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ABSTRACT

This pilot study investigated the projected long-term economic effects of using the Edison Responsive Environment (ERE) machine in teaching 3- and 4-year-old preschool children. The ERE can be programmed in a variety of ways (to talk , play games, read aloud, show pictures and take dictation). The program developed for this study had four phases: (1) child learned alphabet; (2) child learned that letters form words; (3) child learned to read what he or machine typed; and (4) child developed personal stories using his own voice and drawings (for slides). Data collected between 1967 and 1972, on deprived and non-deprived preschoolers, exposed or not exposed to ERE, indicated the effectiveness of this technological approach to the development of prereading skills, considered basic to continued success in school. Statistics based on the concept of the economic dollar value of potential lifetime earnings (which fluctuate according to the level of schooling completed by an individual) indicated that the potential use of ERE technology as a preschool remedial technique for disadvantaged children is economically significant, even when the costs of purchasing and using ERE equipment are considered in the analysis. (ED)

REMARKS ON THE POSSIBLE ECONOMIC SIGNIFICANCE OF EARLY CHILDHOOD EDUCATIONAL TECHNOLOGY

by

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Introduction

Within the past few years educators have directed increasing attention toward the development of "pre-school" training programs. As a result, numerous attempts have been made to determine:

(1) The deficits that accrue to children who seem to lack early experiences leading to school success,

(2) The value of varied approaches to training the young.

For example, Deutsch (7) established a relationship between early stimulation and upper elementary school performance.

Durkin (11), in her research, asserted advantages for earlier readers, and Bereiter and Engleman (1) were working on that premise. After synthesizing voluminous research, Chall (3) pointed to results in later achievement in cases where children had learned the alphabet before reading. The desirability of learning the letters prior to actual reading has also been stressed by Durrell (12).

Moore (26), with Kobler, developed an "automated typewriter" on which children of three and four years of age learned to read, write and compose stories as well as to type.

The machine can be programmed in a variety of ways with any desired sequence of letters or words - to "talk," play games, read aloud, show pictures and take dictation. Known commercially as the Edison Responsive Environment (ERE), the equipment is being used in several settings throughout the country. Since Moore looks upon each learner as unique and individual, programming for the machine varies. The pilot study reported here is an attempt to gauge the effectiveness of the use of the ERE (Model 3) in conjunction with a non-automated typewriter in teaching three and four year olds.

In addition, efforts were made to determine the effects of the treatment upon language facility.

Population

Drexel University's Early Childhood Center has 44 children, integrated SES, ages 2.5 to 6, half tuition paying and half "Get Set," (the early day care component of Head Start). 10% of the children are severely mentally or physically handicapped, integrated in the ongoing program.

PROCEDURES

Treatment

A daily 15 minute session was provided for the three year olds, 20 minutes for the four year olds. The adult-child ratio was 1:1.

All children were offered the treatment daily with daily option of refusing. A combination of both automated and non-automated equipment was used. The choice of instrument for a given day was dependent upon the discretion of the teacher and the availability of the automated equipment. However, all of the subjects received approximately 80% of the total instructional time on the automated machine.

The non-automated booth contained a typewriter, as well as audio-visual equipment and Instructo (19) materials. In this setting, the assistant sat at the child's side in order to operate the equipment manually while in the automated booth, the machine was operated from a central panel and the child was observed through a one-way mirror. A daily record was kept of time spent, stroke count, and performance. During the time of treatment the training area in the automated setting was bare, except for the equipment, and the temperature was controlled at 72°.

A four phase program developed in the automated setting in which each child was:

(1) to demonstrate the ability to match names of alphabet letters to their graphic symbols

(2) to demonstrate the ability to type letters from dictation

(3) to demonstrate skill in reading orally

Phase I

In the first session with the machine, the child was confronted with what appeared to be a standard electric typewriter with colored keys. The child could explore the keyboard freely. After the depression of a key, the name of the letter was pronounced and its symbol appeared. Each depression locked the keyboard until the machine voiced the letter name. The child remained in this phase until he was able to relate the names of the letters to their graphic symbols.

Phase II

After a child learned the alphabet, he was to learn that letters form words. The child typed from instructions provided by the machine program or by the booth assistant. The machine locked automatically so that nothing except the letters for forming desired words could be typed.

Phase III

In this stage, the machine was programmed so that different things (e.g. letters, words, stories) could be typed at will. The child's ability to read what he, or the machine, had typed, was taken as evidence of his sight vocabulary.

Phase IV

The child develops monthly "experience stories" which are his own material that can be programmed using his own voice, and drawings for the slide presentation.

Economic Significance

Projections of the population of the United States in the year 2,000 based upon the Census Bureau's Series E fertility assumptions (2.1 per cent) would result in 264 million people with a radically different age distribution than today. In 1972, 37.2% of the population was in age groups under 15 and over 65, by 2,000 this would be reduced to 33.5%. In 1972, 62.8% was of age to be in the labor force, by 2,000 this per cent would be increased to 65.5.

The much smaller relative proportion of children and older people would mean that the total number of persons of an age that would make them potential labor force participants would be 10 million greater than would be the case were the 1972 population distribution to prevail. Moreover, the growth in the labor force relative to the total population probably would be even greater than this measure suggests, partly because the relatively reduced number of young people in the 15 to 20 age group would mean fewer people in school, and partly because the smaller size of families probably would accelerate the long-standing trend toward a larger proportion of women in the labor force.

What all this would add up to is that a relatively larger labor force would be available to support a relatively smaller non-working population, so that the total supply of all goods and services per capita would be significantly larger. In other words, the total of per capita well-being whether in the form of more goods and services, a shorter workweek, or earlier retirement would be much enhanced. (23).

However, when this "good" distribution is projected for another 30 years, the proportion of population entering the 25-45 age cohort of most productive years is drastically reduced. The burden of non-productive person support per productive individual starts to rise, not decline.

If we really attain zero population growth by 2010, then we (or our counterpart age cohorts in the labor force), will have to run harder and harder to stay in the same place.

Thus, the potential of the individual cannot remain unrealized in the near or middle-distant future, as economists measure cycles, by unequal opportunity, discriminatory training, or lack of incentive for personal development. We will not, in the twenty-first century, have the resources to "waste people", as we have wasted some of our other natural resources, such as oil, gas, metals, chemicals, water, air, timber and land.

The coming publication by the Carnegie Commission on the Future of Higher Education of the National Bureau of Economic Research volume entitled Education, Income and Human Behavior (27) has attempted to eliminate such variables as ability, family background, sex and religious preference from the observed returns to educational differences to achieve a genuinely net or "value added" measure of returns to formal schooling. In "Mental Ability and Educational Attainment," Paul Taubman and Terence Wales concentrate on the interaction between ability and schooling. They provide evidence indicating that despite a continued rise in the proportion of students entering college, the average ability of college students has not fallen. Colleges have become increasingly proficient at identifying, or at least admitting, more able students. At the same time, however, the average ability of high

school graduates who do not enter college appears to have declined.

Can educational attainment of itself be shown to provide returns in the form of earnings if proper allowance is made for intelligence, innate abilities, and other noneducational influences? Taubman and Wales respond with a qualified yes in "Education as an Investment and Screening Device." Their work centers on an analysis of the pure role of formal schooling - as distinct from the combined role of schooling and other variables like mental ability - in the generation of income differentials. They find that omitting ability variables from the analysis of returns to educational attainment results in only slight overestimation of schooling's impact on earnings, with the caveat that the influence of pure schooling (especially postgraduate training) is greater for those in the upper end of the ability distribution. Among the possible reasons underlying these results. Taubman and Wales speculate that since most employers use diplomas as criteria (or screening devices) for employment, rather than more expensive and time-consuming independent determinations of ability, the employee possessing a diploma has a decided edge in locating and assuming available positions.

In "Ability and Schooling as Determinants of Lifetime Earnings," John Hause further qualifies the Taubman and Wales findings. Hause also examines the relationships between ability, educational attainment, and earnings; however, he attributes only a proportional effect to ability's influence on earnings by creating an interaction specification in which the effects of ability depend on the level of formal schooling attained. He finds that ability and schooling interact proportionately to produce significantly higher incomes than would be predicted by a simple mathematical combination of the two. Hause's work empirically substantiates the widely held opinion that the rate of return to education is influenced by the level of basic ability, and that the returns to those with one or more college degrees increase with their level of ability.

Within the past few years, reports have been issued that education itself has little or no influence on individual ability (20); low returns for cost from an additional year of schooling (16); and that schooling differential quality has little or no influence on cognitive inequality (21).

On the other hand, the actual role of schooling as an equalizer seemed to be confirmed by studies of the intergenerational transmission of economic status. According to such analysis, additional schooling exerts a major effect upon earnings or occupational status independent of the social class background of the individual. The apparently large impact of schooling upon earnings is not ascribed to a positive correlation between social class background and the level of schooling. (2,5,9,10,17,18).

The above disputes are mentioned merely to show that we are only beginning to understand measurement of effects of cognition & education - and are a very long way from definitive statistical analysis of correlation and variance.

It is interesting to note that longitudinal temporal study of the effects of early childhood remedial pre-school education is even in a more primitive state than studies of schooling effects. The major analyses more or less throw in the sponge on the grounds that the effects are minimal, and all improvement vanished by the third grade. But, is this true or are we measuring different variables? Can even a motor skill, like dancing on point, be continued without constant exercise of specific lower-lumbar muscles? Can remedial education therefore have a permanent effect without continuance?

Further, speaking purely as an economist interested in the greatest possible societal return for each dollar of individual investment, the entire question of innate ability or learning is a foreign concept. We measure solely by achievement; and for the purpose of increasing national welfare as measured by GNP (Gross National Product) the moron making his own living by washing lipstick stains from coffee cups is worth $490 per month more to society than the moron in an institution (wages of $400 monthly plus $90 not spent on institutional care). Economics knows no "over-achievers" - an illiterate millionaire contributes more dollars to society than a ditch digger with a Ph.D. Anything contributing to differential increased earning capacity is worth the doing, if it costs less than the increase it makes possible.

This concept of economic dollar value (discounted to present day) of potential differential lifetime earnings made the results obtained by Drexel's Early Childhood Center's use of the Edison Responsive Environment technology as a pre-school remedial technique for disadvantaged children significant. If the technique withstood longitudinal scrutiny (which has been started), or if it could be broken into two technologies - one machine and one non-machine, & tested longitudinally; and it could be proven statistically valid, then a major breakthrough in a previous wasteland could be started, and one more technique might be added to methods of reclaiming human potential.

Drexel University's Early Childhood Center has, since 1967, been studying the effect of use of the Edison Responsive Environment technique upon the reading readiness state of both "deprived" and "non-deprived" children. As early as the 1967-1968 school year, it was found that children did acquire primary reading skills through use of the Edison Responsive Environment. The non-tuition children (the deprived slum children) and the tuition children showed similar learning rates despite the fact that I.Q. (such as the Peabody) tests showed a 17 point discrepancy in favor of the tuition group. (31)

In the 1968-69 school year, a study compared the type of pre-school instruction given in a representative nursery school with that given at the Drexel Early Childhood Center, using the E.R.E. as the mainstay of its training instructions.

Two groups of boys and girls of mixed socio-economic and racial make-up, between the ages of 3-0 and 5-0, were organized by matching each member of the E.R.E. group with an equivalent member of the other nursery school group in terms of the following factors; (1) chronological age (within three months), (2) intelligence quotient (within six points) and, (3) psycholinguistic abilities (within four months). They were also paired in terms of sex and race.

Analysis of data revealed that the E.R.E. group made significantly greater improvement in psycholinguistic ($t = 3.00$, $p = .01$) and visual perception ($t = 3.8$, $p = .01$) abilities, as measured by the ITPA and DTVP, than the group from the other nursery school. It should be stressed that the youngsters from the latter group received a considerable amount of pre-reading and readiness activities as an integral aspect of their nursery school activities. Further analysis revealed a ten-months' mean increase in psycholinguistic abilities in the E.R.E. experimental group while the mean increase was five months for the control group. In visual perception, the E.R.E. youngsters managed an eight months' increase as compared to a four months' increase for the control group. No significant difference was noted between the groups in terms of growth in mental age as measured by the Stanford-Binet, Form L-M. No analysis of subtest data from the results of ITPA and DTVP were attempted since the two groups were matched on the total scores and not the subtests.

Research in (1) methods of using the E.R.E., (2) the specific aptitudes which should be stressed, (3) the relationships between the perceptual channels emphasized in program design, and those with the largest score increases, continues at Drexel.

Recently, twelve youngsters, four of whom were girls and half of whom were Negroes between the ages of four and six with the following qualifications were selected: (1) an intelligence quotient as measured by the Peabody Picture Vocabulary Test of 90 or above, (2) average or poor visual perception and (3) average or poor auditory perception. (5) Two groups of twelve children were organized by matching each member of the experimental group (Early Childhood Center, Drexel University) with an equivalent member of the control group (a model nursery school in the same community, operated by the School District of Philadelphia) in terms of the following factors: chronological age (within three months), intelligence quotient (within eight points), visual perceptual quotient (within four points), and auditory perception (within three months).

The experimental Group I received an average of thirteen hours instructional time on the E.R.E. over a seven-month period. The control group received an average of 30 hours of instructional time consisting of a wide variety of "reading readiness" and "cognitive development" activities. In addition to formal instruction both groups followed a regular schedule of nursery school and/or kindergarten activities. Approximately half of Group I's

instructional time was spent with an Edison Responsive Environment talking typewriter. Graduate students, teachers, and supervisors preprogrammed each training session with materials and learning tasks which were individually tailored for each youngster. The material used developed out of the interests and experiences of the child. The machine, regarded here as a delivery system, was especially appealing since it could easily be programmed to emphasize visual or auditory perceptual modalities.

The treatment group was subdivided in half: Group Ia was composed of youngsters who obtained the lowest scores on the test of visual perception (Frostig), while Group Ib consisted of those children who obtained the lowest scores in auditory perception. In the experimental group, three-quarters of instructional time was spent in teaching to the children's deficits, and one quarter of the instructional time was spent in teaching to their perceptual integrities. For Group Ia, at least one of every four learning programs emphasized the development of their stronger auditory modality. For Group Ib, the opposite was the case.

Since the children had been paired off, the desired statistic was found directly from the differences between pairs. The simplest approach was to treat the individual changes as if they were single measurements and then determine paired change values. This procedure is strongly recommended whenever it can be conveniently applied.

The data presented in Table I indicates the pre- and post-test means for each subgroup for I.Q., Frostig Perceptual Quotient, and the combined mean age scores of the three auditory subtests from the Illinois Test of Psycholinguistic Abilities.

TABLE I

Pre- and Post-test Means for Each Subgroup for Peabody Picture Vocabulary Quotient, Frostig Perceptual Quotient, and the Mean Age Scores (months) from the Three Subtests of the Illinois Test of Psycholinguistic Abilities

	GR. Ia		GR. Ib		GR. IIa		GR. IIb	
	PRE	POST	PRE	POST	PRE	POST	PRE	POST
I.Q.	98	101	98	100	98	100	97	99
FROSTIG	88	95	104	107	88	89	105	106
IPTA (MONTHS)	45	52	36	44	47	50	35	37

Table I reveals that the mean scores of the Frostig test for Groups Ia and Group IIa were in the lowest quartile. At post-testing, Group Ia moved close to the fortieth percentile. The Frostig quotients for Group Ib and IIb were above the second quartile after pre- and post-testing, since this was the group with visual perception intact but with deficits in auditory perception. The mean age of all the children was forty-four months.

Table I also indicates that the age scores for the auditory perception test were approximately eight-and-a-half months below chronological age expectation for Groups Ib and IIb. At post-testing, Group Ib had gained an average of eight months (an expected increase since treatment time was eight months), but Group IIb only averaged a two-months' increase, from thirty-five to thirty-seven months.

Table 2 reveals that Group Ia made significantly greater improvement in the evaluation of visual perception (Frostig) while Group Ib did likewise in the evaluation of auditory perception (ITPA). Group Ia's improvement in auditory perception, although not significant, approached this criterion when compared to Group IIa. No significant differences were revealed between Group Ib and Group IIb on the Frostig evaluation.

TABLE 2

Values of "t" for Differences between Groups Receiving a Corrective Teaching Program in Auditory and Visual Perception and Groups Receiving a Typical Early Intervention Program - on Frostig Developmental Test of Visual Perception and Three Auditory Perception Tests on the ITPA

FROSTIG - GROUP Ia vs. GROUP IIa:	t TEST	t = 7.2 p = < .01
ITPA SUBTEST - GROUP Ib vs. GROUP IIb:	t TEST	t = 6.5 p = < .01
FROSTIG - GROUP Ib vs. GROUP IIb:	t TEST	t = 2.1 p = > .05
ITPA SUBTEST - GROUP Ia vs. GROUP IIa:	t TEST	t = 2.1 p = > .05

During three academic years from 1968 through 1971, the Early Childhood Center kept pre- and post-test scores and differences per child for children using the Edison Responsive Environment learning assistance program, as programmed individually for each child by the staff of the ECC.

In 1968-69, the tested population consisted of sixteen (6 Get Set) children, ranging from age two years and nine months to four years and five months. In 1969-70, the tested population consisted of eight (3 Get Set) children, ranging from age two years nine months to four years five months. In 1970-71, the tested population consisted of twenty-nine (14 Get Set) children, ranging from age two years eleven months to five years three months. In 1968-69, the children were tested after six months' use of the E.R.E.; in 1969-70, after seven months' use of the E.R.E.; and in

1970-71, after eight months' use of the E.R.E.

Drexel's ECC takes two types of pupils -- "Get Set" and tuition paying. The former children are black, poor, educationally deprived members of the Mantua slum area in Philadelphia; while the latter are children of upper-middle-income-class parents, from both the city and suburbs.

The three tests given, for which experience was assembled, were the Peabody Mental Ability Test, the Frostig, and the Illinois Test of Psycho-linguistic Ability (ITPA). The Peabody is an intelligence test; the Frostig is a test of visual perception, significantly related to reading readiness; while the ITPA is a series of 9 tests of input-association-output; some of them positively correlated with later reading success.

Differentiation had to be established for the general population during the three years, to see what the pre-test ability of the children was in relation to their chronological ages for the general population, and for the "Get Set" and tuition groups respectively.

For the group as a whole, from 1968 through 1971, there was little, if any, correlation between chronological age and the result of any pre-test, and practically no correlation between the result of one test and the result of another. The correlation coefficients follow:

TABLE 3

Correlation Coefficients for Total ECC Group 1968-1971, between chronological age and Peabody, Frostig, and ITPA Tests

	Chron. Age	Peabody	Frostig
Peabody	0.400		
Frostig	0.552	0.499	
ITPA	0.508	0.702	0.639

The σ ranged between 25% to 79% of the regression coefficient for the dependent variable and 1/3 of the regression coefficient for chronological age. The table showed a totally heterogeneous population, without indication of significant relationship not only between the tests and the chronological ages but between the tests themselves.

Less than 16% of the variation in the Peabody test was attributable to the regression of chronological age; less than 30.5% of the variation in the Frostig test was attributable to chronological age; and less than 26% of the variation in the ITPA was attributable to chronological age.

Upon separating the entire three year group into "Get Set" and tuition children, the reason for the heterogeneous quality of the statistics of the total group immediately became apparent. Following are the correlation coefficients for the "Get Set" and tuition groups:

TABLE 4

Correlation Coefficients

A. "Get Set" Group, 1968-1971, between chronological age and Peabody, Frostig and ITPA Tests.

	Chron. Age	Peabody	Frostig
Peabody	0.423		
Frostig	0.579	0.289	
ITPA	0.599	0.322	0.540

B. Tuition Group, 1968-1971, between chronological age and Peabody, Frostig and ITPA Tests.

	Chron. Age	Peabody	Frostig
Peabody	0.771		
Frostig	0.768	0.598	
ITPA	0.727	0.756	0.716

Looking at the above tables of correlation coefficients, it becomes apparent that the two groups are not only totally dissimilar in their pre-tested abilities, but that the dissimilarity is so great that for the "Get Set" group the correlations between testing results of specific tests are meaningless, even though for the tuition group the Peabody correlates significantly with the ITPA.

A difference of close to 1/3 in the correlation coefficients between the tests (running as high as half in some places) would seem to indicate that the tests may show serious regression for the educationally deprived child; because again the Peabody did not correlate with the ITPA.

With respect to the relative improvement of students using the Edison Responsive Environment machine, a series of correlations was run against the pre-test IQ's (test results in years and months divided by chronological age in years and months) and the number of months improvement. For the total group this correlation, except for the Peabody test was relatively unresponsive. In the case of the Peabody test, there was less than a 3% probability that the negative correlation would occur in any random distribution. Table 5 follows:

TABLE 5

Correlation of Pre-Typewriter Use IQ, (Test Age Divided by Chronological Age) with Average Improvement (in months), by type of test.

A. Total Group

Test	ρ b	a	t	Pr ($t' = {}_1t_1$)[a]	
Peabody	-.315	52	-2.347		3%
Frostig	-.071	53	- .508		65%
ITPA	-.045	52	- .318		75%

B. "Get Set" Group

Peabody	-.698*	22	-4.359		0.1%
Frostig	-.592	23	-3.36		0.5%
ITPA	-.530	23	-2.864		0.96%

C. Tuition Group

Peabody	-.348	30	-1.964	6.21%	6.21%
Frostig	-.260	30	-1.425		17.0%
ITPA	-.150	29	- .788		43.9%

*Significant

b. ρ is population correlation coefficient.

a. n-2 degrees of freedom were used to enter the Student's "t" table to determine Pr ($t' - {}_1t_1$). This represents the probability of obtaining a t value greater than or equal to the absolute value of the calculated t if $\rho = 0$.

Looking at subsection B of Table 5, it can be seen that the "Get Set" group's number of months of improvement after E.R.E. use correlated significantly inversely with the pre-typewriter-use IQ of the child for each test, and that the likelihood of this occurring in any random distribution was less than .1% (1/10 of 1%) in each case. For the tuition group, the pre-test IQ was so unrelated to improvement that it could be assumed, given the low correlations, that these correlations equalled 0.

It can be definitely seen that the relative improvement of the "Get Set" group was much greater than that of the tuition group in the use of the E.R.E. machine. It can then be stated with no significant statistical margin of error

that the E.R.E. was then a useful device for increasing the awareness, responsiveness and reading readiness of the educationally disadvantaged child.

The cost of increasing the general educational level of an individual should be compared to the benefit reaped by the total society from such increase, because this increase is not only infinitely transferable, but does have a tendency as has been shown by Ribich (discussed below) to increase the general level of education of succeeding generations. For this purpose, it may well be necessary to utilize a technique of determining an incremental multiplier effect upon GNP of an individual's incremental lifetime earnings' gain from increased general education.

If the above be true, it would then seem more than applicable to estimate the probable effect of educational readiness in the same fashion as the probable effect of increased general education. It has been shown that without educational readiness, increased general education becomes impossible. Steady retrogression has been shown in school district after school district of inner cities' areas for students who have not been educationally "ready", particularly for the deprived students from U.S. major metropolitan area slums.

The work of Dr. Herman P. Miller of the U.S. Census Bureau, on income differentials by education, type of work, race, etc. is the norm in the United States for the relationship of national and individual income to education. Miller specifically evidenced that the rate of mean income growth from 1950 to 1960 was positively related to the quality and quantity of education. During the 1960's the most rapid income gains in the cases of both whites and non-whites have been made by those in higher educational classes.

The increase in annual and in lifetime income with increasing education is substantial, and has persisted for three Censuses for which data were available -- 1940, 1950, and 1960. High School graduates earned 70 - 80% more than elementary school graduates of comparable ages, while college graduates earned 50 - 75% more than high school graduates of comparable ages. Not only do better educated persons earn more initially, but their peak earnings are higher in relation to their initial earnings. The differential in earnings associated with education remained fairly stable between 1939 and 1959 despite the rise in educational level of the population and in the size of the labor force. Much of this relation between education and income is a reflection of the occupations people enter. Occupations that generally require a higher level of education for entry also tend to command higher income. (9)

It is true that occupations requiring higher education usually pay more, but in checking the ratio of the income of college graduates to the income of high and elementary school graduates it was found that this ratio remained substantial within broad occupations and even within specific occupations. Between 1939 and 1959 the ratio of earnings of white males 35 to 44 years old with a college education to the comparable group with only an eighth grade education was 2.25 for all workers; 2.02 for sales

workers; 1.95 for proprietors, managers and officials; and 1.85 for professionals. For these broad occupation groups the educational differential within occupations was 80 to 90% as great as the differential for all workers. Among operatives, laborers and clerks (the occupation groups with the smallest earnings' differences), the differentials were 60 to 70% as large as for all workers between college, high school and grade school graduates. Within specific occupational groups such as engineers or electricians the earnings' differential between elementary school and college graduates may be 25 to 50%. In occupations with entrepreneurial opportunities, such as proprietors of business or sales workers, the educational differential in earnings is large. (14)

The finding, in the Drexel University analysis of the 1969-70-71 statistics of children using the ERE typewriter, that relative improvement of the "Get Set" children was better than that of the tuition group thus assumes increasing importance. Gwartney, in his article on the non-white/white income ratio has pointed out that an assumption that non-whites have the white educational distribution would indicate that the income gains of non-white males made during the 1950's would have been increased by 3.1 to 3.5% or more, if the educational distribution had been identical with that of whites. During the 1960's, in the North as well as the South, he found the hypothetical income effect so much greater than the average for both males and females (equating non-white educational distribution with that of white) that he obtained a significant indication that the greatest income gains were made by those with the most education. (15)

Expected lifetime income is an approach used by the Census Bureau in comparing income of persons at different levels of education. This is an estimate of the total future income which an individual at a given age and level of education can expect to receive throughout the remainder of his working lifetime, taking into account average life expectancy and changes in income with age. These expected life incomes can be estimated in two ways: (1) as the sum of the expected income for each year in the future; and (2) as the present value of that sum, discounted at a specific rate of interest. The United States Census Bureau issues tables discounting expected lifetime income by age, sex and years of education at various rates of interest for use by economists and others in actuarial estimations, accident and injury cases, workmen's compensation, etc. The Census Bureau also includes incremental productivity increases in some of these estimates.

In general, those with less education reach peak earning years younger than those with more education. The present value of expected income, which is equivalent to supposing that the entire amount of future income is borrowed at the beginning of the earnings' years, with the interest charges subtracted in advance, places expected future income on an equal basis with respect to the time it will be received. At various ages expectations differ, and for children presently in pre-school years expected lifetime income will be much higher then

the tables now used.

It has been generally conceded that in the industrialized market economy, the education of the labor force contributes significantly to a nation's progress. Kaser in his article in the Economics of Education (15) studied a dozen industrialized market economies from the time they began through their growth periods -- roughly from a period of approximately 1860 to 1960 -- and although he did not attempt to study the type of education (vocational or classical) he did find that a classical bias within the general education system is more conducive to economic progress. He also found that there is a specific two decade time lag before educational input starts to result in higher GNP. The time lag grows longer as the economy becomes more complex. He found a rise in per capita GNP linked with increments in secondary and university students in relation to primary enrollments.

In the same volume, Dennison found that to project an increase of 0.10 in national income growth rate over the next 20 years, in addition to all else that might be done (such as prevention of death, cut of one-half in lost time because of illness and accident, an increase of 0.10 of all people in the labor force, doubling the rate of net immigration etc.) an addition of 1 1/2 years to the average time that would otherwise be spent in school by everyone completing school between 1960 and 1980 or "an equivalent improvement of the quality of education" would increase the quality of labor input by 2.4% over and above what it would otherwise have been. (6)

It should be noted that education is not the sole determinant of the rate of a person's lifetime earnings. The level of educational attainment (LEA) is positively correlated with levels of earnings, for males and females, whites and non-whites and for virtually all age groups. However, it is also important to know how much people differ while in school, as a reflection of systematic differences in ability, motivation and family backgrounds and in the quality of the schooling. There has been a great deal of support for the view that these and other factors explain at least some portion of the aforementioned earnings' differentials. Although mean incomes do differ significantly by LEA, there is still overlapping of the distributions between the means. And there has been to date an inability to isolate the quantity importance of school variables with any great degree of precision.

Based upon the foregoing reasons, one can: (1) estimate the actual difference in lifetime median earnings as discounted for black males (based on 1969 distributions of median earnings by years of school completion); (2) increase such lifetime earnings by probable annual productivity increases; (3) discount them to the beginning of an individual's work life from age three (when the use of the Edison Responsive Environment Technique has been established as being of significant importance to the creation of a child's school achievement, reading achievement, and perceptual ability) to the beginning of work life. Unfortunately, although data on black median earnings by years of school completion are available from the 1970 Census of Population, the tables of present value of estimated lifetime earnings are only available for the year 1959 (since they have not yet been estimated for the 1970 Census).

However, this would, if anything, create a downward bias in the estimates, and therefore this table has been used. (25)

The 1970 Census shows the following median income differentials by highest rate of school completed by men 25 to 54 years old for blacks in 1969:

TABLE 6

Median income of Negroes, 1969 by highest number of years of schooling completed by men 25 to 54 years old*

(Yrs. Schooling Comp.) Education	Median Income, 1969 $	Differential Median Income $
∠8 yrs	3,922	
8 yrs	4,472	550
9-11 yrs	5,327	855
12 yrs	6,192	865
13-15 yrs	7,427	1,235
16 & +	8,669	1,242

* U.S. Department of Commerce, Bureau of the Census and U.S. Department of Labor, Bureau of Labor Statistics: The Social and Economic Status of Negroes in the U.S., 1970. BLS Report No. 394, Current Population Reports, Series P-23, No. 38. Washington, D.C.: Government Printing Office, July 1971, Page 34.

Taking the differential median income for males, (even though we realize that present children will have higher median incomes when they enter the labor force, and that this is therefore a downward bias) these median differential earnings were then extended to expected lifetime differential earnings by the following formula:

$$\frac{\text{differential median income}^*}{\text{Entry income at age of entering labor force }^{**}} \times \text{Expected Lifetime earnings discounted to labor market entry age, by 3\% with an annual productivity increase of 3\% }^{**}$$

* From Table 6

** (18)

From the above formula, it was possible to obtain the data in Table 7, showing that the expected lifetime earnings' differential of blacks who had completed

grammar school and blacks who had not completed grammar school, would be a minimum of over $38,000 discounted to age three at 3% and $33,000 discounted to age three at 4%. Table 7 also shows these expected lifetime earnings differentials between those negroes who went on to some high school and those who completed grammar school; between those who completed high school and those who did not complete high school; between those who went on to some college and those who completed high school; and between those who graduated college and/or took graduate work and those who had completed some college. Table 7 follows:

TABLE 7

Expected lifetime differential earnings of Negroes at given work entry ages, at discount rate of 3% with annual productivity increase of 3%.

	Education	Discounted	disc. to age 3	
	<8 years		@ 3%	@ 4%
	8 years	$59,473	$38,173	$33,023
Age 18				
	9-11 years	85,848	55,102	47,668
	12 years	86,852	55,747	48,225
Age 22				
	13-15 years	81,402	46,423	38,637
	16 & +	81,846	46,686	38,855

If one were to establish a national income effect for the above increases in differential earnings, one would have then to multiply the final discounted total lifetime earnings estimate arrived at in Table 7 by the multiplier. The Keynesian multiplier in any single year has been taken since about 1939 to be approximately 2. The Keynesian multiplier over the full length of the cycle is presently estimated as being approximately 10. The marginal propensity to save, from the years 1929 to 1969, has been one-tenth of every marginal dollar. (The estimating equation, which is practically a 45° line in constant dollars when data from World War II are excluded, is that consumer expenditures = 6.7 + (.89776) disposable personal income.) (30) In a single year, these discounted earnings would have a multiplier of 2 and over a period of years, each dollar of differential income increase would become $10.

Even though the above estimates of expected educational earnings' differential over a lifetime is extremely downward biased, we are talking about a major incremental advance in GNP which can be made possible by the increased education of the disadvantaged.

Although Ribich's book Education and Poverty does not allow very much influence for an increase in educational level attained by crash programs for

the education of the underprivileged child, his chapter on educations' role in the war on poverty adds another dimension to the field of possible benefit-cost estimation. He states that an increase in academic equivalent achievement experienced by a first generation will have the same impact on the second generation as would a longer educational career experienced by the first generation. From a first generation's improved education starting at age 4, the first generation's life income will be increased as discounted by 3,798.00 for a two year educational gain, which will have an income effect upon the second generation, net of extra costs, of $531.00. By the same token, if improved education began at age 15, first generation discounted income for a two-year education gain would net the individual $6,349.00, and the effect in the second generation's total income would be $909.00. Thus, although Ribich did not introduce the national income multiplier into his analysis of the effect of extra education upon an individual, he does introduce a form of multiplier which might be the equivalent of a Keynesian GNP multiplier -- an educational multiplier from generation to generation. (29)

The Responsive Environment Corporation which markets the ERE has computed an estimate of the cost for equipping a center with ERE system, Model 3-B as follows: (13)

Equipment Costs

E.R.E. System, Model 3-B $40,000*

Including:

1 E.R.E. - Instrument	1 line Cord
1 E.R.E. - Booth	1 Booth Intercom System
1 E.R.E. - Expandable Keyboard System	1 Booth Control Panel
1 Accent Key - Cover	1 Booth Control Panel Cable
1 Box Typing Paper	1 Attendant - Microphone
1 Projector - Magazine	1 Operation Manual

The basic price also includes:

First year's guaranteed service maintenance contract

One year's supply of material including:
...50 E.R.E. Program Cards and Jackets
...2 Linear Slide Projector Magazines (capacity 36 slides)
...2 Pads of 30 E.R.E. Card Papers
...1 Box NCR Typing Paper
...2 Pads of 25 E.R.E. Program Charts
...1 Flexowriter Ribbon
...50 E.R.E. Reusable Slides - specially edge treated
...E.R.E. Card Cleaner

Installation of E.R.E.
The customer is responsible for site preparation

Two-day seminar of instructions on the operation of the E.R.E.

* Cost 1975 is down to $18,500. If 1,000 typewriters were to be assembled, cost drops to $4,000 per unit.

Personnel Costs

Tests	$600.
Office Supplies	$100.
Communications	$200.
Duplication/Reproduction	$400.
Supplementary Reading Materials	$400.
Transportation (enrichment prog.)	$500.
Enrichment Activities (admission tickets)	$400.
TOTAL	$63,275.00

(Dr. O.K. Moore has estimated that this cost is extremely out of line, and that the cost of operation and personnel for the Edison Responsive Environment System can be reduced by the use of high school students and parents.)

Taking a machine lifetime at twenty years, thus allowing depreciation of approximately $2,000 per year, and variable costs running between $10,000 and $25,000 per year, we can begin to estimate the cost-benefit effect of pre-school use of the Edison Responsive Machine, provided it is a cause of the difference between a child's graduating grammar school and not graduating grammar school, and/or graduating or not graduating high school, and/or graduating or not graduating college, according to the data in Tables 6 and 7 hereof.

For the pre-schooler, average use of the machine is approximately 20 minutes per day, and one E.R.E. machine can therefore service approximately 30 children per year for 20 minutes a day, 5 days a week. The differential educational costs per child per year, therefore, would be between $400 and $900 ($2,000 per year machine cost depreciation, plus $10,000-$25,000 per year.)

This, of course, for 30 children is a differential educational cost of between $50,000 and $65,000 per year. The present value of an educational increment per child, even though biased downward, has been estimated in Table 7, and discounted to age 3 at even 4% the difference between the child's not graduating grammar school and graduation from grammar school has a present value of above $33,000. Multiplied by 30 children, this would give a present benefit of over $999,000 discounted to present age 3 if the thirty children were to graduate grammar school. The benefit-cost ratio therefore for pre-school use of the E.R.E. (since it has been proven that the E.R.E. does influence schooling readiness for children) would be approximately 20 to 1 (even without considering the Keynesian multiplier).

The work of Hansen, Weisbrod and Scanlon of the University of Wisconsin, dealing with the relationships between education, ability and income, has been supported for some time by the Ford foundation. In an article appearing in June 1970, for the first time an attempt was made to isolate the relationship between schooling and earnings of "low achievers," and at this time it was found that LEA (level of educational attainment) suggested that each additional year of schooling contributed an additional $62.00 per year to earnings for the low achievement group. (16) Correlation of education and earnings for low achievers was significant at the 1% level. Note that this is an extremely low estimate because the Hansen, Weisbrod and Scanlon article specifically dealt only with people who were rejected from military service because of failure to pass the AFQT (Armed Forces Qualfication Test. This was a sample of 2400 men, age 17 to 25. Therefore, the earnings upon which Hansen, Weisbrod and Scanlon derive their data would put them in the poor or near-poor classification (near-poor being from 15 to 25% above the poverty threshold) and the earnings' differentials would be nothing like the averages shown by U.S. Census Bureau tables. However, these are presently the only data available on the difference caused by one single year's increment of education, since Census Bureau data are grouped by grammar school and non-grammar school graduates, (notwithstanding the term of drop-out) those having from 9 to 11 years' education and those completing high school; those having some college and those completing college and those students going on to graduate schools. Thus, we cannot obtain an indication of the differential value of a single year's further educational attainment, unless interpolation is performed, and this might not be significant. It should be noted that the Hansen, Weisbrod and Scanlon figure is biased downward in relation to the majority of the American people.

The authors, themselves, state that the estimates understate and therefore provide "lower bound estimates of the effect of schooling on incomes of all youthful low achievers." They point out that they have not been able to estimate the effect on income of different amounts of subsequent schooling for youngsters who are judged to be low achievers at age 10, or age 5 or age 3. They have simply measured the income differential of low achievers at ages 17 to 25. However, many low achievers at an extremely early age move out of this particular bracket at a later age, and the estimate is biased downward even with respect to the low income class attainment of additional education.

Taking this $62.00 per year of earnings as the educational increment for one year's education, even though it is biased on the low side, and using the same method as was given in the formula for estimating the expected lifetime differential earnings in Table 7 above, we would arrive at lifetime differential earnings for one year of schooling at the grade school level at a discount level of 3% with an annual productivity increase of 3% discounted to age 18, (age of entry into the work force), at a figure of $6,704. If discounted to age 3 at 3%, this figure would then become $4,303. Multiplied

by 30 children, even if the E.R.E. did not make the difference between some grammar school education and graduation from grammar school, this figure would then equal a total yearly discounted bebefit to age 3 of over $120,000, which gives a benefit-cost ratio of at least 2 to 1.

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