student Learning	.188	.336
Community Variables	.222	.349
Student Background Variables	.256	.360
Teacher Variables	.387	.410
Classroom Variables	.478	.432

[a]Variable groups are as described in Table 2.

Table 5 shows us that while community and student background variables contribute at most 23% to the variance explained in mathematics achievement over and above that of pre-test score (i.e. total variance explained by all variables minus the variance explained by pre-test score is defined as 100%), teacher and classroom variables explain at least 78%; for spanish achievement the comparable figures are 25% and 75% respectively. Given the multicollinearity that exists between non-controllable (community and student background) variables on the one hand and instructional (teacher and classroom) variables on the other hand, the latter group may have an even greater effect than indicated above.[35] For mathematics, the GROUP variable, expressing the difference between the television and traditional system, has the greatest effect of any single variable, explaining at least 23% of the additional (to pre-test) variance accounted for (TEAOBS is second, explaining 16%). From Table 5 we can also observe that the initial achievement level with which students enter the semester has a much greater effect for spanish than mathematics; indeed, relatively small explanatory power is added by any of the variable groups in our model to the initial level of student competency in spanish.

Males vs Females

To further examine the hypothesis that achievement differences between TS and ED students may reflect differences in the male-female student body composition of the two systems, separate production relationships were estimated for males and females, as shown in Tables 6 and 7. Examining the GROUP variable we find that television makes a strong positive contribution to both male and female achievement in mathematics and spanish. The effect of television appears to be stronger for females than males in mathematics and stronger for males than females in spanish; this may indicate that television has the additional benefit (if one views this as a benefit) of equalizing achievement differences between males and females, since males are usually found to perform better than females in mathematics, and females are usually found to perform better in language.

Insert Tables 6 & 7 about here

It is also interesting to briefly compare the effects of other variables on male and female achievement. By and large, most variables affect male and female performance about the same. Perhaps a little surprisingly, we find that differences in the effect of teacher sex do not exist for male and female students; male teachers do better for both male and female students in mathematics and the sex of the teacher does not seem to matter in spanish. The most striking difference is the absence of an effect of self-expectations and the weakened effect of educational and career aspirations for females, indicating that female students have other motivations to achieve than male students.

Low Ability vs High Ability

We have seen that television does appear to contribute to student achievement in the Mexican secondary school system; however, it has often been suggested that, given the non-individualizable nature of the television medium, programs must be aimed at and paced for the students of middle level ability, thus losing lower ability students and boring higher ability students. In contrast, a classroom teacher is assumed capable of being more flexible, of individualizing the content and pace of the curriculum, and therefore being better able to meet the academic needs of different ability level students than television. This hypothesis, in terms of the effectiveness of television vs traditional instruction on low and high ability students, will be examined below in two ways.

TABLE 6

PRODUCTION FUNCTION FOR MATHEMATICS AND SPANISH ACHIEVEMENT:

Male Students[a]

VARIABLE	MATH	SPANISH	VARIABLE	MATH	SPANISH
PRETEST	0.4082***	0.5448***	MATNEED	0.0582**	0.0182
	(.0242)	(.0241)		(.0254)	(.0269)
	0.3736	0.5200		0.0501	0.0150
STATE-1	0.1042***	0.0810***	INTWORLD	-0.0356***	-0.0099
	(.0154)	(0.0194)		(.0116)	(.0122)
	0.1732	0.1195		-0.0707	-0.0188
STATE-2	0.0950***	0.0894***	TEASEX	-0.0662***	-0.0078
	(0.0149)	(0.0179)		(.0163)	(.0164)
	0.1544	0.1222		-0.1003	-0.0128
STATE-3	0.1156***	0.0532***	TEAED	0.2679***	0.0740***
	(0.0171)	(0.0164)		(.0206)	(.0202)
	0.1843	0.0698		0.3730	0.0868
COMMINC	-0.0405**	0.0400**	TEAEXP	-0.1359***	-0.1172***
	(.0181)	(.0178)		(.0269)	(.0301)
	-0.0681	0.0643		-0.1643	-0.1300
SES	0.0268	-0.0019	TEAGE	0.0855***	0.0512**
	(.0226)	(.0219)		(.0222)	(.0253)
	0.0304	-0.0021		0.1111	0.0609
SEX			TATED	0.1007	0.1532***
				(.0170)	(.0193)
				0.1446	0.1840
SELFEX	-0.0569***	-0.0575**	TEAOBS	0.0605***	0.0415**
	(.0130)	(.0137)		(.0108)	(.0157)
	-0.0987	-0.0953		0.1431	0.0706
ASP	0.0850***	0.0404*	CLSIZE	0.1131***	0.1129***
	(.0232)	(.0244)		(.0254)	(.0259)
	0.0905	0.0412		0.1846	0.1761
ATSECUR	-0.0717***	-0.0518***	GROUP	-0.2921***	-0.2006***
	(.0145)	(.0152)		(.0273)	(.0269)
	-0.1182	-0.0816		0.5156	-0.3383
			R^2	0.4636	0.4543
			CONSTANT	1.4528	1.1943
			N	1177	1123

[a] The first number for each variable represents the estimation of the ordinary regression coefficient. The number below in parentheses represents the standard error of the estimated coefficient. The third number represents the standardized regression coefficient. Level of significance is indicated as follows:

* = significant at 85% ($t \geq 1.5$)

** = significant at 95% ($t \geq 2.0$)

*** = significant at 99% ($t \geq 2.8$)

TABLE 7

PRODUCTION FUNCTION FOR MATHEMATICS AND SPANISH ACHIEVEMENT:

Female Students[a]

VARIABLE	MATH	SPANISH
PRETEST	0.3446***	0.5394***
	(.0309)	(.0349)
	0.3148	0.5277
STATE-1	.1197***	.0743***
	(.0161)	(.0168)
	.1998	.1101
STATE-2	.0900***	.1023***
	(.0167)	(.0182)
	.1353	.1336
STATE-3	.1201***	.0417***
	(.0144)	(.0160)
	.2013	.0617
COMMINC	-0.1472***	0.0491*
	(.0227)	(.0269)
	-0.2495	0.0770
SES	-0.0145	-0.0152
	(.0286)	(.0278)
	-0.0171	-0.0176
SEX		
SELFEX	0.0158	-0.0192
	(.0152)	(.0175)
	0.0288	-0.0324
ASP	0.0895**	0.0386
	(.0344)	(.0396)
	0.0791	0.0316
ATSECUR	-0.0757***	-0.0578***
	(.0170)	(.0196)
	-0.1360	-0.0962
MATNEED	0.1163***	0.0268
	(.0295)	(.0336)
	0.1092	0.0233
INTWORLD	-0.0406**	0.0071
	(.0148)	(.0173)
	-0.0819	0.0132
TEASEX	-0.1656***	0.0245
	(.0216)	(.0226)
	-0.2690	0.0404
TEAED	0.4667***	0.0689**
	(.0300)	(.0287)
	0.6802	0.0802
TEAEXP	-0.2323***	-0.1751***
	(.0392)	(.0470)
	-0.2668	-0.1752
TEAGE	0.0973***	0.0763**
	(.0275)	(.0362)
	0.1327	0.0912
TATED	0.0491**	0.0461*
	(.0217)	(.0264)
	0.0723	0.0539
TEAOBS	0.0802***	0.0871***
	(.0161)	(.0256)
	0.1717	0.1200
CLSIZE	0.3291***	0.1549***
	(.0305)	(.0317)
	0.5681	0.2474
GROUP	-0.5001***	-0.1329***
	(.0363)	(.0379)
	-0.9001	-0.2213
R^2	0.4696	0.3974
CONSTANT	1.1492	1.0427
N	756	749

[a] The first number for each variable represents the estimation of the ordinary regression coefficient. The number below in parentheses represents the standard error of the estimated coefficient. The third number represents the standardized regression coefficient. Level of significance is indicated as follows:

* = significant at 85% ($t \geq 1.5$)

** = significant at 95% ($t \geq 2.0$)

*** = significant at 99% ($t \geq 2.8$)

Table 8

Results of Before and After Achievement Testing in the Federal District

Mathematics	TS	ED
pretest	20.28	20.78
posttest	28.84	23.80
gain	8.56	3.02
N	353	350
Spanish		
pretest	26.06	25.37
posttest	33.22	28.14
gain	7.16	2.77
N	336	340

Within the Federal District (including and surrounding Mexico City) both the TS and ED systems operate, in contrast to most communities where the TS system has entered to fill the void created by the absence of any traditional secondary schools. The demand for TS within the Federal District has resulted in part from the difficulty in entering the crowded traditional system (ED). Students in the TS system in this area are generally individuals who have failed the entrance examination for the traditional system and generally are considered lower ability students than those in the ED system. Examining Table 8 we find that these lower ability TS students gain significantly more (at the .01 level) in mathematics and spanish achievement than do ED students in the Federal District. However, again we have the problem of using a simple t-test to compare populations that may differ systematically along other dimensions; therefore the educational production relationship is examined below for the Federal District.

Table 9 shows the results for the production function estimation for student mathematics and spanish achievement in the Federal District. Examining the GROUP variable we see that television, even after controlling for sex, motivation, class size, teacher differences, and other variables, has a significant positive effect on the achievement of these lower ability TS students. Furthermore, comparing the size of the ordinary regression coefficients here with those of the GROUP variable in Table 4, we can see that the [redacted] effect of television on achievement is [redacted] the same for low ability students as it is for all students.

Insert Table 9 About Here

Examining the remainder of Table 9 we can see that the effectiveness of various inputs differ considerably from the average total relationship estimated earlier (Table 4), perhaps somewhat expectedly due to the differences between the urban capital of Mexico City and its less urban surrounding states, perhaps in part due to the influence on the sample of the lower ability TS students.

Generally, teacher characteristics have effects on achievement in the Federal District similar to that in the whole sample. One exception is that in the Federal District female teachers appear to be more productive than male teachers for spanish achievement as compared to the finding of no significant difference between them in the whole sample. This may be due to males having more higher status alternative employment opportunities in Mexico City than elsewhere, with the city therefore having relatively lower quality male teachers than in other parts of the country.

TABLE 9

PRODUCTION FUNCTION FOR MATHEMATICS AND SPANISH ACHIEVEMENT:

Federal District Students[a]

VARIABLE	MATH	SPANISH	VARIABLE	MATH	SPANISH
PRETEST	0.3313***	0.5849***	MATNEED	0.0294	0.0868**
	(.0275)	(.0324)		(.0294)	(.0344)
	0.3354	0.5340		0.0269	0.0730
STATE-1			INTWORLD	-0.0357**	0.0073
				(.0137)	(.0157)
				-0.0726	0.0137
STATE-2			TEASEX	-0.1332***	0.4862***
				(.0196)	(.0681)
				-0.2328	0.8097
STATE-3			TEAED	0.3873***	-0.0052
				(.0341)	(.0304)
				0.6286	-0.0062
COMMINC	0.1503***	-0.5967***	TEAEXP	-0.5834***	-0.4905***
	(.0519)	(.0846)		(.0559)	(.0515)
	0.1385	-0.5049		-0.6378	-0.5898
SES	-0.0857***	0.0173	TEAGE	0.3601***	0.4036***
	(.0267)	(.0363)		(.0429)	(.1002)
	-0.1105	0.0140		0.5307	0.5405
SEX	-0.0089	-0.0075	TATED	0.0502*	-0.1098***
	(.0168)	(.0193)		(.0276)	(.0349)
	-0.0154	-0.0119		0.0608	-0.1433
SELFEX	0.0014	-0.0484**	TEAOBS	0.0644***	0.3459***
	(.0167)	(.0198)		(.0144)	(.0466)
	0.0024	-0.0742		0.1709	0.7296
ASP	0.1304***	-0.0518*	CLSIZE	-0.2180***	0.7429***
	(.0293)	(.0334)		(.0563)	(.0899)
	0.1326	-0.0484		-0.2756	0.8622
ATSECUR	-0.0725***	-0.0562***	GROUP	-0.3793***	-0.1833***
	(.0162)	(.0185)		(.0458)	(.0374)
	-0.1307	-0.0930		-0.6912	-0.3067
			R^2	0.5384	0.4891
			CONSTANT	3.2425	-1.9892
			N	696	681

[a] The first number for each variable represents the estimation of the ordinary regression coefficient. The number below in parentheses represents the standard error of the estimated coefficient. The third number represents the standardized regression coefficient. Level of significance is indicated as follows:

* = significant at 85% ($t \geq 1.5$)

** = significant at 95% ($t \geq 2.0$)

*** = significant at 99% ($t \geq 2.8$)

It also appears likely that the effects of COMMINC, SES, and CLSIZE are somewhat bound together,[36] measuring the combined effects of community status, a student's relative family status within the community, as well as the effect of class size. It is possible to come up with more elaborate ad hoc explanations for surprising coefficient signs and magnitudes, but to do so would mostly be a fishing expedition; more analysis on various subsamples of the data is really needed before we can achieve a real understanding of what is taking place.

In another attempt to examine the effects of television on students of differential ability, the sample was stratified into low and high achievement students in mathematics and spanish, low achievement represented by a pre-test score greater than one standard deviation below the mean and high achievement represented by a pretest score greater than one standard deviation above the mean. The decision to stratify by achievement was made due to the absence of an ability measure for both TS and ED students with the implicit assumption that there is a fairly close correlation between the two.[37] Actually, however, the initial hypothesis of the non-individualizable nature of the television medium could have been sensibly regarded as implying that television programs were arrived at and geared for middle-level achievement (as opposed to ability) students and thus such programs would lose low achievement students and bore high achievement students.

Insert Tables 10 and 11 about here

Tables 10 and 11 show the resulting production function estimates for low achievement and high achievement students respectively. Examining the GROUP variable in Table 10, again we find the effect of television to be positive and significant

TABLE 10

PRODUCTION FUNCTION FOR MATHEMATICS AND SPANISH ACHIEVEMENT: Low Achievement Students[a]

VARIABLE	MATH	SPANISH
PRETEST	0.0420	0.3583***
	(.0834)	(.0705)
	0.0250	0.2435
STATE-1	0.1098**	-0.0087
	(.0444)	(.0480)
	0.1903	-0.0147
STATE-2	0.1170**	0.0495
	(.0515)	(.0541)
	0.1581	0.0537
STATE-3	0.1988***	-0.0478
	(.0415)	(.0392)
	0.3038	-0.0755
COMMINC	0.0102	0.0290
	(.0527)	(.0539)
	0.0179	0.0457
SES	-0.0683	-0.0034
	(.0528)	(.0397)
	-0.0805	-0.0043
SEX	-0.0113	-0.0059
	(.0286)	(.0275)
	-0.0204	-0.0102
SELFEX	-0.0037	-0.0605**
	(.0281)	(.0260)
	-0.0067	-0.1089
ASP	0.0764	-0.0197
	(.0578)	(.0495)
	0.0773	-0.0214
ATSECUR	-0.1458***	-0.1176***
	(.0324)	(.0332)
	-0.2404	-0.1839
MATNEED	0.0385	0.0873*
	(.0577)	(.0472)
	0.0330	0.0856
INTWORLD	-0.0316	0.0258
	(.0273)	(.0267)
	-0.0633	0.0498
TEASEX	0.0345	0.0630*
	(.0376)	(.0362)
	0.0547	0.0965
TEAED	0.2173***	0.1471***
	(.0450)	(.0505)
	0.3235	0.1827
TEAEXP	-0.2461***	-0.1505*
	(.0699)	(.0883)
	-0.2784	-0.1564
TEAGE	0.0876	-0.1566**
	(.0623)	(.0660)
	0.1101	-0.1865
TATED	0.0659*	0.1013**
	(.0396)	(.0390)
	0.0932	0.1265
TEAOBS	0.0689**	0.0914*
	(.0292)	(.0460)
	0.1574	0.1057
CLSIZE	0.1867***	0.1699***
	(.0590)	(.0557)
	0.3215	0.2899
GROUP	-0.2819***	-0.1281*
	(.0550)	(.0667)
	-0.5080	-0.2266
R^2	0.3762	0.2723
CONSTANT	2.4131	1.4638
N	305	397

[a] The first number for each variable represents the estimation of the ordinary regression coefficient. The number below in parentheses represents the standard error of the estimated coefficient. The third number represents the standardized regression coefficient. Level of significance is indicated as follows:

* = significant at 85% ($t \geq 1.5$)

** = significant at 95% ($t \geq 2.0$)

*** = significant at 99% ($t \geq 2.8$)

TABLE 11

PRODUCTION FUNCTION FOR MATHEMATICS AND SPANISH ACHIEVEMENT:

High Achievement Students[a]

VARIABLE	MATH	SPANISH	VARIABLE	MATH	SPANISH
PRETEST	0.5449***	0.6609***	MATNEED	0.0616	0.0631
	(.1086)	(.1162)		(.0421)	(.0422)
	0.2283	0.3344		0.0657	0.0760
STATE-1	0.1169***	0.0990**	INTWORLD	-0.0257	-0.0102
	(.0395)	(.0380)		(.0189)	(.0195)
	0.2613	0.2493		0.0630	0.0284
STATE-2	0.1098***	0.0247	TEASEX	-0.0749***	0.0127
	(.0381)	(.0387)		(.0262)	(.0340)
	0.2158	0.0599		-0.1578	0.0319
STATE-3	0.0791**	0.0865**	TEAED	0.2665***	0.0841*
	(.0390)	(.0412)		(.0377)	(.0452)
	0.1215	0.1439		0.4323	0.1347
COMMINC	-0.1001***	-0.0768*	TEAEXP	-0.0305	0.0811
	(.0331)	(.0459)		(.0410)	(.0598)
	-0.2093	-0.1834		-0.0457	0.1431
SES	0.0137	-0.0861**	TEAGE	0.0103	-0.0478
	(.0390)	(.0406)		(.0377)	(.0421)
	0.0222	-0.1320		0.0165	-0.0965
SEX	0.0062	-0.0251	TATED	-0.0464	0.0363
	(.0220)	(.0230)		(.0323)	(.0404)
	0.0131	-0.0625		-0.0839	0.0634
SELFEX	-0.0439**	-0.0562**	TEAOBS	0.0375*	0.0216
	(.0217)	(.0219)		(.0206)	(.0410)
	-0.0921	-0.1380		0.1076	0.0545
ASP	0.0777*	0.0790*	CLSIZE	0.0766*	0.1344***
	(.0465)	(.0460)		(.0448)	(.0440)
	0.0918	0.1109		0.1517	0.3014
ATSECUR	-0.0978***	-0.0248	GROUP	-0.2972***	-0.2020***
	(.0226)	(.0218)		(.0464)	(.0459)
	-0.2251	-0.0649		-0.6597	-0.5008
			R^2	0.3762	0.2918
			CONSTANT	1.2487	0.6934
			N	357	312

[a] The first number for each variable represents the estimation of the ordinary regression coefficient. The number below in parentheses represents the standard error of the estimated coefficient. The third number represents the standardized regression coefficient. Level of significance is indicated as follows:

* = significant at 85% ($t \geq 1.5$)

** = significant at 95% ($t \geq 2.0$)

*** = significant at 99% ($t \geq 2.8$)

for low achievement (ability) students. Comparing the GROUP ordinary regression coefficients here with those for the whole student sample given in Table 4, we see that television has a significantly weaker effect (.01 level) for low ability students in mathematics than for students as a whole. The effect of television on high ability students, as can be seen from Table 11, is also positive and significant, its effectiveness also being significantly lower (.01 level) in mathematics than for the average student. Both these results lend credence to the idea that at least mathematics television programs are directed toward the middle level (achievement or ability) students and thus are less effective for lower and higher level students. However, the important point is that television, in both subjects, still aids both low and high level students more than the traditional system appears to.[38]

It is interesting to note that the proportion of variance (R^2) in achievement explained by the production function estimation is considerably less for low and high level students than for students as a whole, that is, our knowledge of factors affecting academic achievement in these students is less than for middle level students. We can observe that the influence of previous achievement (PRE-TEST) is quite a bit stronger for high achievement students than low achievement students, suggesting that we may be relatively less able to influence the academic achievement of higher level students. This is further borne out by glancing through Table 11 and noting the relative lack of significance of most of the instructional system variables. Given the present limited degree of school input variation it appears that television is one of the few school factors that does contribute to the achievement of high level students.[39] For low level students we find that school factors, including television, do have a significant influence on achievement, while there is a general lack of significance of community and student background variables. This (combined with low effect of PRE-TEST) implies that schools can indeed teach low level students; furthermore if we compare the standardized regression coefficients of all the factors affecting these students achievement the use of television appears to be one of the strongest positive influences.

CONCLUSIONS

We conclude that television as currently used in the Mexican secondary school system has a significant positive effect on student achievement in the core subject areas of mathematics and spanish. Telesecundaria students, despite coming from more disadvantaged home and school environments, show larger academic improvements in school than Ensenanza Directa students; this difference appears to be due primarily to television, as opposed to differences in sex, motivation, ability, and class size between the two groups.

We observed that the average production relationships estimated changed considerably as the sample was stratified in different ways; this goes to illustrate Levin's point (discussed earlier--see Levin (1974)) that average production relationships are not necessarily production frontiers and that allocative efficiency recommendations based on the total data set may yield disfunctional results in certain areas and for certain firms (schools).[40] Indeed, it is most likely that the production frontier is different for each individual student (consider the student as the "firm"). However, if policy must be applied at a more aggregate level (and most often it must)--i.e., the classroom, the school, the state, the system--then it is that aggregate level that should be the relevant level of analysis (or base for sample stratification), despite some possible disfunctional consequences.[41] Perhaps the strongest result of the previous analysis is the robustness of the finding that the use of television contributes to student achievement; in each stratification of the data sample tested, for males and females as well as for both high ability and low ability students, television was effective.

Of course, to translate this into even rudimentary policy recommendations an analysis of the costs of the two systems are needed. As reported in Mayo, McAnany, and Klees (1973) or Klees (1974), the TS system, as it now operates, costs, on an annual per student basis, 25% less than the ED system--$151/student vs $200/student. The difference in costs is due to the lower administration, classroom, and teacher costs of the TS system more than compensating for the add-on cost of the production, distribution, and reception of the instructional television programs. Furthermore, if we compare the two systems on a more rational basis than an historical one, the difference in costs becomes even more pronounced; for example, if ED were operating in TS's present more rural environment, with average class sizes of 23 and single sessions, ED system costs would be at least $240/student/year and could go as high as $431/student/year, the latter being almost three times the $151/student/year cost of the TS system.[42] Finally, due to economies of scale the cost of the TS system could drop to as low as $130/student/year if the system was expanded.

Combining the above cost data with the learning results obtained previously and the additional fact that drop-out, promotion, and repetition rates are the same for the two systems (see Mayo, McAnany and Klees (1973), and Klees (1974) for details) we observe that for an equal level of budget the TS system can enroll more students, produce more graduates, and increase (or at the very least maintain) the level of spanish and mathematics achievement for students enrolled, as compared with the ED system. This is what makes Mexico's Telesecundaria project especially significant among the many experiments with ITV taking place around the world today. Almost all such experiments in formal school systems utilize ITV in such a way that it results in larger system costs.[43]

Very few countries have deliberately reduced the costs of the traditional educational system components to more than offset the additional costs of the television system, as Mexico did. Mexico was faced with a shortage of secondary school teachers (and schools) available to meet the educational demands of rural communities, a situation common to many developing nations. At the same time there was an excess (or at least a sufficient quantity) of much less expensive, qualified primary school teachers (the salary of a primary school teacher is about 50% that of a secondary school teacher) willing to teach in rural areas, which although less common, is still found in a number of developing countries.[44] With the simple addition of a rather inexpensive, straight forward, intensive (and perhaps low quality[45]) instructional television system these two apparent deficits were turned into a decided educational advantage for the education of rural youngsters,[46] a possibility other developing nations may want to investigate.

Despite the above comparative assets of the TS system a few important limitations should be remembered. First, this study does not really enable us to examine the effectiveness of instructional television programs, except as they were used in this system; unfortunately this represents a fixed format, with no discernible systematic variations in program quality dimensions to allow us to suggest changes in the TS system that might prove more effective than current practices. Furthermore, this limited variation of educational input patterns does not just apply to the use of television; school, classroom, and teacher policies and practices are not subject to much variation and it is little wonder that a "talking head" on television can teach students as well (or as poorly[47]) as a live "talking head" in the classroom. To improve student performance in school and to understand better the possible effectiveness of schooling systematic experimentation is needed with <u>wide</u> ranges of alternative input combinations.

Finally, there is a growing need for policy-makers and analysts to look beyond the useful but limited domain of alternative school system's effectiveness and tackle the more difficult task of examining the possible societal costs and benefits of alternative courses of action. In the expansion of rural educational opportunities, this need is especially urgent.

Although it is important to learn that Telesecundaria appears to be better able than the traditional secondary school system to meet the burgeoning demand for education among rural communities, the question of whether it is beneficial to the country (or even the individuals involved) still remains. Urban unemployment and under-employment is high and rural and agricultural development and modernization has barely begun in many areas; a program that encourages the most able and motivated rural students to leave their homes and villages and compete for success in the cities, as the Telesecundaria seems implicitly to do (see Mayo, McAnany, and Klees (1973)), is not clearly in Mexico's best interests.

The problem is not with the technology; television can teach, as much research has shown, and can teach rural Mexican students, as this research has shown. People must decide on their priorities--perhaps the direct translation of an urban-oriented academic curriculum to rural students was an outcome of decision-makers priorities of meeting rural educational demands, perhaps a curriculum more oriented toward rural development, self-sufficiency, and growth would be more beneficial to Mexico's people. Whatever Mexican educational policy-makers decide--and the future of the Telesecundaria system is at this moment in their hands--it does seem that television can offer a viable, useful, cost-effective medium for education for Mexico and other developing nations.

Appendix A

Correlations of Post-Test Achievement Scores
With Classroom Observation Variables

Variable	TS and ED		TS only		ED only	
	Math	Spanish	Math	Spanish	Math	Spanish
Teacher Behavior						
Lectures	-.25**		-.32***			-.35*
Dictates					-.33*	
Explains						
Asks Procedure Quest.	.38***	.43***	.43***	.39***		
Asks Memory Quest.					.34*	
Asks Stimulus-Response Memory Quest.					-.29*	
Asks Opinion Quest.						
Asks Research Quest.					.30*	
Asks for Examples						
Uses Blackboard	-.16*		-.21*	.19*		
Uses A-V Materials				-.16*		
Reads Reference Works						
Supervises Individual work	.13***		.33***			
Works Individually With Students		-.15*		-.23*	.37*	
Supervises Groups	.43***		.45***			
Suggests Group Projects						
Assigns Homework						
Assigns Research Homework						
Checks Homework						
Preparation		-.21**				-.32*
Student Behavior						
Expounds	.25**		.22*		.28*	-.30*
Dictates		.15*				
Asks Clarification Quest.			.24**			

Variable	TS and ED		TS only		ED only	
	Math	Spanish	Math	Spanish	Math	Spanish
Student Behavior						
Asks Other Quest.		.14*		.21*		
Gives Opinions					-.28*	
Works Individually						-.30*
Works in Groups	.35***		.35***			
Go To Blackboard	.27**		.30**	.33***		-.37*
Time at Blackboard	.29***		.31**	.16*		-.43*
Uses A-V Materials	.33***	-.14*	.35***			
Uses Textbooks					.29*	
Uses Reference Works		.22**	.26**	.19*		

Appendix B

Summary of Output Results of Telesecundaria With Ensenanza Directa

by Mayo, McAnany, and Klees (1973, Chapter IV)

Result 1: Whereas both TS and ED groups started more or less equally, the TS groups gained slightly more over the semester in Mathematics, Spanish and Chemistry.

Result 2: Change scores on achievement tests indicate a strong pattern of state differences, consistent across the three tests. This pattern shows more gain in learning in the more urban states of DF and Valley of Mexico, less in the more rural states of Hidalgo and Morelos.

Result 3: TS students score below the general [ability] level expected of ED students and below the recorded levels of technical secondary students.

Result 4: General ability results follow an identical order by state as those of achievement; the more urban the state, the higher the level of general ability. Also, general ability is strongly related to achievement and is one of the single largest factors accounting for the variance in achievement.

Result 5: Background factors of parents' education, occupational status of the father and TV ownership all relate significantly and positively to achievement for the ED group. For TS the pattern does not hold for achievement but only for general ability.

Result 6: Background factors of parents' education and fathers' occupation seem to affect achievement for ED more in urban than in rural states; for TS, this influence is limited to Mexico City. TV ownership seemed to be related to achievement only for TS in the more rural areas; not at all for ED.

Result 7: Although sex and age do not have as strong a relationship to achievement as other factors already examined, some consistency emerges: younger male students tend to do better in both ED and TS and within both groups, age and sex differences on achievement were smaller in the rural areas.

Result 8: Teacher behaviors that most prompted active student participation in Mathematics showed a significant relationship with higher achievement for both TS and ED.

Result 9: Students of both TS and ED hold high aspirations for more schooling and better jobs, but the proportions of students desiring university level training and professional careers are much higher in the ED group.

Result 10: Students with high aspirations (for more school, better jobs and higher salaries) were in the DF and Valley of Mexico, while those with lower aspirations were more evident in Hidalgo and Morelos. This was true of both TS and ED.

Result 11: Students with more educated parents who have better jobs and have a television set at home aspire to more education, better jobs and higher salaries. This is true for both groups but the relationship is stronger for ED students.

Result 12: Younger students in both systems aspire for more education, but age is not strongly related to aspirations. On the other hand, boys aspire for much more education, higher status occupations and higher salaries than do girls in both TS and ED; however, girls in ED aspire for significantly more schooling than do girls in TS.

Result 13: The higher the students' general ability and achievement, the higher tended to be their aspiration for more schooling, better jobs and higher salary. Although aspiration tended to be generally higher among ED students, the strength of the relationship between aspiration/learning was about the same for both groups. This pattern was the strongest for rural TS students.

Result 14: Students of both systems responded in a very similar way in the attitude scales although TS students manifested a slight but consistent tendency to be less change oriented. Such a result may be explained by the generally lower socio-economic level from which they come.

Result 15: Students who respond in more "modern" or change-oriented ways were more likely to score higher on achievement and (for TS only) general ability tests. The relationship between learning and attitudes was stronger among ED students. For TS students, the relationship between "modern" attitudes and general ability was stronger than that between attitudes and achievement, although both were statistically significant.

Result 16: Student attitudes toward TS are generally favorable, but it remains up to decision-makers to decide what is an acceptable level of response before taking remedial action.

FOOTNOTES

1. Other outputs examined include student attitudes, system satisfaction of enrollment demand, and system graduates. See Mayo, McAnany, and Klees (1973) and Klees (1974) for details.

2. For a fuller system description see Mayo, McAnany, and Klees (1973).

3. There is in Mexico a shortage of secondary school teachers available to teach in rural areas, whereas there was an excess of primary school teachers, who cost half as much as the former. In some ways this is the true raison d'etre of the TS system.

4. For reviews of the relative instructional effectiveness of media other than television see Jamison, Suppes, and Wells (1974), Schramm (1973), and Chu and Schramm (1967).

5. They add though, that "some evidence indicates that it [television] performs relatively better at lower grade levels." (p.38). Jamison, et.al. (1974) also discuss the general finding of no significant difference in instructional effectiveness between television and other instructional techniques, commenting that "when highly stringent controls are imposed on a study, the nature of the controls tends to force the methods of presentation into such similar formats that one can only expect the 'no significant differences' that are in fact found." (p.36) That is, to exact the most out of any instructional medium, be it television or direct teaching, one must allow it to use its unique strengths (for example, Sesame Street).

6. For a more detailed treatment of the problems in formulating and estimating educational production functions see Bowles (1970) and Michaelson (1970). Also see Levin (1974) for a critique of their potential usefulness and the relationship between output specification and efficiency considerations discussed below.

7. Existing theories of learning are presently too micro in focus, to be useful to this type of production function analysis. Hilgard and Bower (1966) review classical theories of learning for pieces of information and connections between these pieces. Jamison, Lhamon, and Suppes (1970) review micro learning theories in a probabilistic Markov chain framework. Bruner (1960) makes a preliminary attempt at developing a theory of instruction (as opposed to a theory of learning).

8. For a discussion of a number of the presumed reasons for the presence of technical inefficiency in schools see Levin (1971), and for a somewhat revised perspective Levin (1974).

9. Equity has become a concern of many contemporary economists, although beyond formulating rational ways of examining equity-efficiency trade-offs, the predominant view is still that economists can contribute no more to the definition of what is "equitable," than can the ordinary citizen. For the examination of equity concerns relevant to the TS and ED systems see Klees (1974).

10. Allocative efficiency requires that the marginal product per dollar input of all inputs be equal. See Henderson and Quandt (1958) or any other standard microeconomics textbook for details.

11. Technical inefficiency becomes an "economic" problem when we examine the lack of economic motivation to maximize.

12. Differences in production possibilities due to these factors outside management control have typically been grouped by the authors above as part of the problem of technical efficiency. Technological efficiency, in essence, is an attempt to break down the concept of technical efficiency into factors within the control of the firm (technical efficiency as defined in this paper) and those outside the firm's sphere of influence (technological efficiency). It should also be noted that these distinctions may change from the short run to the long run.

13. That is, all firms (in an industry) face the same production frontier, and all firms operate on that frontier.

14. This recommendation would be discernible if teacher motivation was a measured variable in the production function analysis. This type of reasoning has led Levin and Muller (1974) to call technical efficiency a misnomer. They assert that the physical law of the conservation of energy and matter obviously holds, requiring that inputs are not lost in the production process; when one finds "technical inefficiency," what has happened is that appropriate inputs have been left out of the production function specification (such as teacher motivation) or that firm outputs are not appropriately specified (e.g. teacher leisure is lacking). Levin (1974) goes on to argue that production function analysis may be a useless tool as different firms will use different inputs to produce different outputs. We can carry Levin's argument a step further and plausibly suggest that different classrooms, and, indeed, different students, can have different production functions. However, if educational policy is to be applied at some aggregate level then it would seem to us that on the whole production function analysis can yield useful recommendations, as discussed below.

15. Levin's assertion that such recommendations may actually reduce total system efficiency rests on output misspecification. It is indeed true that if, for example, the use of television

in the Mexican system results in the reduction of other (than mathematics and Spanish achievement) desirable outputs (or in the production of undesirable outputs) its use may be disfunctional.

16. It must be remembered that allocative recommendations resulting from production function analysis are marginal recommendations; that is, indications of the effects of changes in resource utilization do not necessarily hold true for large changes.

17. Specific formulations of this general model have been extended by a number of researchers. See Levin(1970) and Carnoy (1974) for examples. However, if this is truly the most sophisticated model we have of the educational process, it is evident that our lack of knowledge and understanding is great.

18. The marginal product of any input variable X_i with respect to output Y reflects changes in Y caused by small changes in X_i; it is given by the partial derivative of Y with respect to X_i, $\partial Y/\partial X_i$. In equation (2) this is a constant, b_i, the coefficient of X_i. The elasticity of substitution reflects the relative ease with which one can substitute two inputs, say X_i for X_j, (due to changes in factor price ratios or marginal productivity ratios, for example) without sacrificing output. For a mathematical definition and discussion see Michaelson (1970, p.25) or any standard microeconomics text.

19. The marginal product of variable X_i with respect to output Y is still the partial derivative $\partial Y/\partial X_i$ which in the logarithmic model equals $b_i\ Y/X_i$.

20. The elasticity of output Y with respect to some input variable X is defined mathematically as $dY/Y \div dX_i/X_i$.

21. Bowles (1970, p.19) also points out that in the logarithmic model "the cross derivatives among any pair of inputs, each of which is positively related to output, must also be positive. This would require, for example, that an increase in the quality of teachers be more effective on children of well educated parents than on the children of illiterate parents."

22. Wells (1974) examines the transcendental logarithmic model and several general variable transformation models.

23. One final consideration not discussed above is the possibility of needing a simultaneous system of equations to model the educational process when dealing with simultaneously produced multiple outputs (see Levin (1970) for a discussion). Due to the short time period under consideration in the production function estimation (one semester) in this study and the

subject specific nature of instructional periods at the secondary school level it was felt that a single equation estimate would suffice.

24. The author was a member of the Stanford Institute for Communication Research evaluation team during this period.

25. Achievement in chemistry will not be treated further in this analysis; the results are included here for the reader's information.

26. The differences between the TS and ED groups are reported in detail in Mayo, McAnany, and Klees (1973, Chapter II).

27. Such students may also have more parental support and encouragement than usual, which is indirectly indicated by the finding that despite their more rural situation, TS students had similar access to the mass media (newspapers, magazines, radio, television and books) in their home or community as ED students (see Mayo, McAnany, and Klees (1973, pp. 20-21)).

28. There is some evidence indicating a positive effect of smaller classes on a child's affective development. See Jamison, Suppes, and Wells (1974) for a review.

29. The ordinary regression coefficients may be interpreted as the percentage change in the dependent variable associated with a one percent change in an independent variable (holding all other independent variables constant.) The standardized regression coefficients represent the standard deviation change in the logarithm of the dependent variable caused by a one standard deviation change in the logarithm of an independent variable. The standardized coefficient is most useful as a comparative measure of the strength of the effect of one independent variable relative to other independent variables, while ordinary regression coefficients can be compared between equations (see Schoenberg (1972) for further analysis of these differences).

30. Even with multicollinearity, estimated regression coefficients are unbiased estimators.

31. The effect of the state of Morelos is contained in the constant term, and is only discernible relative to the effects of the other states.

32. Student socio-economic status and community income are highly colinear and this may account for the apparent insignificance of SES.

33. Mayo (1973) does find a few differences in spanish teaching style between TS and Ed teachers, but perhaps of even more interest is the finding that TS teachers' style "changed markedly from one subject to the other [mathematics to spanish]"

suggesting that the "nature of the subject matter [may] affect the classroom behavior of the instructors who teach it" (p.17).

34. Class size may serve as a proxy for degree of urbanization or community development, which may be inadequately controlled for.

35. The nature of the stepwise regression procedure assigns all the variance explained in common by two or more independent variables to that variable entered first into the regression.

36. It is possible that all three measure aspects of the same phenomena-community urbanization or development.

37. For TS students the correlation between relevant ability measures and mathematics and spanish pre-test achievement was .34 and .32 respectively.

38. It might be worthwhile, even based on the scanty evidence above, to carefully examine the differences between mathematics and spanish television programs in an attempt to understand possible differences in the student achievement/ability level toward which the program is aimed.

39. Relatively limited variation in educational inputs is a problem that plagues this study, as well as other production function studies. The effectiveness of the inputs measured only hold for variations in them within the range encompassed by the sample; the effects of large changes in the organization, quality of the inputs cannot be deduced from this analysis.

40. For example, the production function based on the total data set would lead the administrator not to discriminate between male and female spanish teachers. However, in the Federal District it might be productive to hire relatively more female spanish teachers.

41. Of course, it would always be nice to gear policy to the differing level of efficiencies of different "firms" but such is not always possible nor necessarily cost-effective (see earlier discussion, pp.9-10).

42. Another possibility would be to consider the costs of Telesecundaria operating in an urban environment as Ensenanza Directa does now, with class sizes of 46 and half the schools on double session. In such circumstances, TS could cost as little as $72/student/year and at most would cost $138/student/year (compared to the present ED cost of $200/student/year). See Klees (1974) for details.

43. Using ITV as an instructional improvement appears possible, and in that case it is a question of whether the extra costs associated with it are more than matched by the additional

benefits ITV may provide. However, perhaps the primary immediate possibilities of the use of ITV (and other technological media) is their ability to reduce costs and maintain learning, if used imaginatively to reduce expenditures on direct teaching.

44. It is not clear what level of education is needed for classroom "monitors" or "coordinators" if instruction is carried mainly by ITV. In Niger, a widely-acclaimed ITV system used primary school graduates as the classroom "teacher-monitor" for primary school classes (see Schramm (1973)).

45. The quality of the instructional television programs in the Mexican system is by most standards considered low. Anyone can view the programs by simply turning on their TV set (since broadcasts are open circuit, over a commercial network) and, therefore, TS has been subject to much criticism. However, secondary school teachers in the traditional system are rarely observed by the public and the real question is are the tele-teachers as good or better? Furthermore, the television programs are presently produced on a shoe-string budget; additional money can be spent on improving the quality of the programs and the system can still be cost-effective (see Klees (1974) and Mayo, McAnany and Klees (1973) for some suggestions in this regard).

46. The shortage of secondary school teachers available in rural areas allowed many of the teachers union problems to be avoided that might otherwise be encountered in substituting lower paid primary school teachers for higher paid secondary school teachers.

47. It should be noted that achievement gains for both the TS and ED groups were far from spectacular, according to the measures used, leading to the possibility that the two systems teach equally poorly as opposed to equally well.

REFERENCES

Aigner, D. J. and Chu, S. F. On estimating the industry production function. American Economic Review, 1968, 58, 826-839.

Beeby, C.E. The quality of education in developing countries. Cambridge, Massachusetts: Harvard University Press, 1966.

Bowles, S. Towards an educational production function. In W. L. Hansen (Ed.), Education, income and human capital. New York: National Bureau of Economic Research, 1970.

Brown, M. On the theory and measurement of technological change. Cambridge, England: Cambridge University Press, 1966.

Bruner, J. Toward a theory of instruction. Cambridge, Massachusetts: Belknap Press, 1966.

Carnoy, M. Family background, school inputs and students' performance in school: the case of Puerto Rico. Unpublished paper, Stanford University, 1974.

Chu, G. C., and Schramm, W. Learning from television: What the research says. Washington, D.C.: National Association of Educational Broadcasters, 1968.

Coleman, J. S., Campbell, E. Q., Hobson, C. J., McPortland, J., Mood, A. M., Weinfeld, F. D., and York, R. L. Equality of educational opportunity. Washington, D.C.: Office of Education, 1966.

Cronbach, L. J., and Furby, L. How we should measure "change" -- or should we? Psychological Bulletin, 1970, 74, 68-80.

Dubin, R. and Hedley, R.A. The medium may be related to the message: college instruction by TV. Eugene, Oregon: University of Oregon Press, 1969.

Hanushek, E. A. The education of Negroes and Whites. Unpublished doctoral dissertation, Massachusetts Institute of Technology, 1968.

Henderson, J. M., and Quandt, R. E. Microeconomic Theory. New York: McGraw-Hill, 1958.

Hilgard, E. R., and Bower, G. H. Theories of learning, 3rd ed. New York: Appleton-Century-Crofts, 1966.

Hornik, R.C., Ingle, H.T., Mayo, J.K., McAnany, E.G., and Schramm, W. Television and educational reform in El Salvador. Stanford University: Institute for Communication Research, 1973.

Husen, T. (Ed.) International study of achievement in mathematics: a comparison of twelve countries. New York: Wiley, 1967.

Jamison, D., Lhamon, D., and Suppes, P. Learning and the structure of information. In J. Hintikka and P. Suppes (Eds.), Information and inference. Dordrecht, Holland: Reidel, 1970.

Jamison, D. and Suppes, P. Definitions of productivity and efficiency. In A. S. Melmed (Chairman), Productivity and efficiency in education. Education Panel to the Committee on Automation Opportunities in the Service Areas, Federal Council for Science and Technology, 1972.

Jamison, D., Suppes, P., and Wells, S. The effectiveness of alternative instructional media: a survey. Review of Educational Research, Winter, 1974, 44, 1-68.

Jencks, C. Inequality, a reassessment of the effect of family and schooling in America. New York: Harper and Row, 1972.

Klees, S. Instructional technology and its relationship to quality and equality in education in a developing nation: a case study of instructional television in Mexico, Doctoral dissertation, Stanford University, 1974, (forthcoming).

Lau, L. J., and Yotopoulos, P. A. A test for relative efficiency and application to Indian agriculture. American Economic Review, 1971, 56, 94-109.

Leibenstein, H. Allocative efficiency vs. x-efficiency. American Economic Review, 1966, 56, 392-415.

Levin, H.M. Measuring efficiency in educational production. Public Finance Quarterly, 1974 (forthcoming).

Levin, H. M. Concepts of economic efficiency and educational production. National Bureau of Economic Research, Conference on Education as an Industry, 1971.

Levin, H. M. A new model of school effectiveness. In A. M. Mood (Ed.), Do teachers make a difference? Washington, D.C.: Office of Education, 1970.

Levin, H.M. and Muller, J. The meaning of technical efficiency. Unpublished paper, Stanford University, 1974.

BEST COPY AVAILABLE

Mayo, J., McAnany, E., and Klees, S. The Mexican Telesecundaria: A cost-effectiveness analysis. Stanford University: Institute for Communication Research, 1973.

Mayo, J.A. Teacher observation in Mexico. Stanford University: Institute for Communicative Research, 1973.

Massell, B. F. Elimination of management bias from production functions fitted to cross-section data: A model and an application to African agriculture. Econometrica, 1967, 35, 495-508.

Mayeske, G. W. Teacher attributes and student achievement. In A. M. Mood (Ed.), Do teachers make a difference? Washington, D.C.: Office of Education, 1970.

Michelson, S. The existentialist reality of educational production functions (Their existence has preceded their essence.) Washington, D.C.: Office of Education, 1969.

Rao, P. and Miller, R.L. Applied econometrics. Belmont, California: Wadsworth Publishing Co., 1971.

Salter, W.E.G. Productivity and technical change. Cambridge University (England), 1960.

Schoenberg, R. Strategies for meaningful comparison. In H.L. Costner (Ed.), Sociological Methodology. San Francisco: Jossey-Bass Inc., 1972.

Schramm, W. Big media, little media. Stanford University: Institute for Communication Research, 1973.

Stickell, D.W. A critical review of the methodology and results of research comparing televised and face-to-face instruction, Unpublished doctoral dissertation, Pennsylvania State University, 1963.

Timmer, P. On measuring technical efficiency. Food Research Institute Studies in Agricultural Economics, Trade, and Development, 1970, 9, 99-171.

Wells, S. Technology, efficiency, and educational production. Doctoral dissertation, Stanford University, 1974 (forthcoming).