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ABSTRACT

Computer-based, criterion-referenced testing can be a humanizing process if it is used for diagnostic and remedial purposes in helping individual students to attain their maximum levels of achievement. The procedure is based upon the proposition that certain classroom situations involving cognitive acquisition, when tested at equally spaced time intervals, result in a graph that may be considered a non-stationary time series. For each individual, a computer analysis of succeeding scores can establish a unique learning curve with specified stochastic limits. The teacher can make use of computer printouts a) to allow most of the students to proceed with regular materials, b) to adjust the programs of pupils who fall back of their previously demonstrated ability levels, and c) to establish new horizons for those who exceed their established curves of learning. (Author/PB)

HUMANIZING EDUCATION THROUGH CONTINUOUS

ANALYSIS OF PUPIL PROGRESS

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PURPOSE AND APPROACH

This paper presents a model and a strategy for humanizing education in the classroom, aided by a relatively unobtrusive computer application.

It is proposed that the learning curve for an individual (in certain forms of cognitive acquisition) is an instance of non-stationary time-series. Rapid analysis (by available software) of repeated testing at uniform time intervals may (a) yield a quality control of the progress of learning and (b) provide a means of promoting individual performance to the limit of apparent ability, without reference to intelligence or intelligence testing.

HUMANIZING EDUCATION

General Definition

The prevailing notion of humanizing education is as broad as the long-established goals of education. The individual is conceived as possessing unique needs and abilities, and the purpose of the school is to bring each pupil to his capacity as a learner, rendering him skillful and effective in dealing with his environment.

This paper presents a small subset of this universal notion. The scope is limited to analysis of individual pupil progress in certain classroom situations as the analysis contributes to the humanizing process. The working definition below is specific to the thesis of this paper.

Operational Definition

Essentially, the definition of "humanizing" in this paper refers to the attainment of individual children in contrast to group advancement or group achievement. Thus, an educational program is successful to the extent that it brings a high proportion of its children to learning criterion levels unique to each child's ability.

This point requires belaboring.

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For the past third of a century, almost all the statistical research done in schools has dealt with significant differences between means of groups of children. The literature is a jungle of independent variables, dependent variables, components, indicators, conditions, effects, parameters, correlations, t-tests, variances, co-variances chi-squares, regression equations and a whole host of multivariate analyses. These concepts have served, and continue to serve, worthy purposes. But they all deal with groups, and that is just not the focus of this paper.

What is under discussion is the individual, human child. Consider one pupil at the point of learning and practising a certain skill to be mastered in terms of speed and accuracy. He is capable of reaching a certain criterion level (unknown at the outset by the teacher). At the end of an adequate period of instruction, he reaches his unique criterion level. Now consider another child with a different potential (also temporarily unknown). He reaches his criterion. At the end of a given period of instruction and opportunity, let us say 30 out of 35 pupils have reached their own expected levels. That is the measure under scrutiny. Call it the school's "batting average" or "percent of pupils successful" or anything else that describes it. A program is humanizing, for purposes of this discussion, to the extent that its batting average is high in getting individual pupils to reach their own maximums of attainment.

Basic Problems

Arguments must now be made for (a) determining the apparent potential for each child, and (b) arranging for the computer to monitor the progress and pace of each individual towards his objective. To do this we must review some aspects of the curve of learning and establish its amenability to time-series analysis. Figures 1 to 4 depict these steps.

THE CURVE OF LEARNING AND AN INDIVIDUAL'S PROGRESS

General Features

The classical curve of learning is predicated on group performance (Figure 1) on such tasks as: sending and receiving Morse Code; learning to type; repeating a list of words, names, or symbols; performing arithmetic calculations; matching geographical names and places; and associating historical dates and events. By an inductive leap, one might claim that more worthwhile forms of learning also follow the curve.

The general features of the curve are indicated by Roman numerals on Figure 1:

I Differentiation-analysis-exploration.

Meticulous attention is paid to elements of the process. The code for "A" is "dit-dah." The bottom line on a musical staff is E. The first key in the middle row of the typewriter is A. Little progress in speed and accuracy is made during this phase.

II Integration-combination-patterning.

Elements are put together into meaningful wholes. The code operator hears whole words instead of individual letters. The budding pianist perceives bars instead of notes. The typist presses keys without "thinking". Speed and accuracy pick up, but at a slow rate.

III Practice-drill-experience.

This is the stage of very rapid improvement.

IV Use-application-maintaining highest level of attainment.

Sometimes there is a physiological limit. Speed in typing may be bound by the limit of human strength in the fingers. It may be 60 words per minute for some typists and 120 per minute for champions. (The teacher must watch out for false learning limits called plateaus. These may be broken by changes in method, surroundings, and motivation.)

Experiments involving large groups of subjects whose scores are averaged at each trial and plotted on a graph usually result in the smooth curve shown in Figure 1. An individual's progress is almost always registered as a jagged succession of lines as shown in Figure 2. It is the individual's that resembles what mathematicians call a "non-stationary" time-series graph.

TIME-SERIES ANALYSIS

A bright, new tool for research became available in 1970 with the publication of Box and Jenkins, Time-Series Analysis: Forecasting and Control (1). The book requires the reader to be at a high criterion level in knowledge of series, matrices, bivariate distributions, maximum likelihood estimation, and a few other mathematico-statistical notions. The difference between ordinary and mathematical statisticians lies not in understanding of basic concepts, but in ability to decipher abstruse notation and symbolism.

A Model of Models

A whole class of linear time-series models may be expressed by the following formula (2,p.518):

$$\phi_p(B)(1 - B)^d(Z_t - \mu) = \theta_q(B)a_t$$

The parameters (ϕ_1, ..., ϕp) are called autoregressive parameters, and the (θ_1, ..., θq) are called moving average parameters. (Other basic concepts include: lag, difference, autocorrelation, backshift operator, and shock.) Computer programs exist for (a) reducing the general model to a specific model, given the parameters, and for (b) using the specific model to forecast values at projected time intervals.

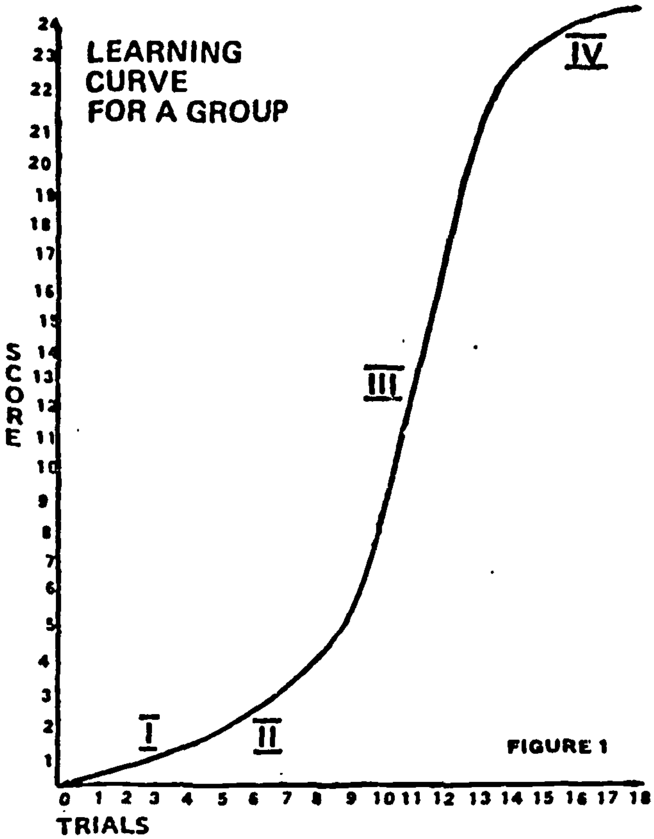

FIGURE 1

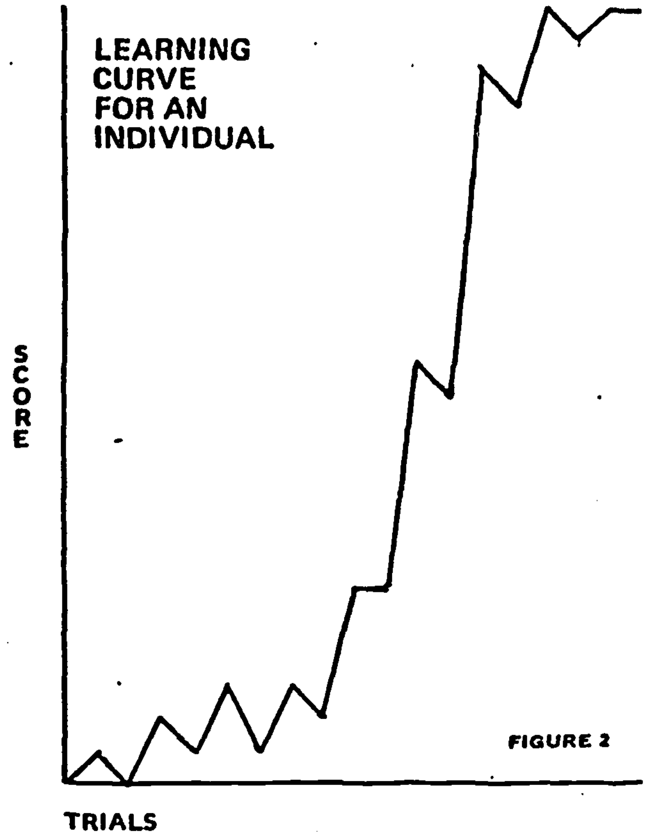

FIGURE 2

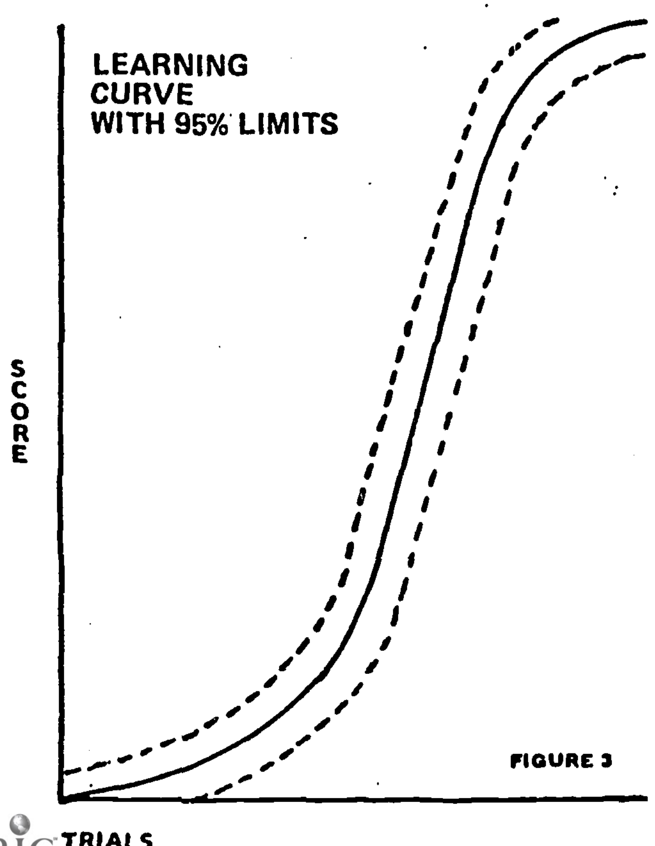

FIGURE 3

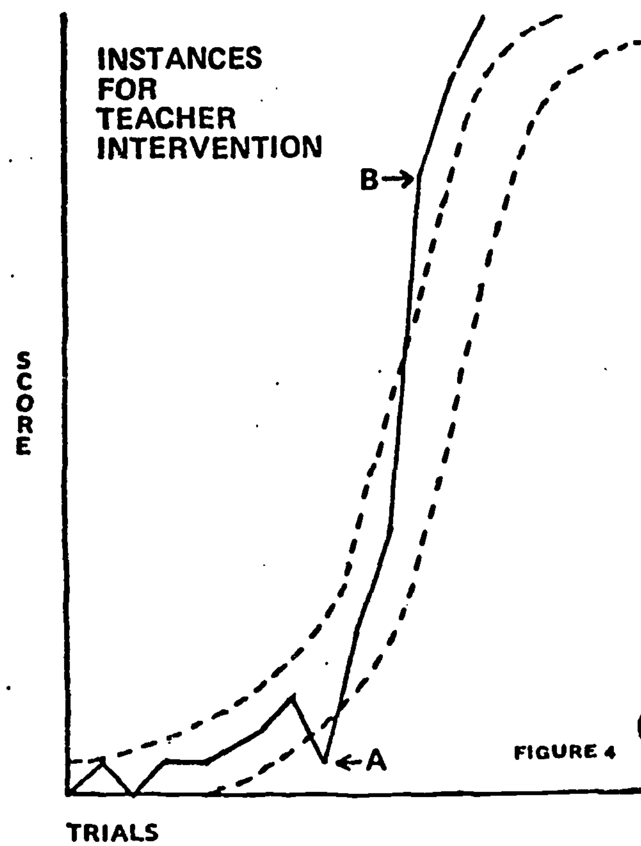

FIGURE 4

Probability or Stochastic Considerations

Time-series analysis is not new, far from it -- it is one of the oldest of statistical concerns. What is new is the computer application that makes possible stochastic models permitting forecasts and quality control with associated confidence limits.

Box and Jenkins (1,p.7) say:

> In many problems we have to consider a time-dependent phenomenon ... in which there are many unknown factors and for which it is not possible to write a deterministic model that allows exact calculation of the future behavior of the phenomenon. Nevertheless, it may be possible to derive a model that can be used to calculate the probability of a future value lying between two specified limits. Such a model is called a probability model or a stochastic model ... A time series $z_1, z_2, \ldots, z_n$ of N successive observations is regarded as a sample realization from an infinite population of such time series that could have been generated by the stochastic process...

Application of Time-Series Model to the Learning Curve

The learning curve may be characterized from the general model by a judicious combination of autoregressive and moving-average parameters. Let the resulting equation contain additional parameters that will permit the computer to generate successive learning curves adjusting to the unique ability of the individual student. Further, let each determination of a curve be accompanied by stochastic limits adjustable to 99%, 95%, or any other percent that may be practical.

While programs exist for identifying a specific model and for forecasting from it, the application to the learning curve awaits development. Perhaps some reader will choose it for a thesis topic.

This would be the procedure:

1. Derive a model from the general model making use of group learning curve data readily available in psychological and educational research. (Or, devise a learning experiment of your own.)

2. Install parameters into your model such that, given a few early readings, the entire curve may be generated.

3. Determine a method of establishing stochastic limits.

4. Write your program so that a message will print out should any reading fall below the lower limit.

5. Write your program so that, if a reading exceeds the upper limit, (a) a message to that effect will print out, and (b) a new learning curve will be generated with new stochastic limits enclosing the new reading.

The resulting general curve with stochastic limits would look like Figure 3. The progress of an individual pupil would resemble Figure 4, with the point A indicating a fall below the lower limit, and B indicating a break through the upper limit.

SOME NEW PRINCIPLES OF EDUCATION

In order to link the foregoing theoretical base with a practical classroom situation it is necessary to interpose some new principles of education in this age of computers.

1. Even good teachers resent re-ordering their priorities to accommodate CAI and other computer applications in their classrooms.

2. In the matter of diagnostic criterion testing, turn-around time longer than about 20 hours benefits only the vendor of tests and neither the teacher nor the pupils.

3. Lengthy, elaborate testing eats into teaching time, doing more harm than good.

4. Not all pupils need remedial teaching; in fact, only a small number in any class do. If a pupil is performing to capacity (whatever that may be) he should be left to carry on at his own pace. Any attempt to "counsel" <u>all</u> pupils (such as 300 by one counsellor) inevitably results in such superficiality as to be worthless.

5. Only <u>some</u> aspects of <u>some</u> school subjects are suitable for computer diagnosis leading to individual remediation.

6. Norm-referenced and norm-producing tests are somewhat non-humanizing; criterion testing for individual diagnosis and remediation to capacity is a natural, humanizing process.

7. The capacity of an individual in any instance of learning can be approached by an adjustment to his unique learning curve based on his scores on early, successive trials.

THE CLASSROOM SITUATION

The generalist teacher who has taught a wide range of subjects at several grade levels will have worked out a stylized sequence of lessons:

1. <u>Exploration</u>: finding how much each pupil already knows about the topic.

2. <u>Motivation</u>: intrinsic, extrinsic or both.

3. Presentation: by a method appropriate to the topic.

4. Discussion: for clearing misconceptions, filling gaps, and reinforcing motivation.

5. Testing: for evidence of learning.

6. Feedback: for reinforcement and deciding on whether or not to go on to another topic.

Such a teacher would recognize that, in nearly every subject-matter area, there occur blocks of material requiring rote memory and practice, interwoven with meaningful application to the main body of knowledge under pursuit. The time to spend on these blocks of material should be small in comparison with the whole teaching process.

Example

In the subject matter area of arithmetic and in the topic of addition there occurs a block of basic data called the number facts. These must be mastered before more complex additions (and other operations) can be pursued. Let us consider a situation in which the pupils are confronted by a large number of items, many more than the best can possibly complete in the five-minute testing period (to be repeated at the same time each day for several weeks), and their responses are to be recorded on a machine-readable answer sheet. (It should be noted that the testing occupies a relatively small part of the teaching period, and the computer application need not even be revealed to the children.)

Application

1. The teacher fills the early arithmetic periods with meaningful experiences in addition, presenting the facts, and motivating; and then gives a 5 minute test.

2. After about 5 testings, the computer produces a unique learning curve, together with limits, for each pupil.

3. After each succeeding testing, the computer will (a) print out the score, (b) test the score to see if it falls within the limits, (c) print out a message if the score is below the lower limit, and (d) print out a message if it is above the upper limit and go on to generate a new learning curve for that individual.

4. For the pupils remaining within their limits, no special action by the teacher would be taken; the pupils could carry on with regular practice material.

5. For the ones who fall below their own lower limit, since they were apparently able to do better, special remedial action would be taken. (See A in Figure 4.)

6. For the ones who rise above previously developed limits, the teacher would take special action to promote the insight displayed and would look for still better performance. (See B in Figure 4.)

This application would adjust demonstrated ability to a maximum, without reference to intelligence level.

Teacher involvement can be held at a maximum by adjusting the stochastic limits so that the number of children presented for special :atment will just fill her teaching time.

In general, the bulk of the children will proceed without special attention. Pupils falling back will receive remedial teaching. Pupils showing high ability will be inspired to even greater effort. And, it is to be hoped, all pupils will proceed to their individual maximums.

SUMMARY

Certain classroom situations involving cognitive acquistion, when tested at equally spaced time intervals, result in a graph that may be considered a non-stationary time series. For each individual, a computer analysis of succeeding scores can establish a unique learning curve with specified stochastic limits. The teacher can make use of computer print-outs (a) to allow most of the children to proceed with regular materials, (b) to adjust the performance of pupils who fall back of their previously demonstrated ability, and (c) to establish new horizons for those who exceed their previously established curve of learning.

This procedure is submitted as constituting only a small part of humanizing education; the whole process involves much more than maximum individual attainment of rote and similar learning.

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