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RETENTION OF BASIC SKILLS AMONG DROPOUTS FROM

EGYPTIAN PRIMARY SCHOOLS

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Abstract

Over the past fifty years, various studies have attempted to document the alleged loss of literacy and numeracy skills afflicting dropouts from primary schools in LDCs. These studies all have employed a cross section sample design and have affirmed that dropouts suffer a rapid and substantial loss of basic skills during the first few years from school. A related hypothesis suggests that existence of a "permanency threshold" for basic skills within the range of primary school grades. Once the threshold level is achieved, a dropout may be expected to retain functional levels of literacy and/or numeracy, regardless of the number of years displaced from school. Such a threshold is often employed to justify the length of the compulsory schooling period.

This paper reconsiders the conventional wisdom regarding the retention of basic skills through a case study of inschoolers and dropouts from Egyptian primary schools. A two-year longitudinal sample design is adopted in order to obtain appropriate and reliable base-line reference points for the set of grade-specific "retention curves" of dropouts, and to define points on the "learning curve" of continuing students. The results contradict many of the received hypotheses within the literature on retention. Some potential implications for educational policy also are discussed.

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1. Introduction

Significant progress in raising adult literacy rates in less developed countries (LDCs) has been achieved in recent years.[1] Within the poorest countries per capita expenditure on education has more than doubled; and in many LDCs education has become the largest public budgetary expense. However, the goal of universal adult literacy is still far removed.

With limited resources, a major concern of educators, economists and planners in LDCs has been to improve the design and efficiency of educational programs. Since completion of the primary school curriculum is expected to confer permanent functional literacy/numeracy, considerable emphasis has been placed on increasing the efficiency of primary schools by decreasing rates of repetition and dropping out.[2] Further, accumulated evidence on the economic rate of return to years of schooling in LDCs justifies the priority accorded basic primary education (for example, Psacharopoulos (1981)).

The joint phenomena of repetition, which prolongs the period of primary schooling, and dropping out, which terminates it prematurely, have come to be known in the literature on developing countries as "educational wastage." The use of this pejorative term is intended, in part, as a rebuke of school administrators who permit school resources to be used inefficiently; but it also reflects the prevailing belief that certain literacy and numeracy

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[1] The IBRD World Development Report reveals that between 1960 and 1980 adult (persons 15 years and older) literacy rates have risen from 23 to 40 percent in the poorest LDCs; from 39 to 59 percent in the middle income group; and from 61 to 76 percent among upper-middle income LDCs.

[2] See Haddad (1979) for a comprehensive treatment of the effects of promotion and repetition practices on school efficiency.

skills acquired while in school are soon lost by dropouts.[1]/ Further, as they
are increasingly displaced from school, dropouts are presumed to lapse into a
permanent state of illiteracy. Accordingly, educational resources previously
expended on dropouts are viewed as completely wasted.

In this paper we focus upon the consequences of the dropout decision
on the retention of basic skills among primary school leavers in Egypt. Over
the past fifty years, various studies in other LDCs have attempted to document
the alleged loss of skills afflicting primary school dropouts. With a
surprising degree of uniformity, these studies have affirmed the hypothesis
that dropouts from any grade suffer a rapid and substantial loss of skills
during the first few years from school.

A second (and related) hypothesis suggests the existence of a
"threshold" level of skills, associated in any country with a particular grade
and above that defining "functional" standards for literacy and numeracy
skills. Once achieved, a threshold level assures that the representative
dropout, while still suffering a possible erosion of skills, will not revert
to a functionally illiterate/innumerate state -- regardless of the number of
years from school. The existence of such a threshold skill level, it is held,
may serve as a guide to educational planners in setting compulsory schooling
levels; and, if enforced, would eliminate much of the wastage due to dropping
out.

This paper reports on our first attempt to separately measure the so-
called "learning curve" of continuing primary school students and the set of

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[1]/ Throughout this paper, we distinguish literacy (the command of reading and
writing) from numeracy (the analogous set of skills pertaining to
arithmetic and mathematical reasoning). References to literacy alone,
however, can be assumed to refer to both, unless the context implies a
particular linguistic skill.

"retention curves" characterizing the basic skills of primary school dropouts in Egypt. A "learning curve" refers to the sequence of skill levels of continuing students associated with the progression of completed grades. "Retention curves" refer to the sequence of skill levels of dropouts from a particular grade -- beginning with the inschool skill level in the grade last attended and continuing with the skill levels associated with each additional year from school. The shapes of the estimated grade-specific retention curves indicate whether or not dropouts lose command over previously acquired skills and, if so, how rapidly the loss occurs. Estimates of learning and retention curves, in conjunction with established standards for functional literacy/numeracy, permit comparisons between the skill levels of continuing students and dropouts by grade, and provide evidence as to the existence of an alleged "permanency threshold" for basic skills within the range of primary school grades.

Previous studies of literacy and numeracy retention have been hampered by the use of a pure cross section sample; tests covering a limited range of skills; and crude statistical methods. In a pure cross section, no information is available on the skill levels of dropouts before leaving school. Where data are available, all inschoolers are often used as a control group for measuring the loss of skills by dropouts. This fails to distinguish between the mean skill levels of continuing students and those of would-be dropouts. If would-be dropouts have significantly lower skill levels than those of their continuing peers, failure to identify the former group will overstate the inschool skill levels of dropouts. The longitudinal sample design adopted in the Egyptian study -- obtained by following up on the ex post status of all sample inschoolers, permits determination of whether the

alleged initial erosion of skills is a genuine phenomenon or a statistical artifact -- arising from the use of an inappropriate control group.

The design of suitable test instruments appropriate to the range of student abilities across many age cohorts is a problem inherent to all retention studies. The Egyptian Study covered grades 3 to 6, and dropouts up to five years from any grade -- including nine age cohorts within the sample. As in other studies, the "width" of some of the tests was not always consistent with the range of abilities present among sample members. This was revealed by large fractions of zero scores and some perfect scores being obtained. We interpret extreme values of the measured test scores as censored observations on the latent skill levels of the sample members. Use of the raw test scores in the presence of such censoring will bias the shape of the learning and retention curves. We thus employ statistical methods that correct for the occurrence of two-sided or bilateral censoring of the dependent variable. We suspect this phenomenon is widespread in educational testing, and that previous studies of literacy retention may have been affected by censoring bias.

To measure the learning and retention curves separately, without imposing any a priori restrictions on their shape, we employ a censored, fully-saturated analysis of covariance (ANCOVA) model. In this model, we estimate the mean skill levels of continuers and dropouts within each grade-year "cell," while controlling for differences in various covariates -- here, sex, rural/urban school location, re-testing and school-specific effects. As there are unequal numbers of observations per cell and the dependent variable has limited range, it is convenient to represent this model as a bilaterally censored regression model (Rosett and Nelson (1975), Hartley and Swanson (1985)).

In Section 2 we review earlier studies of literacy retention and comment on their methodology. In Section 3, we develop a model for the measurement of learning and retention curves, discuss the problem of censoring and define the concept of a threshold for permanency of basic skills. We describe the sample design and test instruments in Section 4; and present our empirical results in Section 5. Some conclusions and policy implications are reserved for Section 6.

2. Previous Studies

Despite the long-standing concern over the lapse of dropouts into illiteracy, there have been relatively few systematic studies of the process by which literacy or numeracy, once acquired, is lost. Much of the evidence is anecdotal. Among those studies specifically designed to measure the loss of skills, there is little agreement on the criteria for literacy and even less on the methodology appropriate to measuring it.

If there is a typical retention study, then it is based upon a single, small, cross section sample drawn from several cohorts of dropouts. The test employed is brief, and emphasizes practical skills; but it is not designed specifically to measure functional literacy.[1]. Test scores are usually referenced to grade-specific norms. The proportion of subjects

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[1] The definition of "functional" literacy has been evolving. In 1978, as a definition of functional illiteracy, UNESCO proposed the following statement:

"A person is functionally illiterate who cannot engage in all those activities in which literacy is required for effective functioning of his group and comunity and also for enabling him to continue to use reading, writing, and calculation for his own and the community's development" (cited by Lestage (1982)).

However, making such a definition operational, in the form of a standardized test, is a daunting task.

scoring less than its norm is taken to be a measure of the loss of skills. Multivariate statistical analyses have rarely been employed; and "control" for individual differences is usually effected by one- or two-way cross-tabulations.

The conclusion that literacy is lost after dropping out depends on the tenuous assumption that members of the dropout sample were once literate. At best, such studies measure the fraction of dropouts (by grade) that are (by the test criterion) illiterates. However, without measurements of the dropout's skill levels in the grade last attended, it is impossible to determine what may have been lost in the intervening years. Comparisons of skill levels among dropouts of different cohorts are less problematic -- provided it can be assumed that each proceeds through the same curriculum with similar school facilities, teacher qualifications, and so forth. If not, control variables should be introduced to account for such differences across schools and over time.

Why literacy, once acquired, should be lost is not well understood. Oshima (1967) suggests the failure to utilize such skills in an out-of-school environment as a major cause, though this argument equally may justify increasing dropout skill levels through reinforcement from post-school activities. Stock (1982) has emphasized the insufficient consolidation of marginally-acquired skills; and certain psychological studies have hypothesized functionally distinct long and short term memories, with unconsolidated perishable skills residing in the latter until their transfer into permanent storage (Bahrick (1984)).

Among the earliest attempts to determine the threshold level for permanent literacy were the studies conducted in Palestine in the early 30's and 40's and reported by Tibawi (1956). Although Tibawi provides few details

of the sampling design and test instruments, his approach is representative of later studies. First, a sample of villages served by primary schools was chosen. Next, a sample of "old boys" who had attended those schools was drawn, located, and tested for functional skills. Finding many school leavers who could neither read nor write, Tibawi concluded that the illiterates had "lapsed into illiteracy," without any evidence that they had ever been literate.

The next (and probably most thorough) investigation of literacy retention was conducted in the Satara district of India by D.R. Gadgil (1955) between 1941 and 1943 and presented in Gadgil and Dandekar, 1955. Gadgil employed an oral reading test and dictated writing test, using short passages from government pamphlets. Despite a high rate of non-response, a sample of 2678 male school leavers from grades two to five, spanning from 5 to 25 years from school, was located and tested. In addition, Gadgil recorded the grade and year-of-last-attendance, age, religion, caste, occupation, type-of-school and teacher qualifications, post-school education, personal income, use of reading and writing and "accessibility" to the community for each subject.

His major findings were that the extent of the "lapse into illiteracy" declined with grade of last attendance -- that is, a larger proportion of school leavers from higher grades were literate -- but that there was no evidence that those who left school years ago were any less literate than more recent dropouts. In fact, in many cases the opposite obtained -- raising the possibility of either a secular decline in school standards or post-school acquisition of skills. School size and teacher qualifications appeared unrelated to literacy scores. Illiteracy was higher among the poor, the lower caste Hindus and farmers; and lower among castes or occupations requiring use of reading and writing -- both found generally to be

low. Programs to encourage the practice of such skills were recommended.

Gadgil's study is remarkable for its time. Apart from the absence of statistical methods and computer software to treat multivariate analysis of categorical dependent variables, the only serious lacuna is the lack of observations on recent dropouts. As the youngest sample members were already five years from school, Gadgil could not explore the leading hypothesis of a serious erosion of skills just after leaving school; nor was there any inschool reference point from which to assess the degree of loss or gain in skills. Subject to these caveats, Gadgil's results suggest, contrary to the maintained hypothesis of a steady erosion of skills over time, that once acquired, skills appear to be preserved and, in some cases, reinforced. Further, there are important social and economic correlates to literacy and, anticipating many later researchers (Simmons (1980), Heyneman (1980)), little association with schooling variables.

Roy and Kapoor (1975) conducted another study of literacy retention in India that closely follows Gadgil, though they emphasize retention of cognitive skills rather than the lapse of functional skills. Like Gadgil, they found literacy increases with grade (or years of schooling), but they also report some evidence that skills decline with years from school. Sex, age, caste and family literacy did not significantly affect skill levels; while community location, family size, income and various indicators of "modernity" had some influence.

In the early 1970s, a number of studies of former participants in adult literacy classes were solicited and published by the UNESCO-funded International Institute for Adult Literacy Methods (IIALM) in Teheran. Among these are studies by Ahmed (1973) in Zambia; Landy-Tolwinska (1970) in Poland; Singh (1970) in India; and Smith (1969) in Rhodesia (Zimbabwe). In addition,

Savicevic (1973) summarizes results from several earlier studies in Yugoslavia. No standard methodology is employed by these studies; nor is there agreement on the appropriate criterion for literacy. All are essentially evaluative in nature. Only Singh is able to assert that his sample was at one time functionally literate, but without evidence of their skill levels. Nevertheless, their results have much in common. All find evidence of the "loss" of literacy: literacy rates in the samples range from 40 to 60 percent. Grade-in-school is positively correlated with literacy skills, as are measures of post-instructional study or use of such skills.

There have been a number of other minor studies of literacy retention. Sheffield's (1977) bibliography summarizes some of these, and additional notes can be found in the annotated bibliography published by IIALM (1970). Like the studies cited above, most find a significant number of illiterates among school leavers. Skill levels are generally positively correlated with schooling, but little evidence concerning the relationship between skill-loss and time-from-school is provided.

Finally, three recent retention studies in LDCs should be mentioned. Simmons' (1976) study of Tunisian workers, though more rigorous than those of his predecessors, is still flawed by a small sample size and the lack of a proper control group. More recently, two comprehensive studies of literacy and numeracy skills amongst school leavers have been conducted by national educational authorities: a major effort in the Philippines (EDPITAF, 1980) and a pilot study in Nepal (New ERA, 1980).

Simmons' study is a continuation of his earlier work on adult education with Allman (1972 and 1973). In 1976, he used a sample of 24 urban workers, aged 15 to 25, who had left school after completing the sixth grade. The control group consisted of 13 students currently enrolled in the

sixth grade. Simmons concluded that there was evidence of a serious loss of skills among school leavers; but, as he points out, choice of the base-line group is biased by self-selection, since some of the current sixth graders will go on to further education, while all of the workers have elected not to. Simmons also reported that both perfect and zero scores occurred.

The Educational Development Projects Implementing Task Force (EDPITAF) of the Philippines Ministry of Education and Culture, in cooperation with the International Development Research Center, began a study of literacy retention in 1970.[1] The principal goals of this project were to look for threshold levels of schooling; to identify variables that affect the ability of school leavers to retain basic skills; and to determine which skills are acquired in school and which are acquired after leaving school.

The study employed a sample of 8,007 primary school leavers -- of which almost two-thirds had left by the end of the sixth grade. A battery of seven tests and questionnaires was administered to each sample member. These included a non-verbal intelligence test, a socio-demographic questionnaire, a personality inventory, three achievement tests in English, Tagalog, and mathematics, and a "performance" test in one of five selected applied subjects. Grade-specific-norms were established for the three achievement tests, and individual performance was rated against these norms. Cases of skill loss and gain were identified by comparing the grade-last-completed with the grade-year equivalent score on the achievement tests. Anyone receiving a combined score of less than the first-grade-norm was considered to be completely illiterate.

1/ This discussion is based on the 1980 "Main Report," which is, in fact, a progress report. Subsequent work may contain a more detailed analysis than that reported there.

Of those who left school after the first grade, 53 percent were found to be illiterate. After the second grade, the proportion of illiterates had fallen to 21 percent and, after the third grade, to 9 percent. Some "retrogression" of skills, however, was found at every grade level. In all, 59 percent of the sample experienced some loss of skills, relative to their grade last completed; 26 percent gained skills; and 15 percent neither lost nor gained. However, no analysis of the effect of years-out-of-school on skill levels is provided. Further, since the standard for illiteracy employed in this study is a score below the first-grade-norm, it is not surprising to find the highest rate of lapse occurring among first graders. Because the rate of lapse into illiteracy beyond the third grade is negligible, the study concludes that completion of the third grade is an "acceptable" goal for the school system. Whether, in fact, achievement of a first grade equivalent-score is an adequate standard for functional literacy is not explored.

Given the broad scope of this study, the absence of accurate base-line measurements is regrettable. Lacking data on the performance of sample members prior to dropping out, it is impossible to determine whether the deficit occurred after leaving school or while still in school. Similarly, improvement in skill levels, relative to the grade-norm, may have occurred after leaving school or may have arisen while in school.

The use of grade-equivalent scores as the sole measure of inschool performance is also unfortunate. This results in a considerable reduction of the precision of the data, with only minor compensating benefits in exposition. In effect, all tests results are "trimmed" to interval-levels; and the range of the grade-equivalent scores is limited to twelve grades. The interpretation of the results crucially depends upon the accuracy of the norms

adopted, and upon the correct statistical treatment of the limited-dependent-variable.

The Nepalese retention study was designed to determine whether three years of primary school education is sufficient to impart "permanent" literacy skills. The sample was chosen from third grade school leavers in twenty-one remote, "disadvantaged" schools in the Kavre Palanchok district, and included 217 children, covering four cohorts or classes. The average age of the sample ranged from 13 years (in the youngest cohort) to 16 (in the oldest). School records were found to be incomplete, and locating eligible sample members was difficult and time-consuming. As a result, the estimated coverage rate for the sample is only 60 percent. Five tests were designed for the study. Four of the five (reading, writing, reading comprehension, and arithmetic) were explicitly referenced to the third grade curriculum. The fifth was a functional literacy test, that required the child to write a short letter on a set subject.

The study did not find any evidence of the deterioration of skills over time. On the contrary, the skill levels of the older cohorts were generally higher than those of more recent school leavers. Again, using a cross section sample and lacking base-line data on skill levels while in school, it is impossible to determine when these differences arose. Using scatter plots of skill levels against demographic variables, no association between skill levels and age, economic status, family size, family educational status, or language-spoken was found. Facilities for multiple regression analysis were not available at that time.

The only common theme of these studies is that most school leavers have skill levels below the established norms for the grade they last attended. Evidence of the systematic deterioration of skills over time (that

is, after leaving school) is generally absent. Where data on covariates are available, social and economic characteristics are frequently found to be related to skill levels, but schooling variables show less correspondence.

One of the major deficiencies of most of the studies presently reviewed is the lack of evidence concerning the skill levels of students while in school and of dropouts immediately after leaving school. Since the strongest case for the existence of educational wastage is based on the claim that the skill levels of dropouts rapidly deteriorate after leaving school, the failure to examine this critical time period is particularly striking.

3. Measurement of Learning and Retention Curves

The process of learning and retention of basic skills occurs over time. Upon entering primary school, students proceed through a succession of grades -- each with an associated curriculum. In each grade, a student's acquisition of basic skills may be measured by suitable test instruments. A learning curve, for a particular individual, refers to the locus of points obtained by plotting a given skill-level against grade-completed. However, in any grade within the primary sequence, some students may elect to drop out during the school year, while others will continue in school. As partial attendance is commonplace in LDCs, separation of the inschoolers tested in any grade/year into "continuers" and "dropouts" will only be revealed to the investigator, ex post, by inspection of the registration lists in the following school year. If the student is found to be registered again, then the test score in the preceding year defines a point on the learning curve. If not (and if school records do not indicate a transfer or a death), then the child is considered to be a dropout from the grade in the preceding school

year, and the test score defines the initial reference point for the level of skills acquired in that grade. A dropout's grade-specific retention curve is initiated by the inschool reference point, and continues with the locus of points traced by the skill level in each successive year from that grade.[1]

Our objective is to measure the learning curve and the set of grade-specific retention curves of the representative individual for various literacy/numeracy skills. Ideally, we would like to follow a random sample of one or more cohorts of entering students within a multi-year longitudinal sample design -- associating the sequence of measured skills with each student's career path. As the time and monetary cost of such an extended longitudinal design is prohibitive,[2] all previous retention studies of literacy/numeracy have adopted a pure cross section design. Since the principal hypotheses regarding retention require a comparison of the dropout's base-line or reference skill level with the sequence of subsequent post-school levels, obtaining an accurate and appropriate estimate of the initial inschool reference point is crucial.

In this respect, the pure cross section design employed in previous studies, in general, is inappropriate. Some early studies ignore the reference point entirely, and estimate only a later portion of a retention curve (Gadgil (1955), Roy and Kapoor (1975)). Others (such as the EDPITAF Philippines study) employ grade-specific norms or mean scores, relative to all inschoolers. In such cases, points on the learning curve are treated as

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1/ To accommodate grade repetition, we again must separate inschoolers into the two relevant groups. We employ the average skill level in that grade for repeaters who then continue in school; whereas if a dropout decision occurs during the year of repetition, the former skill level completes the learning curve, and the latter initiates a retention curve.

2/ In addition, sample attrition among dropouts is likely to be severe.

coincident with the initial reference point for each retention curve. If, as is likely, would-be continuers have significantly higher skill levels than would-be dropouts, then the rapid erosion of basic skills during the first year from school may be only a statistical artifact caused by the use of an inappropriate reference point.

To rectify this potential difficulty, our approach introduces a longitudinal feature into the sample design. As in a pure cross section, we must: (1) obtain a sample of current inschoolers and previous dropouts, spanning the relevant grades and years-from-school of interest; (2) subject each sample member to a battery of tests; and (3) collect ancillary information to attempt to control for individual-specific differences. In addition, at a minimum, we must follow up all inschoolers one year later to determine their status -- continuer or dropout. This, in turn, conditions whether the previously observed skill level of an inschooler belongs to the learning or to a retention curve.

3.1   A Simple ANCOVA Model of Learning and Retention

Let i denote an individual sample member; t denote the school year; and s denote a particular skill. Let (j_{it}, k_{it}) define the grade/year "cell" associated with individual i in year t; where j_{it} denotes the grade-last-attended, and k_{it} is the number of years-from-school. Thus, for any cell, if $k_{it} = 0$, individual i is registered in school in year t ; whereas $k_{it} > 0$ indicates a dropout from grade j_{it} in year $t - k_{it}$.

Let d_{it}^{*} define the "dropout-status" indicator of individual i in year t -- taking on the value 0, if a continuing inschooler in year t; or

1, if a current or prior dropout in that year. As the dropout decision in Egypt is irreversible, but not revealed until the following year's registration, we define the binary variable,

$$d_{it}^* = \begin{cases} 0 & , \quad \text{if both} \quad k_{it} = 0 \quad \text{and} \quad k_{it+1} = 0 \ , \\ \\ 1 & , \quad \text{otherwise .} \end{cases} \tag{3.1}$$

From (3.1), it is evident that the value of d_{it}^* is _latent_ or unobserved in year t, since the value of k_{it+1} is not known to the investigator until year $t+1$.

Let $y_{it}^{(s)}$ denote the score obtained on a test instrument for skill s by individual i in year t -- measured on the closed interval, $[0,100]$. Let $y_{it}^{(s)*}$ denote the individual's corresponding unobserved or latent ability for skill s, defined over the open interval, $(-\infty,+\infty)$. Finally, let $\underline{x}_{it}$ denote an observed vector of individual-specific covariates.

We now formulate a simple analysis of covariance (ANCOVA) model for the learning and retention curves of a representative individual in terms of the _latent abilities_, $y_{it}^{(s)*}$. We next motivate the process of censoring of the $y_{it}^{(s)*}$ -values, which generates the observed test scores, $y_{it}^{(s)}$; and then consider maximum likelihood estimation of the parameters in the ANCOVA model in the context of a random sample.

We adopt the following ANCOVA model for each skill, $s = 1,2,\ldots,S$; that is,

$$y_{it}^{(s)*} = \alpha_{j0}^{(s)L} \cdot (1-d_{it}^*) + \alpha_{jk}^{(s)R} \cdot d_{it}^* + \underline{\beta}^{(s)'} \cdot \underline{x}_{it} + \varepsilon_{it}^{(s)}$$

$$\tag{3.2}$$

$$\equiv \mu_{j0}^{(s)L} \cdot (1-d_{it}^*) + \mu_{jk}^{(s)R} \cdot d_{it}^* + \varepsilon_{it}^{(s)} \ .$$

This distinguishes between the mean inschool skill levels of continuers, $\mu_{j0}^{(s)L}$, and that of dropouts, $\mu_{j0}^{(s)R}$. The subscripts, $j = j_{it}$ and $k = k_{it}$, define the (j,k) grade/year "cell" for individual i in year t. Then,

$$\mu_{j0}^{(s)L} = \alpha_{j0}^{(s)L} + \underline{\beta}^{(s)'} \cdot \underline{x} , \tag{3.3}$$

for $j = 1,\ldots,J$, defines the <u>learning curve</u> for skill s of the representative continuer $(u_{it}^* = 0)$ within each grade j with covariate vector $\underline{x}$; whereas

$$\mu_{jk}^{(s)R} = \alpha_{jk}^{(s)R} + \underline{\beta}^{(s)'} \cdot \underline{x} , \tag{3.4}$$

for $k = 0,1,\ldots,K$, defines the <u>retention curve</u> for skill s of the representative dropout $(d_{it}^* = 1)$ with covariate vector $\underline{x}$ from each grade $j = 1,\ldots,J$. The disturbances, $\varepsilon_{it}^{(s)}$, are assumed to be normally and independently distributed; that is,

$$\varepsilon_{it}^{(s)} \sim \text{n.i.d.}(0,\sigma^{2(s)}) . \tag{3.5}$$

The model, (3.2), may be recast as a linear regression model by the introduction of suitable dummy variables for each of the cells associated with the learning and each of the retention curves.

Apart from the censoring of the $y_{it}^{(s)*}$-values, estimation of the constant parameters, $\{\alpha_{j0}^{(s)L}\}$ and $\{\alpha_{jk}^{(s)R}\}$, which define the <u>shape</u> of the learning and retention curves, respectively, as well as the "shift" parameters, $\underline{\beta}^{(s)}$, associated with the covariates, $\underline{x}$, is <u>conditional</u> upon knowledge of the dropout-status indicators, $\{d_{it}^*\}$. We already have noted

that d^*_{it} requires information from year, $t+1$. In general, this requires a longitudinal component in the sample design. However, in the special case where the points on the learning curve are <u>coincident</u> with the reference points for each grade; that is, if $\alpha^{(s)L}_{j0} = \alpha^{(s)R}_{j0}$ for <u>each</u> j when $k = 0$, then equation (3.2) collapses to the model,

$$y^{(s)*}_{it} = \alpha^{(s)R}_{jk} + \underline{\beta}^{(s)'} \cdot \underline{x} + \varepsilon^{(s)}_{it} . \tag{3.6}$$

This model may be estimated from a <u>single</u> cross section, and is a prototype for many earlier retention studies (see, in addition, Hartley and Swanson (1980)).

A special case of the above model, (3.6), obtains when there are <u>no</u> <u>covariates</u> (that is, $\underline{\beta}^{(s)} = \underline{0}$) . Such a model results in a 2-way "saturated" analysis of variance (ANOVA) model, in which all interaction terms are present. Under this interpretation, grade-last-attended and years-from-school are viewed as "treatments", which result in the skill level, $y^{(s)*}_{it}$. In this case, in the absence of censoring the $\{\alpha^{(s)R}_{jk}\}$ may be estimated from sample means of test scores for individuals in each cell, and would be appropriate for a purely longitudinal study in which individuals may serve as their own controls.

3.2 The Problem of Censoring

Censoring of the distribution of test scores, $y^{(s)}_{it}$, for any skill, s, is revealed by an accumulation of probability mass at the two extreme values -- here, 0, denoting a zero score, and 100, a perfect score. We first motivate the process by which censoring occurs, and then describe its

accommodation and consequences within our ANCOVA model.[1]

In any year, each individual is assumed to possess (or acquire) a stock of latent (unobserved) basic skills. To measure such skills, individuals are subjected to a battery of test instruments -- each containing a finite set of test items of varying difficulty. The aggregate test score is the sum of the correct item responses, scaled on a percentile basis. Thus, we have

$$0 \leq y_{it}^{(s)} \leq 100 \; . \tag{3.7}$$

On this "measurement scale", the test instrument cannot discriminate between underlying latent skill levels below 0 and above 100 -- just as a thermometer cannot measure temperatures outside _its_ particular range. Thus, $y_{it}^{(s)}$-measurements of 0 and 100, themselves, do not convey actual values, but rather only the information that the individual's latent skill level is less than or equal to 0 or greater than or equal to 100, respectively.

The relationship between the unobserved latent skill level, $y_{it}^{(s)*}$, modeled via (3.2), and the observed test score, $y_{it}^{(s)}$, thus is defined by

$$y_{it}^{(s)} = \begin{cases} 0 & , \text{ if } y_{it}^{(s)*} \leq 0 \; , \\ y_{it}^{(s)*} & , \text{ if } 0 < y_{i}^{(s)*} < 100 \; , \\ 100 & , \text{ if } y_{it}^{(s)*} \geq 100 \; , \end{cases} \tag{3.8}$$

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[1] Our motivation follows the Rasch-model of Wright and Stone (1979). Here, the probability of an individual's correct response is formulated as a Logit model involving the _difference_ between latent individual-ability and latent item-difficulty. We depart from this paradigm in order to make full use of the information in the extreme values, which otherwise would have to be discarded.

representing the fact that $y_{it}^{(s)*}$ is not observed directly (over its entire domain), but only over the range of the test instrument.

We now consider the problem of obtaining maximum likelihood estimates (MLEs) of the parameters, $\{\alpha_{j0}^{(s)L}\}$ and $\{\alpha_{jk}^{(s)R}\}$, governing the shape of the learning and retention curves, respectively; along with the covariate parameters, $\underline{\beta}^{(s)}$, and variance, $\sigma^{2(s)}$, separately for each skill s. We assume, for the present, that the data, $\{y_{it}^{(s)}, j_{it}, k_{it}, d_{it}^*, \underline{x}_{it}\}$, represent a random sample. In the next section, we introduce sampling weights -- inter alia, to accommodate our two-stage stratified sample design. From (3.2) and (3.5), we may define the probability density function of the latent skill level, $y_{it}^{(s)*}$, as follows:

$$f_{it} \equiv f(y_{it}^{(s)*}) = \frac{1}{\sqrt{2\pi}\sigma^{(s)}} \cdot \exp\left\{\frac{1}{2\sigma^{2(s)}} \cdot (y_{it}^{(s)*} - \mu_{it}^{(s)})^2\right\} . \quad (3.9)$$

Here, using (3.3) and (3.4), we have implicitly defined the mean skill level,

$$\mu_{it}^{(s)} \equiv \mu_{j0}^{(s)L} \cdot (1-d_{it}^*) + \mu_{jk}^{(s)R} \cdot d_{it}^* , \quad (3.10)$$

which is conditional on knowledge of d_{it}^*. Thus, the observed test score, $y_{it}^{(s)}$, defined by (3.8), has the censored p.d.f.,

$$g_{it} \equiv g(y_{it}^{(s)}) = \begin{cases} F_{it}(0) & , \text{ if } y_{it}^{(s)} = 0 \\ f_{it}(y_{it}^{(s)}) & , \text{ if } 0 < y_{it}^{(s)} < 100 \\ 1-F_{it}(100) & , \text{ if } y_{it}^{(s)} = 100 , \end{cases} \quad (3.11)$$

with

$$F_{it}(c) = \int_{-\infty}^{c} f_{it}(y_{it}^{(s)*}) \, dy_{it}^{(s)*} . \quad (3.12)$$

Maximum Likelihood Estimates (MLEs) of the parameters, $\alpha_{j0}^{(s)L}$, $\alpha_{jk}^{(s)R}$, $\underline{\beta}^{(s)}$ and $\sigma^{2(s)}$, are then obtained by maximizing the log-likelihood,

$$L(\underline{\alpha}^{(s)L}, \underline{\alpha}^{(s)R}, \underline{\beta}^{(s)}, \sigma^{2(s)}) = \sum_{i,t} \log g_{it}(y_{it}^{(s)})$$

(3.13)

$$\equiv \sum_{y_{it}^{(s)}=0} \log F_{it}(0) + \sum_{0<y_{it}^{(s)}<100} \log f_{it}(y_{it}^{(s)}) + \sum_{y_{it}^{(s)}=100} \log (1-F_{it}(100)) \ .$$

A class of initial consistent estimators is developed and various methods (the Newton-Raphson, Gauss-Newton, Scoring and Expectation-Maximization algorithms) to calculate the MLEs, $\hat{\underline{\alpha}}^{(s)L}$, $\hat{\underline{\alpha}}^{(s)R}$, $\hat{\underline{\beta}}^{(s)}$, and $\hat{\sigma}^{2(s)}$, of the regression coefficients are discussed in Hartley and Swanson (1985).

While it is clear that the latent skill levels, $y_{it}^{(s)*}$, have mean, $\mu_{it}^{(s)}$, of (3.10) and variance, $\sigma^{2(s)}$, the effect of censoring at the two extremes affects both of these measures. In particular, it can be shown that the mean test score is given by

$$E[y_{it}^{(s)}] = \mu_{it}^{(s)} \cdot [F_{it}(100)-F_{it}(0)] + 100 \cdot [1-F_{it}(100)]-\sigma^{2(s)} \cdot [f_{it}(100)-f_{it}(0)],$$

(3.14)

and its variance is given by

$$Var[y_{it}^{(s)}] = -\sigma^{2(s)} \cdot [(100-\mu_{it}^{(s)}) \cdot f_{it}(100)-(0-\mu_{it}^{(s)}) \cdot f_{it}(0)]$$

$$+ 2 \cdot \mu_{it}^{(s)} \cdot [\mu_{it}^{(s)} \cdot \{F_{it}(100)-F_{it}(0)\}-\sigma^{2(s)} \cdot \{f_{it}(100)-f_{it}(0)\}] \quad (3.15)$$

$$+ (\sigma^{2(s)} - \mu_{it}^{(s)2}) \cdot [F_{it}(100) - F_{it}(0)] - [\mu_{it}^{(s)} \cdot \{F_{it}(100) - F_{it}(0)\}$$

$$+ 100 \cdot \{1 - F_{it}(100)\} - \sigma^{2(s)} \cdot \{f_{it}(100) - f_{it}(0)\}]^2 .$$

These differ from $\mu_{it}^{(s)}$ and $\sigma^{2(s)}$, respectively, whenever (as in the present case) the lower and/or upper limits are finite. In particular, (3.14) shows that, ignoring bilateral censoring, use of OLS regression estimates (employing the measured test scores directly as dependent variables) will result in biased and inconsistent estimates of the learning and retention curves. Further, use of the sample variance (based on the residual sum of squares) will underestimate the true variance in skill levels. In particular, since censoring at zero is preponderant (increasing marginally with years from school, while decreasing with grade last attended), the effect of the bias incurred from using OLS on the measured test scores is to understate the skill erosion of dropouts by grade. Further, with censoring at both extremes, the set of retention curves across grades give an exaggerated appearance of convergence to a common asymptote.

3.3 Thresholds for Permanency of Basic Skills

We conclude this section with a brief discussion of threshold levels for permanency of basic skills. We assume the existence of an exogenously determined standard for functional levels, $\mu^{(s)}$, for each particular skill, s, based upon an item-analysis of the associated test instrument.[1] For any choice of the

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1/ See Section 4.2 for a discussion of the functional standards, $\{\mu^{(s)}\}$, with further details available in Hartley and Swanson (1984).

covariate vector, $\underline{x}$, the learning curve, $\{\mu_{j0}^{(s)L}: j=1,\ldots,J\}$, may be employed to define the grade, j^*, at which continuing students <u>first</u> achieve functional levels. Thus, $\mu_{j^*0}^{(s)L} \geq \mu^{(s)}$ and $\mu_{j0}^{(s)L} < \mu^{(s)}$ for $j < j^*$.

In general, however, we expect the skill levels of dropouts in their last year of school to be inferior to those of their continuing peers; that is, $\mu_{j0}^{(s)R} < \mu_{j0}^{(s)L}$ for each grade j. A threshold grade for permanency, j^{**}, if it exists within the range of primary grades at all, requires not only that dropouts <u>achieve</u> functional levels during the grade last attended, but also <u>retain</u> functional levels in each successive year from school. The threshold grade, j^{**}, is the <u>first</u> grade, j, such that $\mu_{jk}^{(s)R} \geq \mu^{(s)}$ for <u>every</u> $k = 0,1,2,\ldots$ It is also presumed that for all subsequent grades, $j > j^{**}$, functional levels are also permanently retained. In short, the threshold grade is the first instance where the <u>entire</u> retention curve lies above the functional standard, $\mu^{(s)}$; and the level of skills required for dropouts to permanently retain functionality is $\mu_{j^{**}0}^{(s)R}$.

4. Sample Design and Test Instruments

Our choice of a two-year longitudinal sample design reflects both the requirements of measuring the learning and retention curves for representative continuers and dropouts from Egyptian primary schools and certain deficiencies in implementation of the original retention study design revealed <u>en route</u>.

4.1 Sample Design

In the first year (1978/79) of the Egyptian Study, the MOE records indicated a total population of 10,341 public primary schools; of which 35.6

percent were in urban areas.[1/] We employed a two-stage stratified sampling design. In the first stage, 30 urban and 30 rural schools were selected at random from the school population.[2/] From these sixty sample schools, an inschool and a dropout sample were selected. In the belief that a threshold for permanency, if it existed, lay between grades 3 and 6, and also on grounds of economy, the study was restricted to those four grades.[3/] Our inschool sample within these 60 schools was obtained by drawing at random from those students attending grades 3 to 6 in 1978/79. For urban schools, a 50% sampling rate was employed; for the smaller rural schools, it was 66-2/3%. Attendance is defined by presence on the official school registration list, which is prepared for the MOE on November 15 of each year.[4/] Dropouts by grade and year at each of the sample schools were identified by school principals from the enrollment lists for the four preceding school years. Excluding transfers and deaths, any student enrolled in grades 3 to 6 in the preceding year, and found not to be in attendance in the next year, was considered to be a dropout from that grade in the preceding year. All dropouts who were so identified, who were locatable and who were amenable to testing,

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1/   The official MOE definition of "urban" includes schools in the major
     cities of Cairo and Alexandria and the capitals of all governorates.
     Schools in smaller cities, towns and villages are classified as "rural."

2/   In a purely random sample of 60 schools, one would expect 21.4 urban and
     38.6 rural schools. Our stratification design undersamples rural schools
     by 41 percent; and thus requires the use of sampling weights in subsequent
     analyses, if our results are to be representative of Egypt as a whole.

3/   Attendance through grade six is mandatory, but unenforced, in Egypt.

4/   For inclusion on the registration list, a single school-attendance during
     the first six weeks of term is sufficient. In some cases "paper
     promotions" of known dropouts from earlier years are employed by
     principals to inflate enrollment figures ... school budgetary allocations
     from the MOE are related to official enrollments.

were included in the dropout sample.[1]

All members of the inschool and dropout samples in 1978/79 (except for unlocatable absentees) were given a battery of up to nine achievement and intelligence tests, appropriate to the school curriculum.[2][3] The test forms also collected information to identify the student, sex, school-location (rural/urban), grade, school year and sample school. In addition, one-third of the full, inschool sample (subsequently called the "core inschool sample") and all members of the dropout sample were given a brief supplementary questionnaire regarding family background and socio-economic characteristics. The following analyses will refer to this core sample.

By appropriate design, in the second year (1979/80) of our study, it should have been sufficient simply to record the dropout status of each member of our core inschool sample in 1978/79. However, a variety of difficulties in the original design and/or implementation of the first year of the study required further information. These included: (1) the failure to administer all test instruments to all members of the original core sample; (2) the mis-classification of certain inschoolers and dropouts by grade/year cell; (3) the small numbers of dropouts located for certain cells; and (4) the inadequate nature of the original questionnaire. To rectify these matters, it was

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1/ Dropouts in the sample were paid a small "honorarium" to compensate for the opportunity cost of their time. This may have resulted in a non-random sample. However, as such "absentees" could not be located and tested, there is no obvious way to correct for potential biases arising from treating the dropout sample as random within each stratum.

2/ It was revealed, in certain schools, that principals deliberately excluded poorer students in the erroneous belief that their schools were being evaluated. Such absentees subsequently were rounded-up and re-tested.

3/ See Section 4.2 for a discussion of problems created by this testing protocol.

decided to give the complete battery of tests, again in 1979/80, to all members of the 1978/79 core inschool and dropout samples, as well as to certain "new" dropouts which were located in the second year. An extensive investigation of the available school records of all sample members was conducted to validate or reclassify the individual's dropout status and/or cell.[1] Finally, an extensive longitudinal questionnaire, which sought retrospective information on the individual, family background, socio-economic status, teacher and school characteristics, was developed and implemented in the second year.[2]

Our planned sample design in 1978/79 and 1979/80 was first stratified by school location. Different sampling rates for urban and rural schools were then applied to inschoolers and dropouts. However, our realized sample in each year also reflected differential rates of absenteeism, locatability and attrition among planned sample members -- varying by school-location, dropout-status and the grade/year cell. Finally, our reclassification exercise also resulted in varying ex post sampling rates by grade/year cell.

To correct our realized sample for the various a posteriori sampling rates within each stratum of the relevant population, we introduced sampling weights, w_{it}, for each observation, (i,t), within the log-likelihood, (3.13). Weighted maximum likelihood estimates (WMLEs) are then obtained by maximizing

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1/ See Hartley and Swanson (1984) for a discussion of the protocol and information hierarchy involved in reclassification.

2/ Unfortunately, but perhaps not unexpectedly, obtaining longitudinal data via retrospective recall resulted in many missing responses. Accordingly, in this paper, we do not incorporate these data within the measurement of learning and retention curves.

$$L^*(\underline{\alpha}^{(s)L}, \underline{\alpha}^{(s)R}, \underline{\beta}^{(s)}, \sigma^{2(s)}) = \sum_{i,t} w_{it} \cdot \log g_{it}(y_{it}^{(s)}) \qquad (4.1)$$

with respect to the parameters in L^*, where the $\{w_{it}\}$ are treated as constants and g_{it} is defined by (3.11).[1/]

A stratum will be defined in terms of the index-values for dropout-status, d_{it}^* ; grade-last-attended, j_{it} ; years-from-school, k_{it} ; school location, ℓ_{it} ; and sample year, t . Admissible values for each stratum-indicator are as follows:

$$d_{it}^* = \begin{cases} 0 & , & \text{if a continuing student and } t = 1 , \\ * & , & \text{if } k_{it} = 0 \text{ and either } t = 2 \text{ or } j_{it} = 6 , \\ 1 & , & \text{otherwise} , \end{cases} \qquad (4.2)$$

$$j_{it} = \begin{cases} 3,4,5 \text{ or } 6 & , & \text{if } k_{it} > 0 \text{ or } k_{it} = 0 \text{ and } t = 1 , \\ 4,5 \text{ or } 6 & , & \text{if } k_{it} = 0 \text{ and } t = 2 , \end{cases} \qquad (4.3)$$

$$k_{it} = \begin{cases} 0,1,2,3 \text{ or } 4 & , & \text{if } t = 1 , \\ 0,1,2,3,4 \text{ or } 5 & , & \text{if } t = 2 , \end{cases} \qquad (4.4)$$

$$\ell_{it} = \begin{cases} 0 & , & \text{if the school is in a rural community} , \\ 1 & , & \text{if the school is in an urban community} , \end{cases} \qquad (4.5)$$

$$t = \begin{cases} 1 & , & \text{if the observation is in 1978/79} , \\ 2 & , & \text{if the observation is in 1979/80} . \end{cases} \qquad (4.6)$$

[1/] The WMLE is consistent (see Manski and Lehrman (1977) for the case of a choice-based sample), but not asymptotically efficient (Coslett (1981)). This assumes, however, that within each stratum the observations represent a random sample.

In the above, the dropout-status indicator, d_{it}^*, is unknown (*) for all
inschoolers ($k_{it} = 0$) in 1979/80 and for all sixth graders, $(j_{it}, k_{it}) = (6,0)$,
in both years.[1] Also, the protocol in 1979/80 does not introduce a new third
grade inschool cohort (see (4.3)); but does extend the range of observations
on dropouts, K, to five years (see (4.4)).

For any admissible (d^*, j, k, ℓ, t) -value, let $n_{d^*,j,k,\ell,t}$

denote the number of <u>sample</u> observations in that stratum, with corresponding
<u>population</u> counterpart, $N_{d^*,j,k,\ell,t}$. Let $n = \sum_{d^*,j,k,\ell,t} n_{d^*,j,k,\ell,t} = 8398$

denote the total sample size and $N = \sum_{d^*,j,k,\ell,t} N_{d^*,j,k,\ell,t} = 5{,}116{,}900$ define

the total population in all admissible strata within our study. Then, the
appropriate weight for observation, (i,t), is defined by:

$$w_{it} = \frac{\frac{1}{N} \cdot N_{d_{it}^*, j_{it}, k_{it}, \ell_{it}, t}}{\frac{1}{n} \cdot n_{d_{it}^*, j_{it}, k_{it}, \ell_{it}, t}} . \tag{4.7}$$

To construct such weights, we utilized the aggregate MOE data on
enrollments (by grade) for each school year from 1974/75 to 1979/80, using the
marginal rates for rural-versus-urban enrollments (by grade) for the school year

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[1] It was not feasible to follow continuing sixth grades to the appropriate
secondary school. Hence, their dropout status was indeterminate, and such
points on the learning and retention curves of sixth graders could not be
recorded directly.

1976/77 to disaggregate by location in all other years.[1/] As the official

dropout rates by grade are confounded by the same causes of misclassification

that were encountered in our own sample of sixty schools -- that is, "paper

promotions, errors in school records, and so forth; we calculated dropout rates

by grade, year and location within our sample, and applied such rates to the

official MOE enrollment data. From this information, we are able to construct

estimates of <u>both</u> the population <u>and</u> sample totals required within each stratum,

and thus define the $\{w_{it}\}$ in (4.7) for all sample observations.[2/]

4.2 <u>Test Instruments</u>

Seven skill-specific achievement tests and two "general-intelligence"

tests were developed for the Egyptian Retention Study. Following piloting and

revision, the tests were applied to 8,570 inschoolers in grades 3 to 6 -- a third

of which defined the core inschool sample -- and to 1,794 children originally

classified as dropouts in 1978/79. The same set of tests was reapplied to the

1979/80 overall core sample, with adjustment for reclassification, sample

attrition and new sample members.[3/]

The original protocol in 1978/79 targeted the achievement tests to grade

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1/ Disaggregation by both grade and school location was only reported by the
    MOE for the school year 1976/77.   \

2/ See Hartley and Swanson (1984) for further discussion of the sample design
    and derivation of the sample weights.

3/ Thus, two sequential observations are available on <u>most</u> sample members.
    With sample attrition, only the 1978/79 data are available; and additions
    to the original sample result in only a 1979/80 observation. This
    complicates fully exploiting the "panel data" features of our sample --
    particularly since we are interested in modeling skill <u>levels</u>, rather than
    skill <u>differences</u> between cells.

levels consistent with the school curriculum. There were four literacy tests. Two of these, Reading A (given to grades 3 and 4) and Reading B (given to grades 5 and 6), pertained to reading skills; and each contained 30 multiple choice items. The remaining two, Writing A (given to grades 3 and 4) and Writing B (given to grades 5 and 6), required the child to write words, sentences and an entire paragraph. The numeracy portion included three achievement tests. The Simple Operations test contained twenty-eight problems in basic arithmetic operations, and was given to all grades. The Problem Solving test presented fourteen "story" problems, and was given to students in grades 4 to 6. The Geometry test contained eight problems, targeted for grades 5 and 6; and required identification and manipulation of elementary geometric figures. Finally, the two "intelligence tests" were intended to capture non-curriculum-dependent abilities. The Verbal Intelligence test contained thirty items derived from a comprehensive standardized test. The Non-Verbal Intelligence test had thirty five multiple choice items, requiring elimination of the figure not belonging to the set. These were given to students associated with all grades. Summary percentile scores for each of the nine tests were calculated for each respondent, and were based on a scoring system designed relative to each item. A time limit was imposed for each test.

In 1978/79, in part on grounds of economy, inschoolers were given only the subset of tests corresponding to their appropriate grade; whereas dropouts were given all tests, regardless of the grade-last-attended. As there were no common items across tests, using these data alone, it was impossible to impute scores on items in the missing tests, and thus estimate commensurate points on the learning or retention curves for all inschoolers. Accordingly, in 1979/80 all inschoolers and dropouts were given all tests. The Rasch (Logit) model then was employed to impute the missing test scores from the 1978/79 protocol, using

the 1979/80 item responses as an "anchor" sample.[1] This procedure assumes that the item difficulties did not change over the two years.

Following imputation, a complete set of test scores was available for each sample member over one or two of the sample years. Inspection of the distribution of scores by test revealed that left (right) censoring is more prevalent on the harder (easier) tests; and, for each test, more prevalent among dropouts than inschoolers for a given grade. Further, the pattern of censoring on a given test indicates that the proportion of left- (right-) censored observations: (1) increases (decreases) among dropouts from a given grade with the number of years from school; and (2) decreases (increases) with the grade-level, for a given number of years-from-school. As noted earlier, such a pattern would systematically bias estimates of learning and retention curves, if OLS were applied to the raw test scores.

For each test, two approaches were considered in defining the functional standard, $\mu^{(s)}$, for each test, $s = 1,\ldots,S$. Such a definition is inevitably culturally determined. As Oxenham (1980) conjectures: "The level of literacy which is adequate for the needs of an average citizen has to be determined within the context of a given society. In some societies, it may be well above the level needed for 'permanent' literacy" (p.93). Among educators in Egypt, there is a widespread belief that completion of the fourth grade curriculum is sufficient to establish functional levels of literacy and numeracy. An alternative approach is to evaluate each item within each test in terms of its relevance to "functionality." To this end, we convened a panel of Egyptian educators to assess the suitability of each test item. The scores associated

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1/ See Wright and Stone (1979) for a discussion of the Rasch model and Hartley and Swanson (1984) for discussion of the imputation methodology.

with all functionally-relevant items (adjusted for guessing and rescaled on a
percentile basis) provided an alternative measure of functional skill levels.
The two approaches were found to yield very similar results. Therefore, for ease
of exposition, in the sequel we shall consider the functional standard to be
coincident with <u>completion</u> of the fourth grade.[1]

1/   Since our tests were administered approximately halfway through the school
year, the functional standard, $\mu^{(s)}$, is calculated as the (suitably-
weighted) <u>average</u> of the estimates for the learning curve at grades four
$(\mu_{40}^{(s)L})$ and five $(\mu_{50}^{(s)L})$. However, as we shall see in Section 5, our
conclusions regarding the existence of a threshold for permanency are quite
robust with respect to alternative definitions of functional standards.

5. Empirical Results

In this section, we present estimates of the learning and retention curves for each of the seven achievement tests; as well as for the two intelligence tests and the "combined" literacy and numeracy aggregates. We adopt the simple ANCOVA model, (3.2), of latent ability for each skill, $s = 1, 2, \ldots, 11$, and employ a weighted maximum likelihood estimator (WMLE), obtained by applying the sampling weights, w_{it}, of (4.7) within the weighted log-likelihood function, (4.1), under bilateral censoring. To facilitate presentation, we consider (here) only the covariates obtained directly from the test instruments:[1]

$$sex_{it} = \begin{cases} 1 & \text{, if individual } i \text{ is male,} \\ 0 & \text{, if individual } i \text{ is female;} \end{cases} \quad (5.1)$$

$$\ell_{it} = \begin{cases} 1 & \text{, if individual } i \text{ resides in an urban community,} \\ 0 & \text{, if individual } i \text{ resides in a rural community;} \end{cases} \quad (5.2)$$

$$rtst_{it} = \begin{cases} 1 & \text{, if individual } i \text{ was re-tested in year } t, \\ 0 & \text{, if individual } i \text{ was not re-tested in year } t; \end{cases} \quad (5.3)$$

and, for $m = 1, \ldots, M-1$,

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[1] Results employing the complete set of covariates, obtained from the socio-economic and longitudinal questionnaires, are given in Hartley and Swanson (1984). These exhibit very similar learning and retention curves. However, the configurations of missing data for each (i,t) within $\underline{x}_{it}$ requires repeated recalculation of the sampling weights, since each alternative model specification has a different set of (complete) observations. The present choice of $\underline{x}_{it}$ avoids such complications, and makes use of every sample member -- thus permitting a sufficient number of observations within each cell. Further, it greatly simplifies presentation of the results. Finally, we had a very limited computer budget for this revision.

$$sch^{m}_{it} = \begin{cases} 1 & \text{, if individual } i \text{ was associated with} \\ & \text{school } m \text{ in year } t, \\ 0 & \text{, otherwise ;} \end{cases} \qquad (5.4)$$

where $M = 60$ is the number of sample schools. The "re-test" variable in (5.3) is included to examine the consequence of "learning-by-doing" on performance, due to an individual taking the same test again in the second year.

5.1 Results

In Figures 5.1 to 5.3 we exhibit the learning and grade-specific retention curves for each of the individual literacy and numeracy achievment tests, as well as the intelligence tests -- each using only sex, school location and the re-testing dummy variables as covariates in (3.2). The functional standard, $\mu^{(s)}$, is super-imposed on each figure referring to an achievement test, $s = 1,\ldots,7$, and approximates the skill level associated with completion of the fourth grade.

In Figure 5.3, we also present the intelligence tests and the combined literacy and numeracy test results -- the former obtained as the sum of the scores on the pairs of reading and writing tests and the verbal intelligence test, and the latter from the simple operations, problem solving, geometry and non-verbal intelligence tests -- all rescaled to percentiles. In the combined literacy and numeracy tests, the 59 school-specific dummy variables in (5.4) now have been included, along with the covariates in (5.1) and (5.3).[1]

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[1] The rural/urban school-location variable was eliminated in the analysis of the combined models, $s = 10$ and 11, as it is perfectly collinear with the set of school-effect variables.

Figure 5.1: Learning and Retention Curves for the Literacy

Achievement Tests
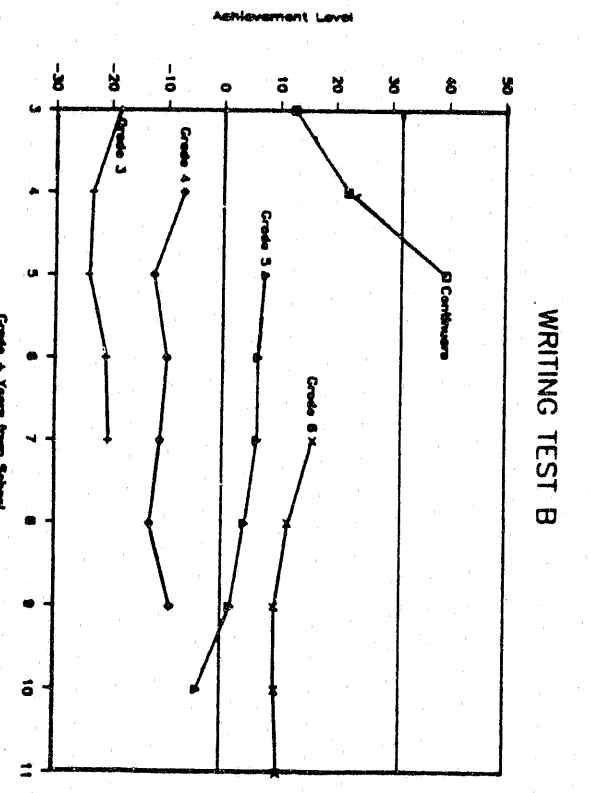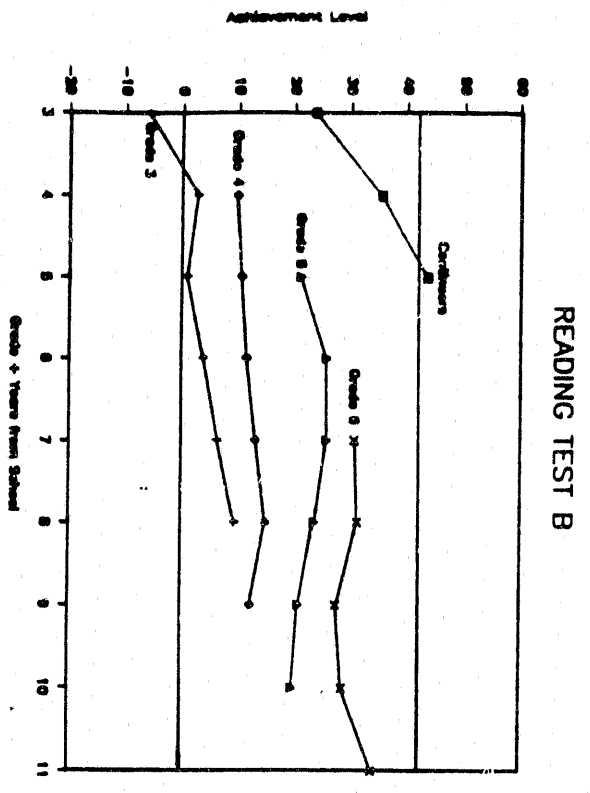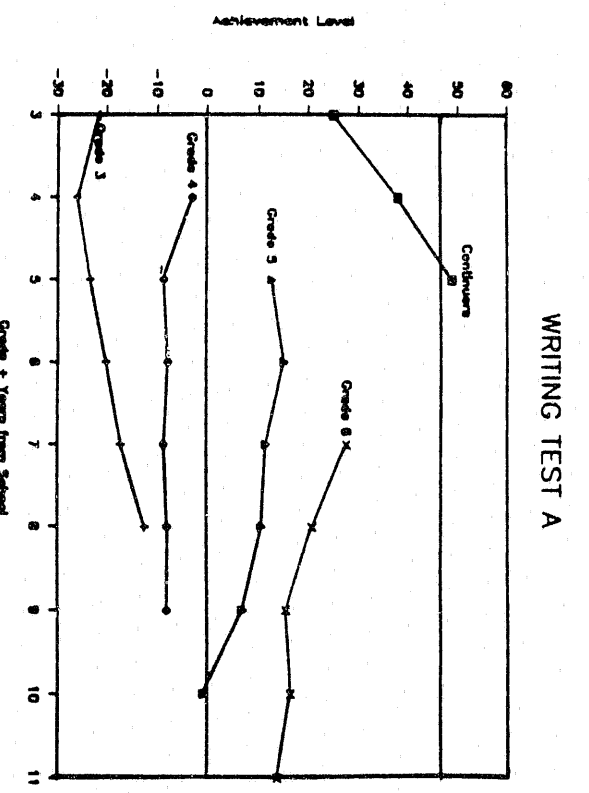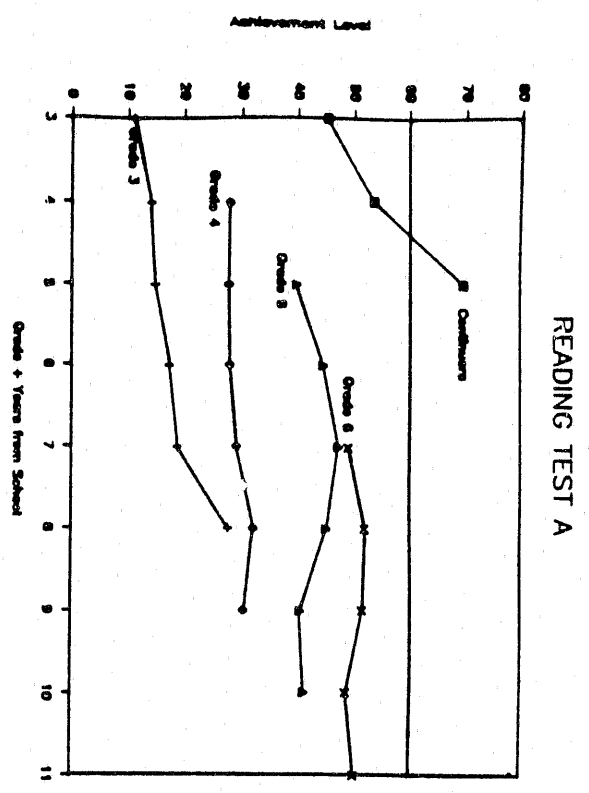
Figure 5.2: Learning and Retention Curves for the Numeracy

Achievement Tests

SIMPLE OPERATIONS TEST

PROBLEM SOLVING TEST

GEOMETRY TEST
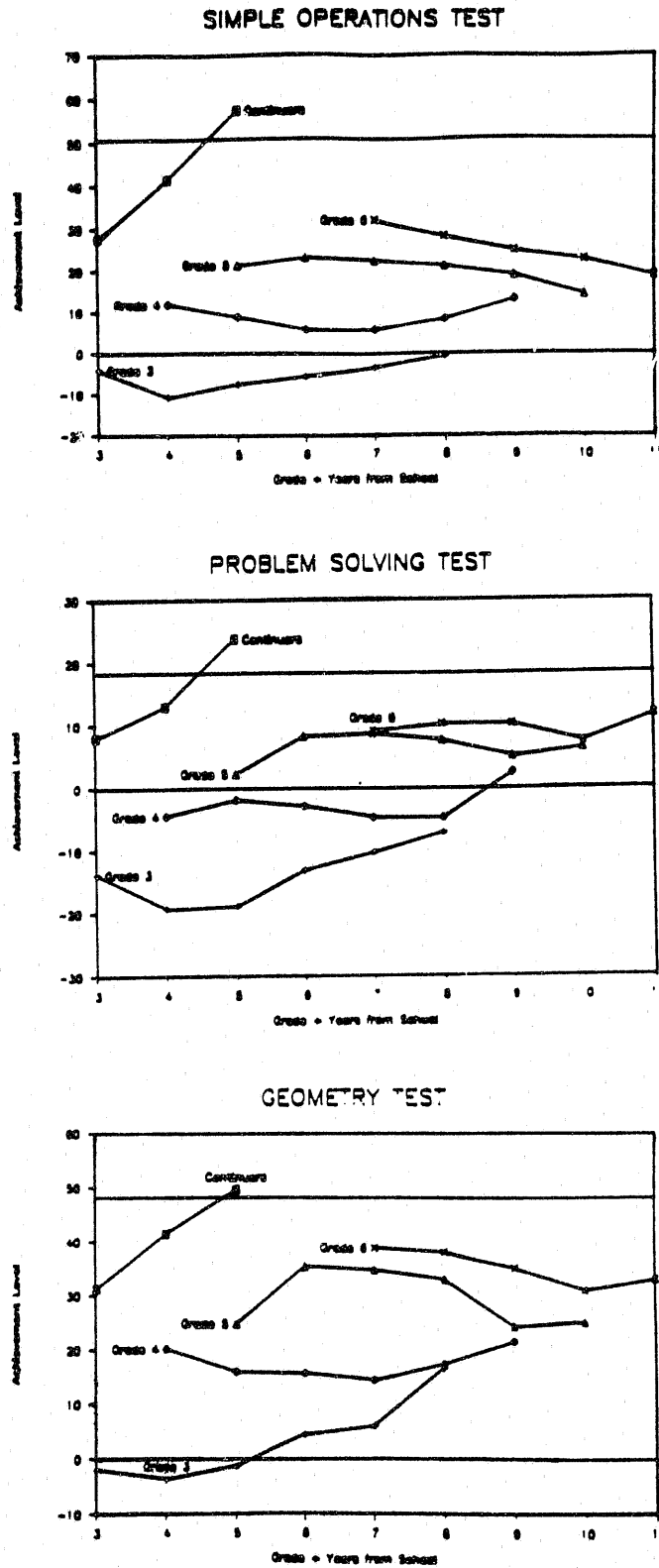
Figure 5.3: Learning and Retention Curves for the Intelligence and Combined Literacy and Numeracy Tests
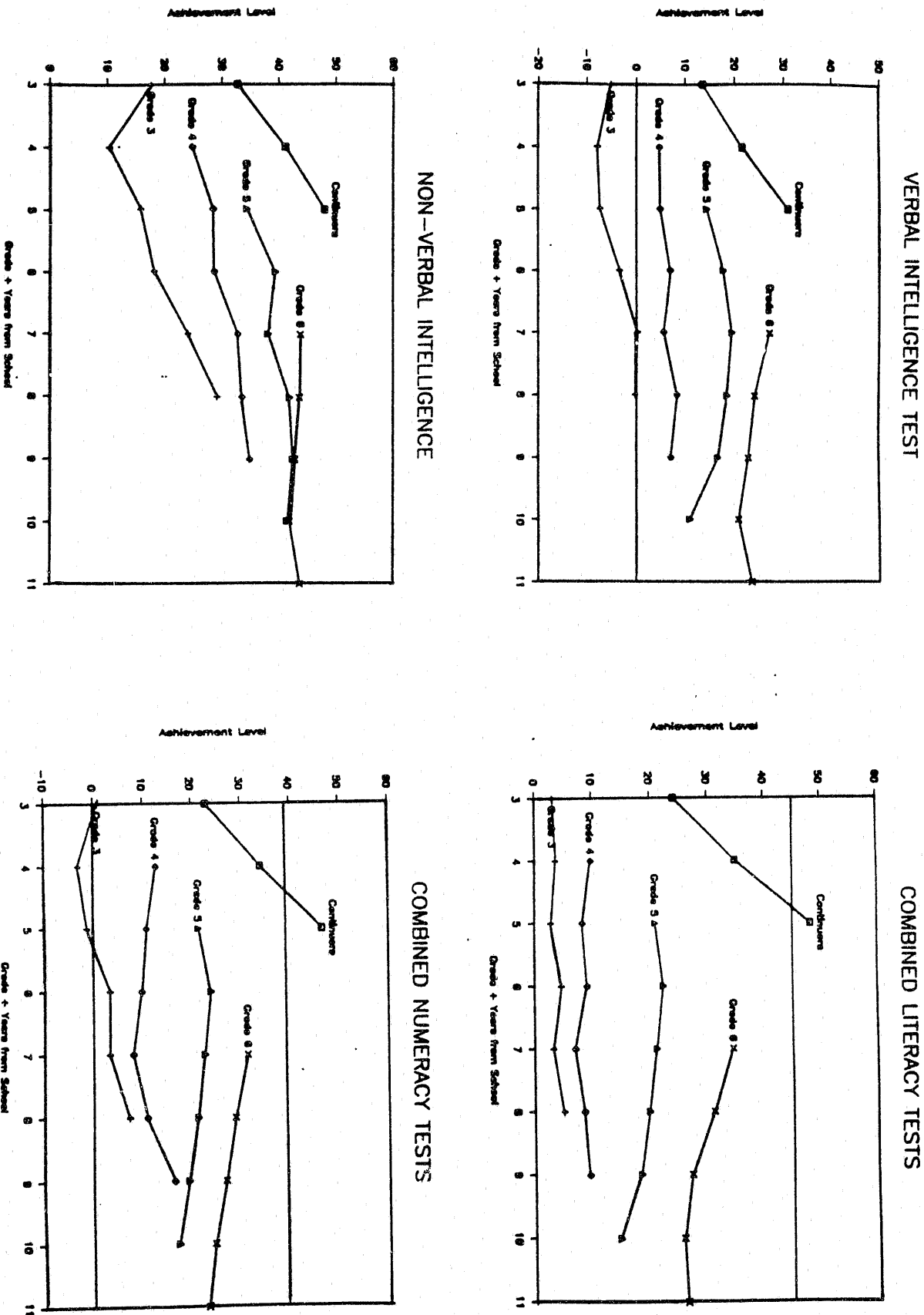
Table 5.1: Coefficients on (School-Location,

Sex and Previous Testing) Covariates

Test:	School Location	Sex	Previous Testing	Residual Variance
Reading A	13.82*	1.92*	3.43*	554.74
Reading B	13.87*	0.97	3.40*	540.76
Writing A	15.07*	1.04	9.02*	825.15
Writing B	12.34*	1.26*	4.24*	596.92
Simple Operations	11.05*	1.61*	5.22*	534.04
Problem Solving	13.32*	2.97*	5.30*	417.55
Geometry	14.03*	1.41	7.68*	617.78
Verbal Intelligence	10.08*	1.73*	3.70*	312.66
Non-verbal Intelligence	10.36*	0.71	5.16*	339.68
Combined Literacy Tests**	..	1.23*	3.14*	394.15
Combined Numeracy Tests**	..	4.59*	2.29*	309.80

* Significant at 95% level (two-tailed test).

** Also includes school-specific effects (see Table 5.2).

Table 5.2: School-Specific Effects

	School	Combined Literacy	Combined Numeracy		School	Combined Literacy	Combined Numeracy
+ 1.	Tarek Ben Zeiad	20.54*	13.13*	31.	Kafr Sendanhoun	1.93	1.87*
+ 2.	Al-Suez City	2.16	3.96	+ 32.	Al-Akbat	14.92*	8.83
+ 3.	Al-Falah	11.50*	10.66*	+ 33.	Al-Bealy	16.46*	10.71*
+ 4.	Hussein Fahmi (evening shift)	19.14*	12.72*	+ 34.	Mougamaa Benoot	-7.05*	-3.70
+ 5.	Ahmed Maher	29.94*	24.40*	35.	Abou Taha	11.91*	8.72
+ 6.	Al-Nasr (morning shift)	8.67*	9.72*	36.	Moustafa Abed El Nabi	4.28	6.95*
+ 7.	Al-Shourafa (evening shift)	24.06*	17.06*	37.	Naser Kafr El Naeem	7.79*	5.86*
+ 8.	Khaled Ben Walid	26.71*	22.62*	38.	Egbet Al-Baz	-3.42	-0.78*
+ 9.	Al-Shourafa	19.33*	17.98*	39.	Nasser Al-Areed	3.93	0.97
+ 10.	Thamaret Al-Tawfik	6.16*	8.96*	+ 40.	Mabarret Faraskour	27.17*	23.31*
+ 11.	Omer Ben Khatab	19.57*	23.86*	41.	Al-Shaheed Saad El Asmer	13.61*	6.76*
+ 12.	Al-Houriah	16.57*	20.74*	+ 42.	Sixteenth of March	11.50*	12.14*
+ 13.	Al-Hanafy	14.49*	11.08*	43.	Al-Shaheed Moustafa Kafr Hefna	5.09	2.44
+ 14.	Amin Al-Rafee	5.06	2.60	44.	Al-Rouda	-11.77*	-9.26*
+ 15.	Dar Al-Safa	29.87*	18.55*	+ 45.	Abu Ayaad	1.48	7.54*
+ 16.	Om Al-Moemeneen	8.74*	10.06*	+ 46.	Al-Shaheed Gawad Hosni	9.66*	10.54*
17.	Al-Shaheed Zakaria Attia	-3.42	-5.09	47.	Kafr Kandil	-5.63	2.82
+ 18.	Sabah Salem	4.57	2.40	48.	Nasser Mater Tares	-8.14*	-3.98
+ 19.	Al-Ahmodiah	29.77*	26.36*	+ 49.	Ahmed Hassan	-7.19	-3.23
20.	Farsees Girl's School	5.53	6.04*	50.	Menshat Al Dahab Al-Kebliah	-7.35*	-7.83*
21.	Kafr Shamakh	4.65	10.50*	51.	Tendah	-4.23	-7.93*
22.	Meet Habeeb	12.93*	11.10*	52.	Der Al-Garnouse	-6.53*	-1.83
23.	Teda (morning shift)	4.32	3.46	53.	Maasarat Haggag Bany Mazar	-11.26*	-11.49*
+ 24.	Al-Hedaia	10.01*	7.19*	54.	Koum Matay	0.74	0.25
+ 25.	Al-Gomhoriah	6.97	3.20*	55.	Al-Salamoun Tema	5.03	-3.06
26.	Kafr Al Sheekh Shehata	-8.71*	-7.77	56.	Bany Wassel	-4.13	-8.05*
27.	Moassaset Meet Bera	-6.97*	1.94	57.	Nagh Gad Al-Karim	5.89	6.48*
28.	Begerem Girls' School	-1.57*	-2.02	58.	Al-Dababia	-6.23	-9.01*
+ 29.	New Shebeen Al-Kanater	4.54	6.97*	59.	Nagh Al-Gameh	-5.00	-9.32*
+ 30.	New Al-Hourriah	3.71	12.38*	+ 60.	Taha Hussein	xxxx	xxxx

* Significant at 95% level (two-tailed test)
xxxx Excluded from regression
+ Urban School.

The coefficients associated with each of these covariates in the models of the achievement and intelligence tests (sex, school location, and re-testing for s = 1,...,9) in equation (3.2) and for the combined literacy and numeracy tests (sex, re-testing and school-specific effects for s = 10 and 11) are reported in Tables 5.1. and 5.2.[1][2].

5.2 Discussion

In our discussion of the empirical results, we first consider issues associated with the _shapes_ of the various learning and retention curves, and then examine the effect of each of the _covariates_ in shifting these patterns.

As noted above, the leading hypothesis regarding retention of basic skills suggests a significant and rapid decline among dropouts immediately upon leaving school.[3] In the present case, in which continuers are separated from

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[1] Due to the limited number of covariates, the Newton-Raphson algorithm was the most efficient in models, s = 1,...,9.

[2] In the case of the two combined tests, including the school-effects increased the total number of regressors in each of these models to 87. In problems of this size, the E-M algorithm, which avoids repeated inversion of a moment matrix in successive iterations, was almost twice as fast as the Scoring or Newton-Raphson algorithms. See Hartley and Swanson (1985) for discussion of various algorithms to calculate the MLE under various forms of censoring and/or trunction of the dependent variable.

[3] It should be noted that the results in Hartley and Swanson (1980), based upon _only_ the first year's cross section data, and using model (3.6), which assumes that points on the learning curve are coincident with the base-line reference points for each retention curve, while also correcting for censoring, strongly "confirmed" this hypothesis for _every_ grade.

dropouts, our results do not support this hypothesis.[1] Inspection of Figures

5.1 to 5.3 reveals no significant loss during the first year from school. In

fact, on the reading tests dropouts register an increase in skills relative to

their in school levels; while (except for 5th graders) writing skills decline in

the first year from school. Numeracy skills exhibit a mixed pattern: third grade

dropouts lose slightly; fourth graders have a mixed pattern; and fifth graders

gain during the first year out of school.

More important, however, is the fact that dropouts' skill levels are

significantly lower than their continuing inschool peers. Roughly speaking, at

the time a dropout decision is taken, the skill levels of school leavers are two

grade-levels or more below those of students who decide to continue in school.[2]

As we might expect, the learning curves (labeled 'Continuers' in

Figures 5.1 to 5.3) are monotonically increasing over grades 3 to 5, with rates

of increase varying across tests. This is also the case for our so-called

"intelligence tests", suggesting that they are not independent of the school

curriculum. In all cases, functional levels (here, by definition) are attained

by the fifth grade.

Evidence of the importance of censoring at the lower extreme is manifest

by the presence of negative latent achievement levels portrayed in Figures 5.1 to

5.3. These refer to rural females without retesting. Learning and retention

curves for males, for urban students and/or for those re-tested require parallel

shifts. Here, adjustments in the scales of the $\{\hat{\alpha}_{ij}^{(s)R}\}$ values must be made in

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[1] Grade-specific retention curves in Figures 5.1 to 5.3 are labeled
'Grade j' for j = 3,...,6. Recall that Grade 6 retention curves do not
have an inschool reference point.

[2] This may be seen in Figures 5.1 to 5.3 by comparing the base-line skill
levels of fifth grade dropouts with those of continuing students from the
third grade.

an amount given by the coefficients associated with the appropriate covariates given in Tables 5.1 and 5.2. The pattern of resulting negative values confirms our earlier observation on the raw test scores -- left-censoring is more prevalent among dropouts from the earlier grades and on the more "advanced" tests.

Correction for censoring, however, does not remove the tendency for the set of retention curves for a given test to converge to a common asymptote. Retention curves for third and fourth graders exhibit a significant increase with the number of years from school -- a direct confutation of the leading hypothesis on retention; while those of fifth and sixth graders exhibit slight decreases on balance. The latter is of potential importance, since it suggests the possibility of a threshold level for literacy and/or numeracy skills.

Inspection of the levels of the functional standards on the achievement and combined literacy/numeracy tests, $u^{(s)}$, plotted as horizontal lines in Figures 5.1 to 5.3, reveals that this issue is moot. Recall from Section 3.3 that our definition of a threshold-grade is the first instance where the entire retention curve lies above the functional standard. The retention curves for the achievement and intelligence tests in Figures 5.1 to 5.3 refer to those for the "representative" rural, female dropout with no previous testing. The coefficients in Table 5.1 define the "shift parameters" for urban and/or male students. For such students, the learning curves, retention curves and the functional standard will all shift by the same amount, relative to the covariate values associated with the "representative" sample member. Since, for all of the individual achievement tests, the retention curves are uniformly below the functional standard, there can be no possibility of a threshold for permanency within the range of primary school grades.

Dropouts are not functionally literate or numerate (relative to the appropriate functional standard) at the time they elect to leave primary school. Hence, there can be no "lapse" into illiteracy or innumeracy, since functional levels of such skills were not attained in the first place. It should also be noted from Figures 5.1 to 5.3 that this conclusion is quite robust with respect to alternative definitions of functional standards much lower than those associated with completion of the fourth grade. In Egypt, a threshold for permanency, if it exists at all, occurs in secondary school or even later.

Next, we consider the coefficients on the covariates given in Tables 5.1 and 5.2.

The location of a school always has a significant and positive effect on skill levels -- a continuing student in an urban school has achievement levels approximately one grade-level above that of his/her rural counterpart.

Sex (being male) also has a positive effect on skill levels, but is of mixed significance on individual achievement and intelligence tests. On the combined tests, however, sex is on balance both positive and significant -- with a much greater effect on numeracy than on literacy.

A student previously exposed to a given test always scores significantly higher, regardless of the skill. We interpret this as "learning-by-doing", and our results indicate the importance of controlling for re-testing in longitudinal studies of retention. Examination of the pattern of such coefficients indicates a somewhat larger benefit from re-testing on literacy than on numeracy tests.

Finally, we examine the school-specific effects in Table 5.2. We note, as expected, that most urban schools have a significant and positive impact on

achievement levels.[1]/ All significant negative school-effects refer to rural schools. Of some independent interest is the fact that the relative magnitudes of the school-effect coefficients largely conform to the _a priori_ rankings of our Egyptian collaborators at the NCER as to "school-quality". In effect, introduction of the school-specific effects into the models of the combined tests removes much of the irregularity in the shapes of the learning and retention curves -- compare the achievement tests in Figures 5.1 and 5.2 with the combined test results in Figure 5.3. This leaves open, however, the nature of the characteristics (including school, teacher, community and individual-specific covariates) which distinguish one school from another. This, we leave to another paper.

6. Conclusions

We first review the main conclusions of this paper, and then consider some policy implications.

The principal finding of this paper contradicts conventional wisdom regarding the retention of basic skills. Rather than suffering a rapid and significant erosion of skills after leaving school, dropouts, when last in school, had substantially lower skill levels than their continuing peers. This skill-deficit is estimated to have reached the equivalent of two grade-levels or more by the fifth grade.

Further, the pattern of retention is certainly not one of uniform and steady decline. Dropouts from the earlier primary school grades clearly do

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1/ For example, school numbers 1 to 13 are in Cairo; and 14 to 16 are in Alexandria.

acquire additional skills in an external environment, but, it should be stressed, at a much slower rate than their peers who continue in school. However, there _is_ evidence of erosion of skills among dropouts from later grades -- a phenomenon equally prevalent among literacy and numeracy skills. This suggests a possible convergence of the retention curves of dropouts from _all_ primary school grades to a common positive asymptote. The existence of a possible common asymptote for the retention of basic skills by primary school dropouts, though well below that which is regarded as a functional level, is clearly of importance. Contrary to the conventional view, in which all school resources expended on dropouts are considered to be completely wasted, it is evident that dropouts _do_ acquire and retain some basic skills--possibly indefinitely. These are surely of both private and social value.

The question of the existence of a threshold grade for permanent retention of "functional" skills within the range of Egyptian primary schools was found to be moot. As dropouts left school with skill levels already well below functional standards, such a threshold must be sought among the secondary school grades. These were beyond the scope of the present study. As Oxenham (1980) asserts: "... the time needed to make a person adequately literate will vary according to the level (functional standard) determined. However, the period necessary for 'permanent' literacy is likely to be at least four years of schooling for children" (p.93, parentheses added). In Egypt, four years is clearly insufficient -- not only for dropouts but also for continuers.

Our results indicate considerable disparities in achievement levels between urban and rural schools. Why this is the case is not apparent from the analysis provided here. This issue is complicated by the existence of a centralized administration (MOE) that has implemented a standardized primary school curriculum and a system of resource allocation that is proportional to

official school enrollments. While it may be tempting to prescribe a compensating reallocation of MOE resources in favor of the rural schools in the hope of relieving such skill-deficits. the validity of such a prescription would require first establishing the efficacy of school-specific inputs -- as opposed to (say) the socio-economic status of the child's family.[1]/ Then, a social cost-benefit analysis of alternative allocations (see, for example, Little and Mirrlees (1969)) should be conducted. The latter was not feasible given present data.

Males generally have higher achievement levels than females, while controlling for other covariates. This may reflect cultural and institutional country-specific features. While Egypt has been not only a leader in education, but also the most progressive of Arab countries with respect to the emancipation of her women, the process is clearly incomplete.

Finally, we return to certain policy implications of our findings on dropout retention. Attendance in the first six primary school grades during our study was "compulsory", but the law clearly was not enforced...and probably was unenforceable. While grade-specific dropout rates vary considerably (Hartley and Swanson (1984)), the aggregate MOE data indicate that of those who actually enrolled in primary school in 1973/74, twenty-five percent of all males and thirty-three percent of all females left school permanently before completing the sixth grade. Such rates, however, are low, relative to those found in many other LDCs.

1/ The efficacy of school-specific inputs is a matter of considerable
    controversy in the education literature on LDCs (see, for example, Simmons
    (1976, 1980), Heyneman (1980), Jamison and Moock (1984)). Our results in
    Hartley and Swanson (1984) suggest the "socio-economic status" of the
    child's family is a more important determinant of achievement; and is also
    closely associated with urban/rural location.

The Egyptian government is in the process of implementing a new law which extends the "compulsory" period of schooling to eight years.[1] While our results do not permit comment on whether or not dropouts would permanently retain functional literacy or numeracy standards, if forced to complete eight years of schooling, it is quite clear that these have not been attained within the six-year primary school curriculum at the time of our study.

Our results contradict the received doctrine that dropouts from the later grades of primary school, having attained functional levels, rapidly lose command over such skills and eventually "lapse" into an illiterate/innumerate state. Rather, such dropouts never attained functional levels while in school in the first place. Such results would not have been revealed had we not introduced a longitudinal component into our sample design. As would-be dropouts are about two years behind their continuing peers, responsibility for the "dropout problem" apparently lies with the schools, and is not due to a "lapse of memory" on the part of school-leavers.

Given the magnitude of the skill-deficit of dropouts, relative to continuers, this suggests that the problem will not be solved solely by mounting extensive "dropout prevention" programs. Rather, we believe, the problem lies in the rigid, uniform nature of the national school curriculum in Egypt. It appears, to us, that such a policy has not met the educational needs of a sizeable segment of the enrolled primary-school-age population. Remedial and special education programs within primary school, targeted to the needs of the less-advantaged, will be required to achieve further increases in subsequent adult literacy rates in Egypt, and, we suspect, elsewhere. Further, additional

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[1] Subject to a student's qualifications, education through the university level is largely at government expense. The net effect of this policy is likely to be regressive.

facilities are required to extend even the opportunity of primary schooling to those children presently without ready access. Unfortunately, these cannot be achieved without a cost.

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