## MEASURES OF CLASSROOM PERFORMANCE

MARILYN A. COHEN
N. DALE GENTRY
WILLIAM J. HULTEN
GRANT L. MARTIN

The purpose of this chapter is to explain how a student's response rate can be used to evaluate various dimensions of classroom performance. Rate as a basic measure of performance was originally suggested by B. F. Skinner (1953)[1] and applied in education by O. R. Lindsley.[2] Rate is defined by Webster (Third International Edition) as "quantity, amount, or degree of something measured per unit of something else . . . ." as in the rate of pay per month or rate of speed per minute. However, the reader can better understand the dimensions discussed in this chapter if he is aware of the basic components of "precision teaching" where rate is defined as movement cycles or responses divided by time.

There are many popular misconceptions about precision teaching. It is important to realize that precision teaching is not just one more method of teaching. It is a rapidly growing set of procedures with which the teacher can plan, carry out, and analyze the application of any particular teaching method or technique. A precision teacher believes very strongly that each child is unique. Thus, all the teacher's endeavors are attempts to provide for truly individualized instruction including only activities suited to the student's ability. A precision teacher accepts responsibility for his students' success in learning. The only evidence he has that his teaching is effective is the performance of his students. For this reason, the measurement of that performance is a critical part of the process.

[1]Many authors have suggested that rate is a useful measure of performance (Bijou, et al., 1968; Ferster & Perrott, 1968; and Skinner, 1961, 1966, 1968).

[2]Classroom application of rate has been elaborated by Haughton (1969) and by Kunzelmann, Cohen, Hulten, Martin and Mingo (1970).



Until now, teachers have not had adequate analytical tools to measure performance accurately, completely, and continuously. Traditionally, teachers have not been aware of the *various* and *numerous* events or conditions in the classroom which profoundly affect the quality and efficiency of the student's learning. Furthermore, performance has been evaluated at infrequent intervals. A teacher must know whether his strategy is effective day by day, not after a student has perhaps suffered from it for 6 weeks, 1 quarter, or even a semester. Next year's textbook will not help this year's student. What will help the teacher make better decisions are daily measurements of the student's performance. These data are less vulnerable to error than traditional hunches, "guesstimates," or inferential judgments.

If we are to know that learning has taken place, we must have some visible evidence of it. Otherwise, we are merely inferring, guessing, and operating on subjective assumptions. We must specify exactly what changes in performance a student will display as a result of learning. What exactly will he be doing? It is not enough to specify merely what the student will "know" at the end of a course of instruction; it is necessary to indicate what he will be able to ***do***, since only observable changes in behavior can constitute evidence that learning has taken place. Rather than specifying that the student will "know subtraction," the instructor must indicate exactly the types of problems the pupil will be able to work, with what degree of accuracy, under what conditions, and so forth. What he will be doing depends heavily on what he can do before he gets to the classroom. What are his entering competencies or behaviors? The teacher who knows what a student can do now, and what it is that he wants the student to do after a course of instruction, is ready to begin implementing a program for that student. He will need to have feasible methods of observing, that is measuring, the student's performance, and he will need to analyze those data so as to make better predictions about the usefulness of his teaching methods. Precision teaching provides a set of tools with which to accurately and continuously measure the progress of a student as well as to determine what conditions influenced that progress.

There are four basic components in precision teaching. First, there is a careful pinpointing of educational objectives which specify the behavior the student is to acquire (or modify) as a result of learning. The characteristics of this behavior must be a) that it contains movement; b) that the child can control it; and c) that it is repeatable (has a definable beginning and end). A unit of behavior which meets these criteria is called a *movement cycle.* Examples of movement cycles presented later in this chapter are *write letters, write numbers, say words, talk-outs,* and *out-of-seats.*

The next component of precision teaching is the determination of the precise lesson plan to insure consistent and accurate arrangement of teaching conditions. This method of planning allows for changing both instructional and motivational procedures. Having accurately specified the teaching plan, a teacher is later able to determine which components were functional for any given student.

The third component is the daily charting of student performance to provide the student and teacher with a visual display of the effectiveness of the teaching plan.

The specific chart used in precision teaching to display students' daily performance is called a 6-cycle semi-logarithmic chart. A recent issue of **CHANGING TIMES** summarized the advantages of semi-logarithmic or ratio chart paper:

> *You have probably noticed graphs that are drawn on peculiar-looking graph paper. The vertical scale doesn't look quite right. The units start large at the bottom and get smaller as they go up. This odd paper, sometimes called ratio paper, uses a vertical logarithmic scale. It is better than the ordinary kind for certain purposes. Understand it and you can learn a lot more from the graphs you see. For practical purposes, the difference between standard arithmetic chart paper and semi-log paper is that semi-log paper best shows the rate or percent of change.* [p. 34]



The analysis of data is the fourth component of precision teaching. The balance of this chapter describes the application of these analysis techniques.

## RATE AS THE DEPENDENT MEASURE OF CLASSROOM PERFORMANCE

The rate at which events occur is an extremely important consideration in human affairs. In health, we are concerned about blood pressure or rate of abnormal cell growth. Financially, we watch with concern the rate at which we earn money, spend money, and pay interest; economists carefully study the rate at which our economy expands. The rate of occurrence of disasters such as automobile accidents, fires, and floods is of great concern to those affected.

Similarly, the rate at which certain behaviors occur has important implications for educators and psychologists. Suppose, for example, that an individual has a high rate of hitting other people, of stealing money, or of having automobile accidents. If allowed to continue unabated, a high rate of these behaviors may produce even more drastic personal and social consequences. However, if the rate of occurrence decreases, both the individual and his society may benefit. Suppose, on the other hand, that a person has an extremely low rate of reading signs, putting on clothing, or communicating with peers and supervisors. In order to make a satisfactory life adjustment, the individual must increase his rate of these behaviors.

Briefly, *speed,* or rate, of performance is an important behavioral measurement. This is not to imply that the rate of all behaviors should increase. It will be desirable to accelerate the speed, or rate, of some behaviors. It will be desirable to decrease the rate of others and to maintain the rate of still others at their current level.

To determine rate or speed of performance is relatively simple. One simply counts the number of times a given event occurs and notes the length of his counting time. He then divides the count by the time to find rate. It is useful to use a common unit of time so that

data from different sources will be comparable. Movement-per-minute has proved to be a convenient unit, and its use is fairly widespread. For example, reading teachers have long used words-per-minute as a measure of oral reading ability.

The following example illustrates, in an extreme case, the importance of speed as a performance measure. During an initial teaching phase, a 14½-year-old boy, whom we shall call Toby, was instructed to write the correct answers in a programmed reading text. On the first day, Toby wrote more than one correct answer per minute, but on successive days his rate dropped to 0.0 (see Figure 1). The teacher initiated a plan in which Toby earned certain classroom privileges for writing correct answers in the reading text. Under these conditions Toby's average (median) rate rose to about four responses per minute.

In another example, a teacher asked Jack to write the answers to math problems. During 1 week he wrote a median of .1 answers per minute or one answer every 10 minutes (Figure 2). Under a condition where Jack earned 1 minute of free time for every 15 correct answers, his rate rose to an average of two per minute. When Jack and the teacher agreed that doodling would be counted as free time,

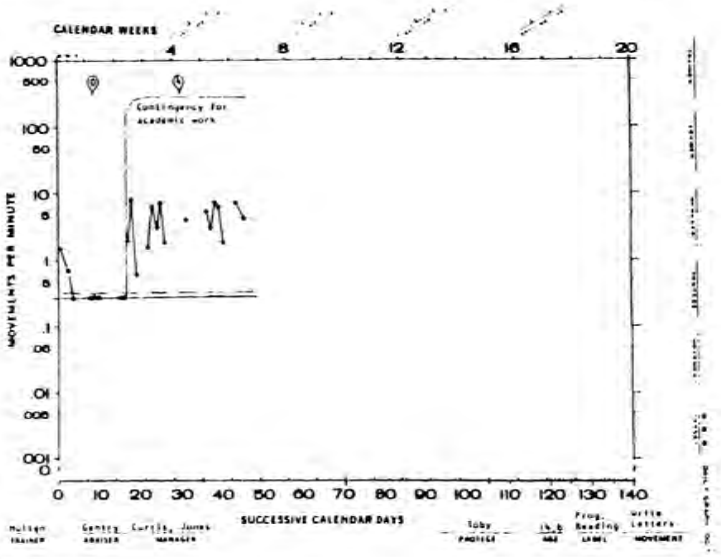



FIGURE 1



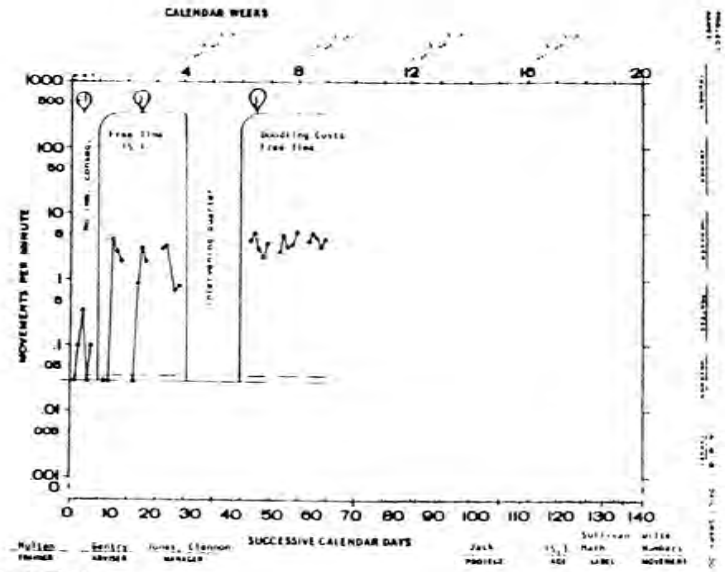



FIGURE 2

his average rate of doing correct math problems increased to three answers per minute. In this example a measure of speed of performance clearly differentiates Jack's performance under different conditions. This is in contrast to a less precise approach, where differences might not even be noticed, far less accounted for and ultimately controlled.

The same approach has been applied to social behavior. A teacher was concerned about Kirk's tendency to physically harass other students. The teacher pinpointed Kirk's physically aggressive acts: hitting, pinching, scratching, or poking others. She counted these behaviors during lunch hour for 2 weeks and found that Kirk engaged in them slightly more than once every 10 minutes (Figure 3). Kirk's high rate of harrassment was clearly a classroom problem whose seriousness was not fully apparent until rate data were taken. Rate proved to be a sensitive measure of this social behavior.

The teacher began a program whereby she awarded Kirk points to be exchanged for free time when he did not engage in the pinpointed behaviors. As Figure 3 shows, Kirk dropped to a median rate of 0.0

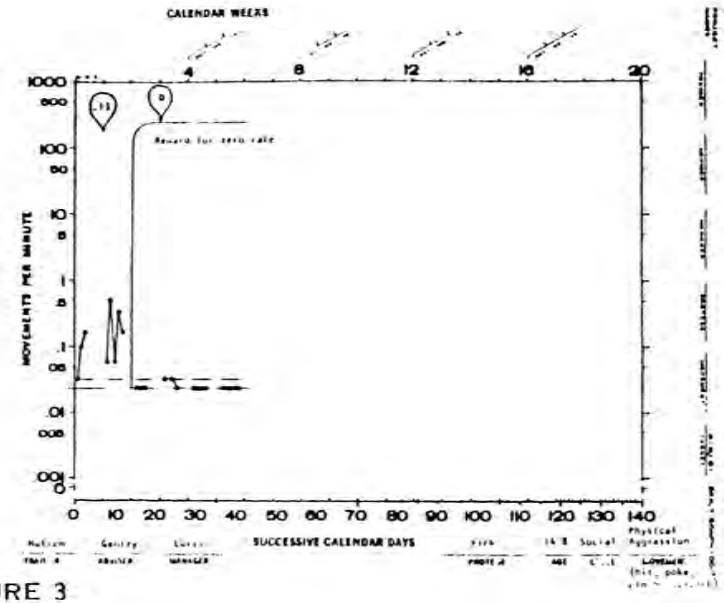



FIGURE 3

physically aggressive behaviors. Educators should be concerned about more than simply how fast an individual can perform a given academic task. Social behavior is an important teaching responsibility, too.

There are many ways in which rate or movements per minute, when displayed on the 6-cycle semi-log chart, can be used to view and evaluate classroom performance. The ways to be discussed in this chapter are *accuracy* of the student's work, as well as *endurance* of performance level, direction of progress or *improvement*, and *outcome* or prediction of what the student will achieve.

## ACCURACY

Rate, as we have discussed it earlier, basically means speed—how fast something is happening. Critics often try to discount the importance of rate by saying that it isn't speed that educators are interested in measuring, but accuracy. In other words, *quality*, not quantity, is most important. On consideration, however, one sees that neither dimension of performance can be discounted. If quality alone is emphasized, the result may be a group of extremely accurate



individuals who insure their accuracy by performing very slowly. On the other hand, if too great an emphasis is placed on quantity with no attention to quality, the group may work at high speed with a great many errors.

Accuracy is generally expressed as percent correct. It is an expression of the relationship between right and wrong answers, and does not reflect the student's speed of work. However, there is a way to retain the benefits of both the quantity (speed) and quality (accuracy) statements. After considering the relationship between correct performance rate, and error performance rate, one can make a statement of quality (accuracy). Figure 4 is an example of how this can be done. In this data simulation, the child performing oral reading tasks reads three

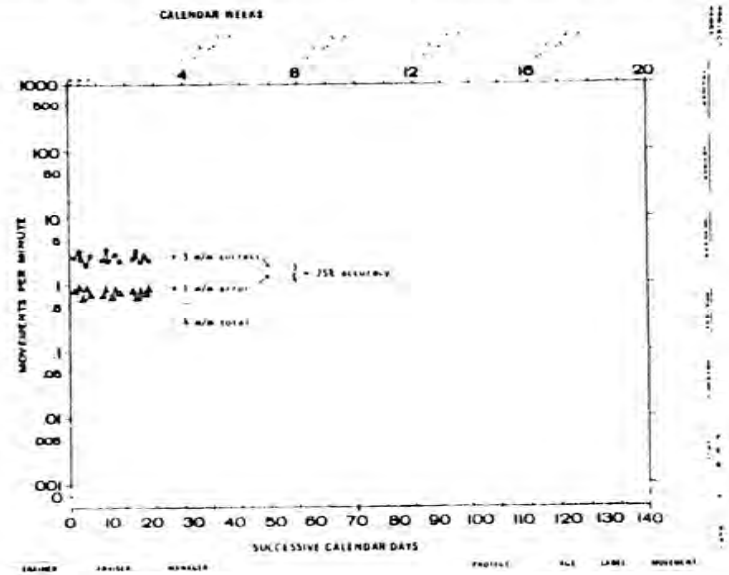



FIGURE 4

sentences per minute correctly and one per minute incorrectly. By considering the relationship between correct performance rate and error performance rate a teacher can determine the student's accuracy. This relationship can be computed simply by adding the correct rate to the error rate and dividing the sum into the correct rate as shown in Figure 4. Consider another performance by the same child.

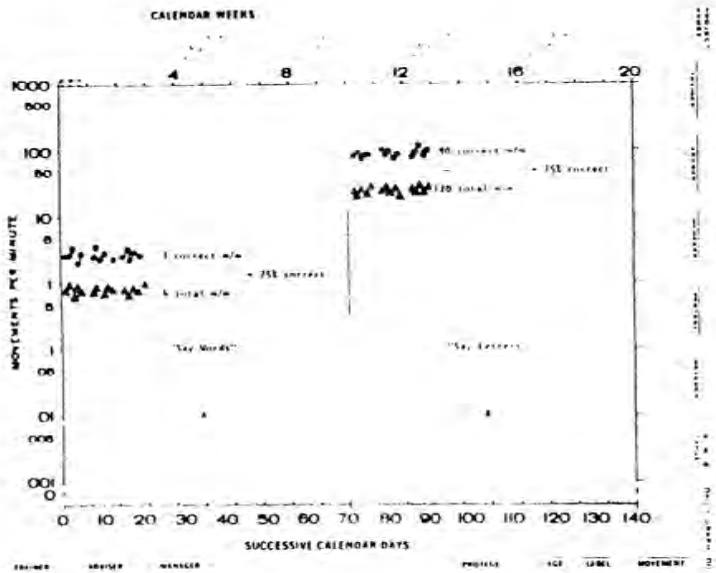



FIGURE 5

Figure 5, section B, shows that he can correctly say 90 letters of the alphabet per minute with approximately 30 errors per minute. The child's *say letter* rate is 30 times greater than his *read sentence* rate (see Figure 4) but the accuracy is exactly the same. A major advantage of using semi-log or ratio chart paper is demonstrated here. Since the chart is on a ratio scale and since accuracy is a ratio statement, accuracy is directly readable from the chart, no matter where the data fall on it. Note in Sections A and B of Figure 5 that the distance between correct and error performance rates in each instance is exactly the same. Since the accuracy (percentage) is the same, the distance will remain the same, and provides a direct *measure* of the accuracy.

Accuracy statements alone, however, can mask the different ways changes in accuracy occur. Figure 6 depicts three different kinds of accuracy changes. The upper half of Figure 6 shows correct and error performance rates and changes in each. The lower half of



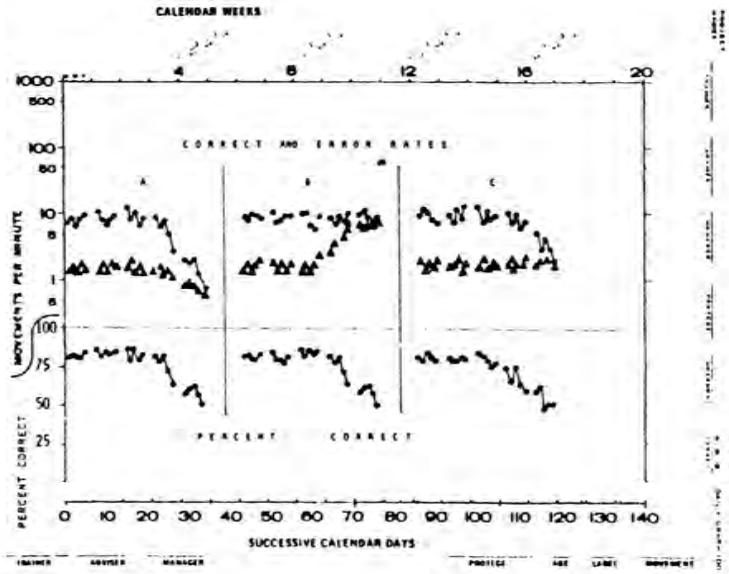



FIGURE 6

Figure 6 shows three percent correct charts for the performance indicated directly above each. In Section A of Figure 6, for the first 3 weeks of data, the individual's performance rate was approximately eight per minute correct and two per minute wrong. Data directly below this section show 3 weeks of 80% accuracy: eight per minute right and two per minute wrong for a total of 10 per minute, of which eight per minute were correct. At the end of the third week in Section A, the correct performance and error performance began to decelerate. The correct performances decelerated more rapidly than the error performances. After approximately 2 weeks, correct performance met error performance at one per minute—that is, an accuracy of 50%. The corresponding chart below shows this drop from 80% accuracy to 50% accuracy.

In Section B, the data from the first 3 weeks of performance are the same as for the first 3 weeks of performance in Section A. However, the last 2 weeks of Section B indicate that the individual's correct performance continued at exactly the same rate while the

error performance accelerated and met the correct performance at eight per minute. This is a significantly different change in performance from that in Section A, but the corresponding accuracy chart below indicates exactly the same change as in Section A.

Section C shows another kind of performance change. In the first 3 weeks, performance was constant at eight per minute correct and two per minute wrong. But at the end of this time, the correct performance began to decelerate while the errors remained stable. At the end of 5 weeks, correct performance dropped until it met error performance, yielding an accuracy of 50%. The lower charts showing *accuracy alone* reflect exactly the same kind of changes for performance in each of the three sections. However, by indicating both correct and error rates it is possible to observe differential rate changes while retaining the ability to discriminate accuracy changes.

To summarize: one can directly determine accuracy changes from changes in correct and error rates; at the same time, one can see changes in the performance rates. Such a measure is indispensable for the teacher since the changes are the only evidence he has that his teaching strategies are effective or ineffective.

## ENDURANCE

Speed and accuracy are important dimensions of the measurement of behavior. However, it is also desirable to know whether an individual can maintain his performance over a period of time. This measurement dimension can be called endurance. Two aspects of endurance will be discussed here.[3]

[3] A knowledge of the term "record floor" will enable the reader to better understand the ensuing discussion and accompanying charts. The record floor is the point on the graph at which one occurrence of a behavior is plotted. One divided by the length of time observed is the lowest point, other than zero, which can be plotted, and is referred to as the record floor. For example, suppose a pupil completes one correct answer in a 20-minute session. One divided by 20 is .05. The figure 1 is used to signify a single occurrence of the behavior, since a zero or fractional occurrence would be a contradiction in terms. The record floor, in this instance, is .05 and signifies a recording time of 20 minutes. A charting convention is to draw a solid line from Monday through Friday to indicate the location of the record floor. An accompanying convention is to locate the zero line directly beneath the record floor.



What is the effect on performance of altering the length of time in which an individual performs?

What is the effect of changing the length of time one observes an individual perform?

The following example illustrates the effect of altering the length of time an individual works. Robby's teacher compared Robby's *write numeral* rate for addition and subtraction facts when he worked for different lengths of time (Figure 7). Robby completed four 1-minute samples each day. The median rate on these samples was 30 correct

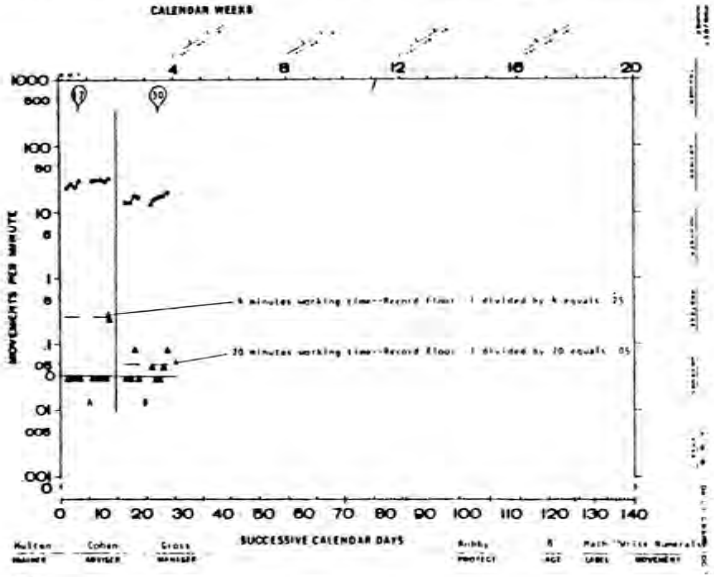



FIGURE 7

numerals per minute, as shown in Condition A. He also worked on identical problems for a 20-minute session each day. His median performance here was about 17 correct numerals per minute, nearly half his rate on the four 1-minute samples.

In another instance, Dennis' parents wanted to improve his knowledge of basic addition facts. They determined that he could write answers to easy problems (sums from 0 to 2) at an average rate of

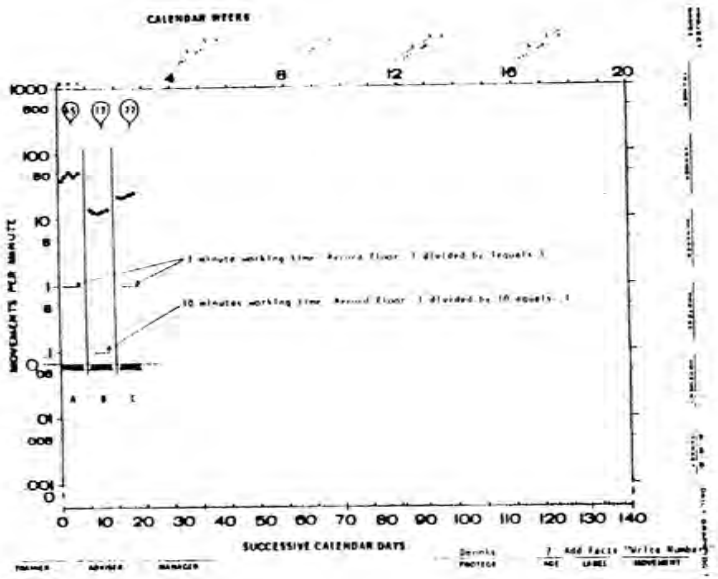



FIGURE 8

45 correct answers per minute for 1 minute as shown in Condition A of Figure 8. The parents decided to aim for 45 answers per minute on more difficult problems (sums to 18) also. They then gave him a worksheet with all the problems having sums to 18. This took approximately 10 minutes each time; his median rate was 12 per minute, as shown in Condition B of Figure 8. However, the length of time Dennis worked on the easy problems was 1 minute, compared to 10 minutes on the difficult problems. When 1-minute samples of the difficult problems were administered, Dennis performed at an average rate of 22 answers per minute, nearly double his rate on the 10-minute session.

Several observations may be made about varying lengths of performance. Obviously, performance rates are likely to vary with the length of time the pupil performs. It is probably that there is a systematic change for any given individual with varying amounts of time.

One may also ask whether children can be expected to improve on the endurance dimension. Can they gradually work longer and still maintain speed and accuracy? Several factors will influence the answer to this question. One consideration is proficiency. As the child increases his performance rates to a mastery level, he may be able to work longer with less decrease in performance quality. Factors which affect motivation are also likely to influence endurance significantly. There is much evidence to show the beneficial effects of contingent reinforcement on students' performance rates. It would be desirable to know also how changes in length of working time affect adult performance rates, since adults presumably have developed some endurance.

A very significant issue is how endurance affects a pupil's academic improvement. Does the pupil who can work for longer periods of time increase his performance rates and accuracy more rapidly than a pupil who can work only for brief periods of time? What is an optimal work period for a given pupil? This determination may be made by systematically altering the length of time pupils work and noting the effect on their subsequent performance.

The second issue is the effect of changing the length of time one observes and records performance. This is important when considering social behaviors which may occur throughout the entire day. Suppose a pupil hits other people. A sample recording period of 30 minutes per day might yield a 0.0 rate of hitting, but hitting might occur at other times during the day. Increasing the length of the recording period to the entire day would result in a more sensitive measure of the actual incidence of hitting.

Let us consider an actual example. David's teachers recorded his rate of talking-out during 15 minutes of class time. During the first 2 weeks, David talked-out a median of six times in 10 minutes, as shown in Condition A of Figure 9, and increased near the end of that time to almost two times per minute. In Condition B, David recorded his own talk-outs on a sheet of paper for 20 minutes each day. The result was a decrease to a 0.0 average rate of talking-out. However, this zero rate held for only 20 minutes per day. By

increasing the recording period from 20 to 30, to 40, and finally to 60 minutes, it became evident that David could refrain from talking-out for at least an hour. His endurance had been demonstrated.

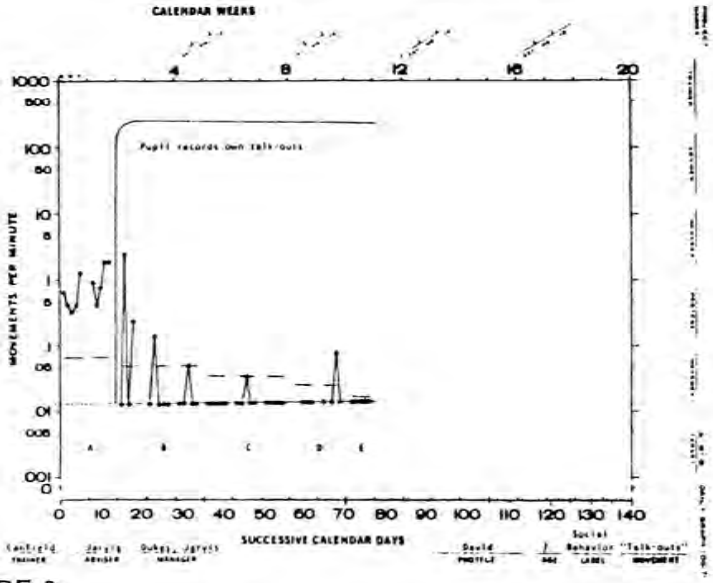



FIGURE 9

In summary, the dimension of endurance has at least two relevant aspects: the length of time a pupil is asked to perform, and the length of time one observes performance. Performance rate is likely to vary with the length of time during which performance occurs. Endurance can probably be built by altering a pupil's performance level, by altering the consequences of his performance, or by gradually lengthening the time he performs. Endurance can be increased also by extending the length of time during which behavior is recorded.

## IMPROVEMENT

The dimension of measurement called improvement provides the teacher and student with a description of how current performance compares with past performance. Whether the performance



improves or not, this measurement is called "improvement," just as a "measure of success" often reflects failure to succeed. In this section, we will discuss the definition of improvement, the importance of considering it as a dimension of classroom measurement, and methods of calculating it.

## DEFINITION OF TREND OR LINE OF PROGRESS

The term improvement implies that analysis is being made on two dimensions. First, there is measurement of the present level of the behavior in question—the speed and accuracy at which the behavior is occurring. The second level of analysis compares the present rate of performance to past performance. A statement of improvement means that a student is doing better now than he has done in the past. Precision teaching makes this comparative statement in terms of "movement cycles per minute per week," or "trend." Trend can also be referred to as a line of progress since the trend line reflects the general directions of the student's progress.

There are three possible directions for a given trend line. First, a movement cycle can be accelerating or increasing. Second, it can be maintaining or remaining the same. Third, it can be decelerating or declining. This statement of the exact trend or line of progress merely serves to quantify the amount of increase or decrease. When a statement of direction is made using the semi-log graph paper, the quantification is in terms of a multiplying or dividing factor.[4]

[4] "Semi-log" means that one of the two scales on the graph (the vertical one) is logarithmic, while the other (the horizontal one) is not. "Logarithmic" means that the horizontal lines are spaced in accordance with the logarithms of the numbers that you see assigned to those lines. Remember your algebra? You multiply by adding logarithms and divide by subtracting them. Moving up and down the log scale, you are really multiplying or dividing, not adding or subtracting, as you are on regular graph paper. (**CHANGING TIMES**, Nov. 1970, p. 34)

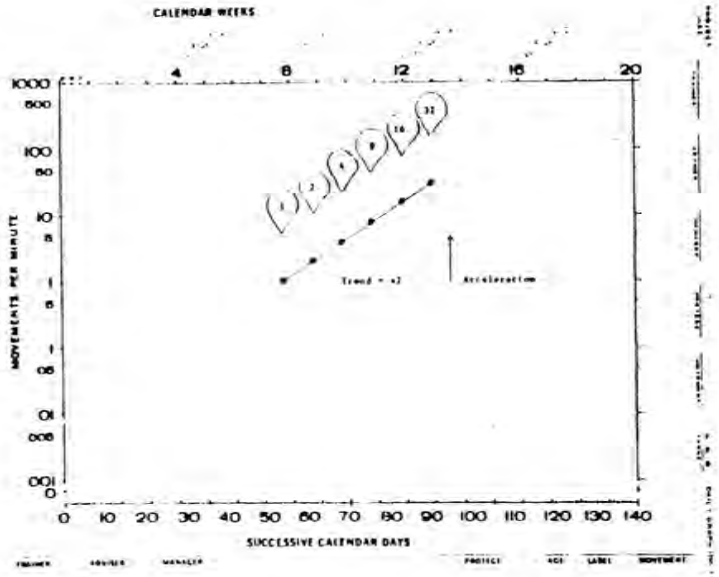



FIGURE 10

For example, in Figure 10 a section of the chart shows a x2 [read: times two] trend line. This illustrates that with a x2 trend the average performance during a week will be twice the average performance of the preceding week. During the first week in the example, the average response rate was one movement per minute. If a x2 trend existed, one would expect to find the student performing at two responses per minute the following week. If the general trend of performance continued in a similar fashion over the succeeding weeks, the student would then be performing, as the figure demonstrates, at levels of 4, 8, 16, and 32 movements per minute. Trend is, thus, defined as a data change in terms of movements per minute per week.

A deceleration trend is calculated in the same fashion as an acceleration; it simply happens to be moving in the opposite direction. A deceleration trend means that the rate is dividing each week. Figure 11 shows an example of a deceleration trend. The first week the average performance was 16 movements per minute. If a ÷ 2 [read:



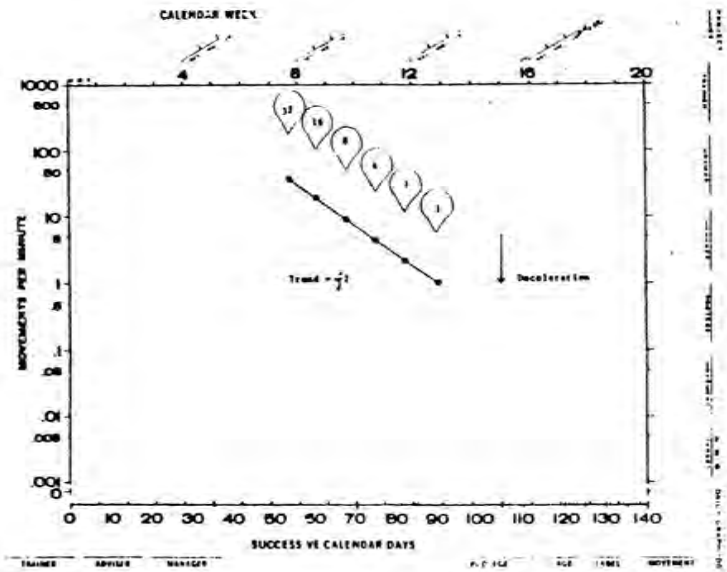



FIGURE 11

divided by two] trend existed, the second week's performance would be half that of the first week (16 ÷ 2 = 8): 8 movements per minute per week, then 4, 2, and 1 movements per minute in the succeeding weeks.

If the performance of a student is simply maintaining or staying the same, it is called a x1. This means that each week the behavior is the same as it was the preceding week; it is not increasing or decreasing. This trend would resemble the figure shown in Figure 12.

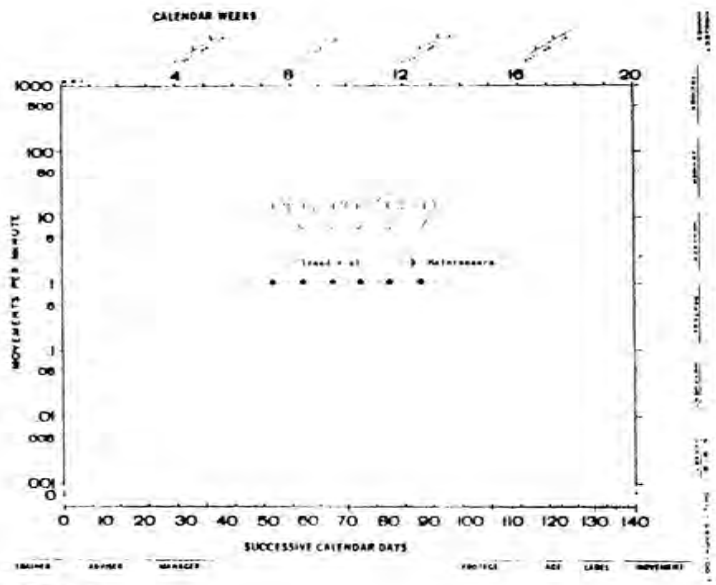
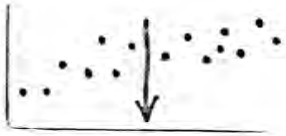



FIGURE 12

## CALCULATION OF TREND

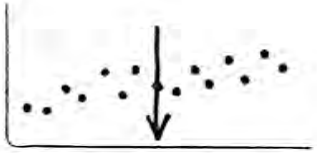
A trend line should approximate as closely as possible the direction of a given amount of data. The following steps in determining the trend line seem to be the most direct and beneficial to precision teachers at the present time. Changes in all analysis procedures, including trend, will be made when and where appropriate.

1) Divide the phase into two equal parts. That is, count the total number of data plots for the phase and draw a line dividing the plots in half.
   a) If there is an equal number of plots, such as 14, the line would be drawn between the seventh and eighth plots.

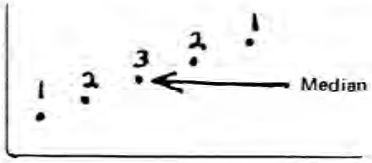




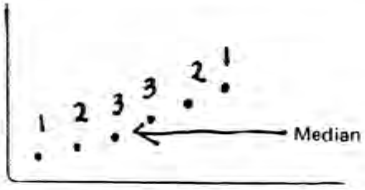
   b) If there is an unequal number of data plots, such as 15, the line would be drawn through the eighth plot and this plot would not be used in any further trend calculations.



2) Find the mid-middle for each half of the data. The mid-middle is the median value of the data placed in the horizontal (chronological) middle of each half of the data.
   a) The median is the middle score in a range of plots. If there is an unequal number of plots, such as 5, in the first half of the data, the median would be the middle or third plot down from the highest plot.

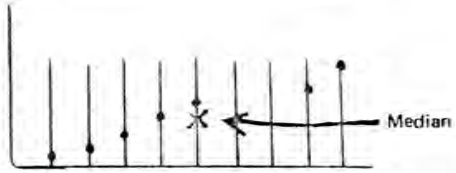



   b) If a sequence of data contains an equal number of plots, such as 6, the median would be halfway between the third and fourth plots in rank order.

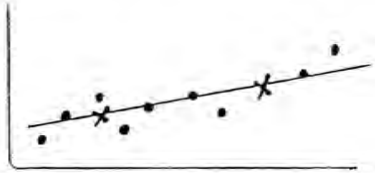



   c) Determine the middle of the data by counting the total number of days, including weekends, which are included. Remember to count all days, even if there were no data collected on some days. Then determine the "mid-middle" value by placing an x on the spot where the

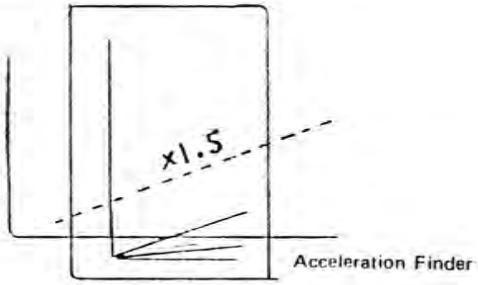
median and middle values intersect.




3) After indicating the mid-middle values for each half of the phase, simply connect the two points with a line.



4) The value of the trend line is then found by using a clear plastic template or acceleration finder, such as the one available from Behavior Research Company. The acceleration finder has a number of trend lines on it; the value of your line is found by determining which slope fits your line best and reading off the appropriate value.




## EXAMPLES OF THE USE OF TREND ANALYSIS

The following section describes three students' performances in three academic areas. Each chart illustrates the benefits of looking for a trend or line of progress in determining the total effect of teaching or management changes.



**Example 1.** The chart in Figure 13 describes a math program in which the movement cycle was ***writing letters and numbers.*** The first phase shows that the student was working at a median rate of seven correct movement cycles per minute. (The median error rate was zero and remained zero for the duration of the period, therefore it will not be discussed in this example.) After about 3 weeks during which there was no increase in correct rate, a

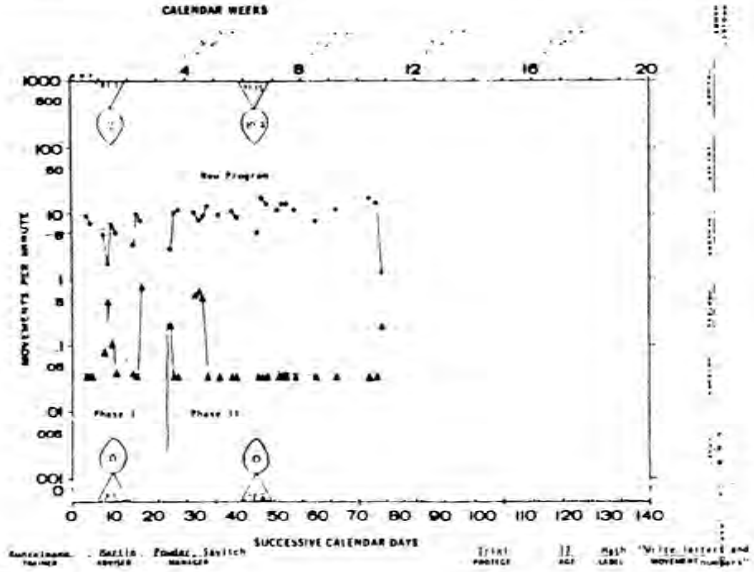



FIGURE 13

teaching change was made. This is illustrated in Phase 2 on the chart. The change in the teaching plan was a change in material. The teacher began using a set of individual math assignment cards rather than the programmed text used in Phase 1. The nature of the problems remained constant. However, the program format did vary.

What is evident, then, is a median of 7 responses a minute in Phase 1 and a median of 10.2 responses a minute in Phase 2. Apparently, there is a difference in the performance. The first conclusion that one might draw is that the teaching change was effective and that

the new material was allowing the student to work at a higher rate.

It is at this point that the line of progress for the two phases should be described. Notice that the trend line or line of progress has been drawn for each phase of the data with its corresponding value entered above the data in a large triangle. The line of progress for the first phase was x1.1. This was an accelerating trend as indicated by the times factor based on the 3 weeks of data. A trend of x1.1 means that the student was increasing her rate of doing math problems from approximately eight responses a minute the first week to approximately nine responses the third week.

Besides describing data that have already occurred, a line of progress allows the teacher to make a prediction about what will happen to the performance if the conditions remain relatively constant. Using a x1.1 trend as the best prediction of what will happen over the next 8 weeks, the teacher predicted that during the last 8 weeks of the study the student would be responding at about 17 movements a minute. This prediction was made based on the trend statement or line of progress found during the first phase. A question, then, is whether the initiation of the new materials significantly altered the line of progress for the second phase.

When the data for Phase 2 are analyzed, they show that an almost identical or x1.1 line of progress was maintained during the entire second phase. In fact, by the eighth week of the study, the student was performing at a median of 17 movements a minute.

The conclusion reached on the basis of these data was that the child was increasing her rate of math responses during the initial phase of the project, but that the addition of the new material did not significantly alter the rate at which she was improving. Using the line of progress as an additional component of analysis, the teacher observed no significant change in the behavior. Rather, the responses continued to improve in a consistent and predictable pattern. On the other hand, if only the medians of the two phases had been compared with 7 responses a minute contrasted with 10.2 responses a minute, the teacher



would have falsely concluded that the change of program significantly increased the rate of math responses.

**Example 2.** A second example concerns a teenage boy's spelling. The movement cycle under consideration was ***writing letters.*** Bill's performance is described in the graph presented in Figure 14. The first phase of the data in Figure 14 shows the student working at

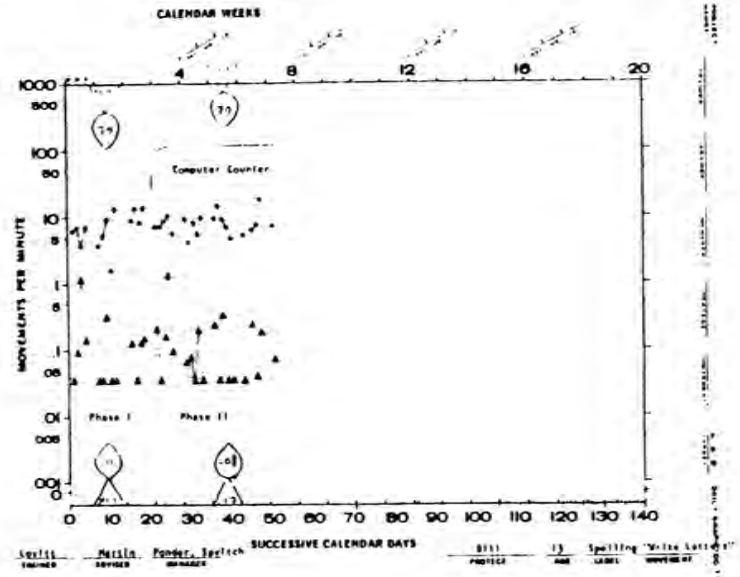



**FIGURE 14**

a median correct rate of 7 responses a minute. Also during this initial phase, Bill was receiving 1 minute of free time for every 10 correct letters completed. He had the opportunity to take free time whenever he chose. The points were accumulated on an event sheet on the student's desk and were counted and recorded by the teacher. The teacher corrected the student's work, and based on the number of correct answers, she wrote down the total number of points earned on the event sheet.

The second phase began when a rather sophisticated counting device was used to accumulate the points the student had earned in his work. Instead of having the teacher determine the points, the machine was set so that the student could count his own responses

by pressing a button for each correct response. The machine was preset so that the counter would be activated after every 25 presses of the button. The ratio of 25 responses to one point was an additional change for this phase. The teacher's idea was that the automatic counter might prove to be more fascinating to the student and he would therefore work harder to activate the points on the machine. The median response rate for this second phase was 7 responses a minute, which is identical to the median for correct responses in the first phase.

If the teacher had assumed that the median comparison was sufficient to decide the effectiveness of the teaching procedure, he might have concluded that there were really no significant differences between the phases and that the automatic counter was of no significant advantage *or* disadvantage. Using a line of progress analysis, however, provided an additional source of information to evaluate the efficiency of this change.

The trend line for the first phase was x1.4 for the correct responses. This means that the student was accelerating at a fairly rapid rate and that if conditions had remained the same as in Phase 1, he would have continued to do quite well in making correct responses. However, when the line of progress was drawn for Phase 2, it became evident that the trend was a ÷ 1.1. The student was decreasing in terms of his correct response rates. With the information from the line of progress one can make a more sensitive decision regarding the efficacy of the procedure. Although the medians were identical, the use of the automatic counter seemed to have the effect of depressing the correct rate. It should be pointed out, however, that a ratio change from 10 responses to equal one point in the first phase, to 25 responses to equal the one point in the second phase was an additional component of the teaching change. With only these data available, it is not possible to draw a firm conclusion that either the change in arrangement or the use of the counter most significantly affected the student's performance. Whatever the reason, the performance was adversely affected.

The error analysis for Bill shows that his median error rate in Phase 1 was .11, while in Phase 2 the median was .08. No really significant differences in median rate are attributable here. When a trend



analysis is made as in Figure 14, a trend of x1.1 in the first phase and a trend of ÷ 1.2 in the second phase is apparent. This decline of errors in the second phase may very possibly have accompanied the decline in correct rate, indicating that the student was generally slowing down his entire performance.

These data suggest that even though the average response rate between two phases may not appear to be different, there still may be a very significant difference in the line of progress. In the case presented here, the teacher subsequently made the decision to remove the automatic counter since it did not seem to be as effective as he anticipated in either this subject or other subjects on which data were kept.

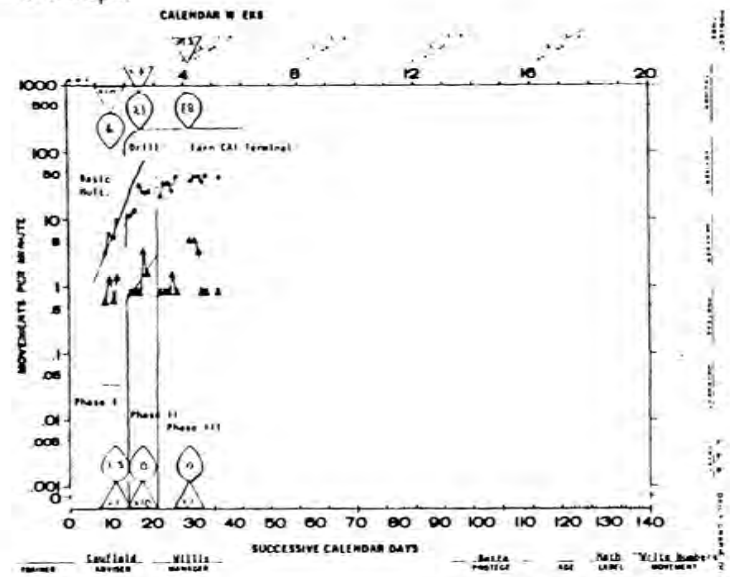



FIGURE 15

Example 3. Figure 15 shows data on a sixth-grade girl in a regular public school working on basic multiplication facts. During Phase 1 Bette was given basic multiplication fact sheets which she worked on for 30 minutes daily. The resulting data showed that she had a median response rate of 6 correct responses a minute with a line of improvement of x10.0, a rather significant trend.

In Phase 2 the teacher made up a program to give additional drill and practice in the area of basic multiplication facts. The teacher wanted to see if the use of a teacher-made program occurring prior to a 1-minute practice sample improved the acquisition of basic multiplication facts. The median for the second phase is 28 responses a minute with a trend of x4.0.

In the third phase, the student was placed on the following contingency: for every day she made 36 or more correct responses a minute, she could spend approximately 10 minutes at a computer-assisted instruction terminal located adjacent to the classroom. The data show a median of 38 responses a minute and a trend of x1.2 for correct responses. The correct response data shown in Figure 15 show three phases with a median going from 6, to 28, to 38 responses a minute. The interesting fact is that the line of progress deteriorates over the three phases. In Phase 1 it was x10.0. In Phase 2, when the teacher-made program was initiated, the trend was x4.0. When the computer was used as a reinforcer the line of progress was only x1.2. Here again there is evidence that, although the medians were significantly different, the trends became increasingly lower. The suggestion here is that the two phase changes utilizing the teacher-made program as an adjunctive drill exercise and the computer as a reinforcer may have slowed the student down rather than served to maintain the acceleration shown in Phase 1.

## SUMMARY

In the early development of continuous classroom measurement, most teachers looked only at the average or median differences between instructional change periods to determine the most effective procedures. If a student first averaged 5 responses per minute, then, following an instructional change, produced a rate of 10 responses per minute, the teacher may very well have concluded that the intervening teaching procedure was beneficial. The preceding three studies illustrated that such a conclusion is often not warranted unless the dimension of improvement in terms of trend or movement cycles per minute per week is also considered.



## OUTCOME

We have seen that rate can give us information which allows us to view different aspects of the individual's performance such as accuracy, endurance, and improvement.

One critical dimension of any measure of performance, however, is that of prediction. Predictive or probability statements are considered important for any discussion of a child's performance. Although an educator may be able to report that Johnny now works faster and more accurately and over longer periods of time and that he has shown improvement over his previous work, he may not feel totally satisfied with these measures of performance because in stating educational objectives for Johnny the important dimension of time needed to achieve the objectives has been left out. The curriculum guide for a district often gives some guidelines for the amount of time which should be allotted to achieving stated objectives. School administrators also have their views concerning time guidelines for certain educational goals. Preparing a child to enter another classroom within a school may impose further time limits for reaching objectives. The school board and the public, which includes concerned parents, may also impose their ideas about a "reasonable" amount of time to reach a desired goal.

How, then, does rate as a measure allow the educator to respond to the demands of his administrators and the public which he serves? Through an analysis of the data, he may calculate a trend statement. This trend statement allows the educator to determine the amount of improvement that has taken place in a child's performance when a specific teaching plan has been employed. The trend statement also provides another crucial piece of information, however. It enables the teacher to predict at what rate the child will continue to improve or to fail, given a like set of teaching conditions in the future.

The case of Tod serves to illustrate the aspect of predictability. The teacher, Miss Wong, was concerned about Tod's low rate of talking

to others. She decided to watch Tod during a 20-minute play period in the classroom each day. Tod was allowed to play with whatever toys he chose and to interact with the teacher or the children in the playroom during this play period. Before starting her daily observation of this particular 20-minute period, the teacher had not realized how very *infrequently* Tod was verbalizing (see Figure 16). Each

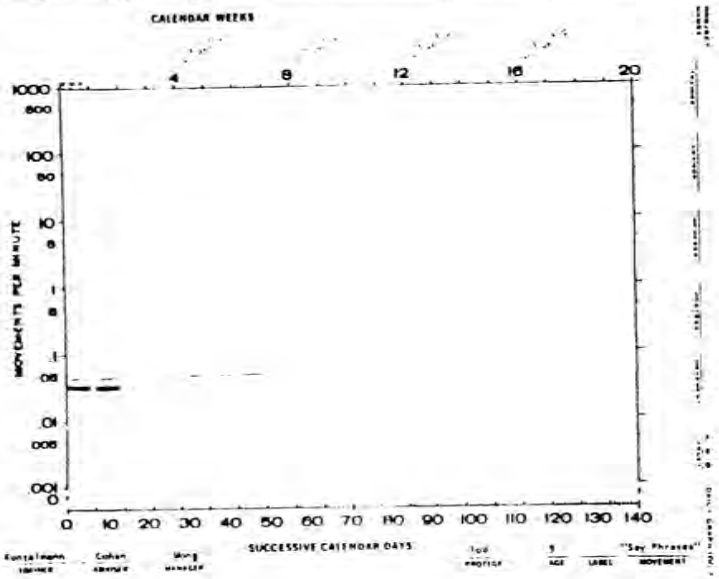



FIGURE 16

day of the 2-week observation period, the teacher recorded on her 6-cycle graph an 0.0 *say phrases* rate for Tod. Based upon the 2 weeks of data, what might this teacher have expected in the third week?

In order to predict what would happen in the third week, the teacher must find the best "fit line" or trend line for the 10 data plots which have been recorded. The best fit line will yield information not only about the progress a child has made up to the present time but also permits a prediction of his progress. The best fit line, or trend, in this example is a x1.0 (see Figure 17). As Tod had an 0.0 *say phrases* rate at this time, and the best fit line through these data



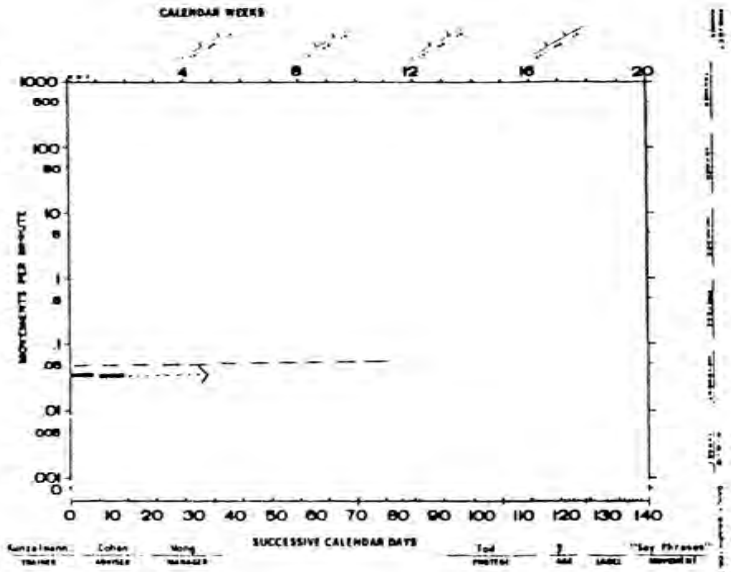



FIGURE 17

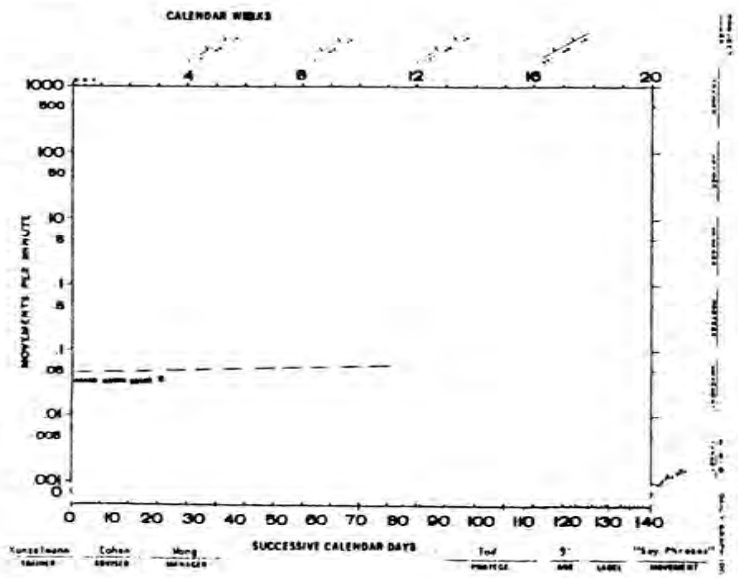



FIGURE 18

plots is a x1.0, the teacher predicted that unless some changes were made in the plans for Tod's play times, he would continue not talking to others in the third week. Since the teacher required more time to formulate her plan for a change, conditions remained the same during the third week. As she continued recording, she saw her prediction become a reality (see Figure 18).

During the third week the teacher decided upon a plan. She had observed that Tod frequently picked up certain objects (e.g., records) during the play period. He played only certain bands on each of the records and he repeatedly picked up the arm of the record player in order to play a particular band once more. Also, he left the playroom at least once during the play period each day to go to the bathroom. Since she knew from other data that Tod could talk, the teacher's plan was to utilize Tod's movements as opportunities for encouraging verbalization. Rather than allowing him to go about his activities unobtrusively, she decided to make a verbal requirement for each of Tod's movements. When Tod came over to take a record, the teacher placed her hand on the record and for the first two or three times each day, she prompted Tod to say: "I want record," or "I want record player." She physically prevented Tod from completing movements such as taking the records, putting the record on the record player, moving the arm on the record player, etc., until he had provided the necessary verbalization. Figure 19 indicates the change in Tod's verbalization.

In the first 10 days there was approximately a x1.6 increase. As more data were gathered, however, a definite leveling off was noted, as indicated by the straight line. (Figure 20) The trend for the entire 28 days of this condition thus indicated a less optimistic prediction for the future than had the first 6 days. The trend, a x1.1, would indicate that if this tactic were continued, a small increase in verbalization would be seen; however, the progress would be very slow.

At that rate, Tod was asking for each of the objects with which he wished to play; in the third week he began asking for the objects



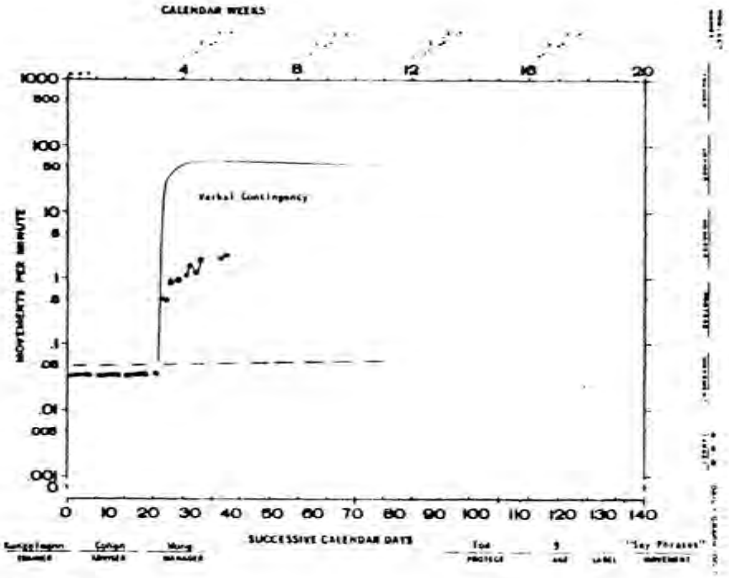



FIGURE 19

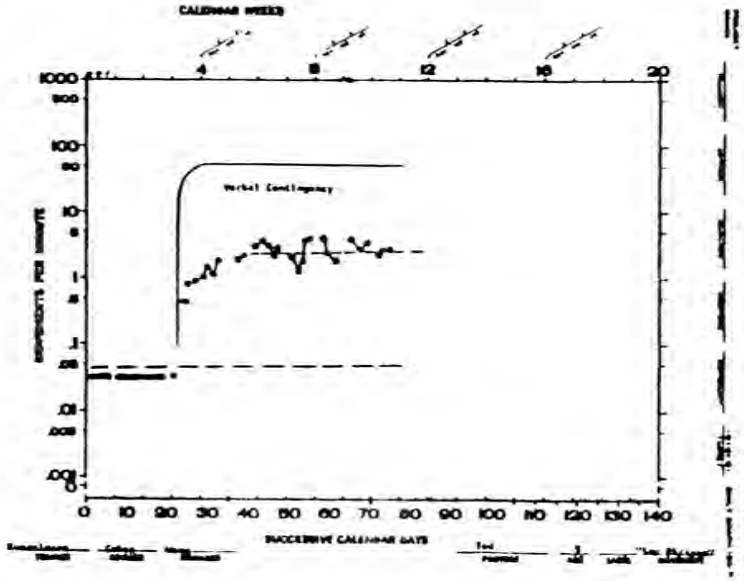



FIGURE 20

without being prompted by the teacher or being physically held each time. However, his verbalization throughout the entire 21 days did not extend beyond the basic requests. The data indicated that other teaching strategies would be necessary in order to bring about further increases in Tod's verbalization in the future.

Such a pattern might be referred to as a deceleration; the individual is slowing down in his movement forward. (Figure 21)

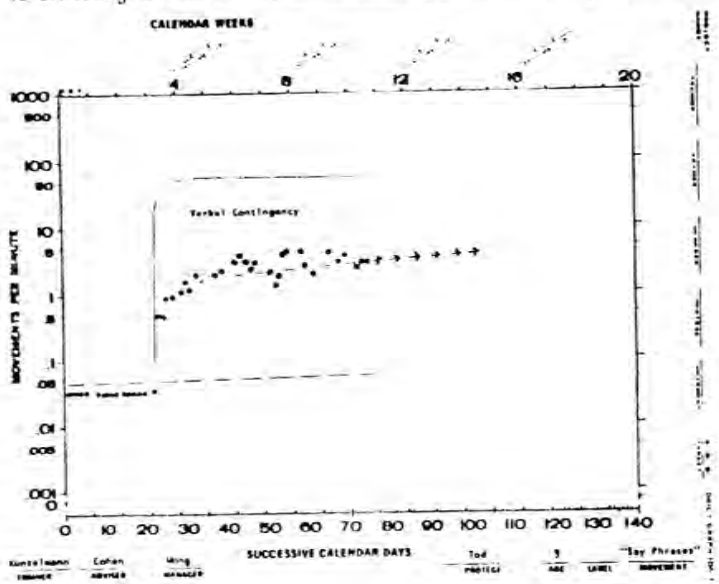



FIGURE 21

Turing to another example where the rate data prediction dimension has proved useful, let us consider the problem of 6-year-old Karla's whining. Other teachers reported finding Karla an "unpleasant" child with whom to work. Karla's present teacher pinpointed the problem as one of whining. She felt that if Karla were to stop her whining whenever she talked to the teacher or answered questions she would be a less difficult child. The teacher usually turned from Karla when she was whining and came to her only when she was using her "normal voice"; she continued this tactic and began recording the total



number of whines each day. After 7 days of recording, the teacher's data showed that Karla's whines were increasing at a rate of x1.6.

At this rate of increase, Karla would soon be whining approximately once every 10 minutes throughout her 200 minutes in the classroom. The teacher felt that an immediate change was necessary.

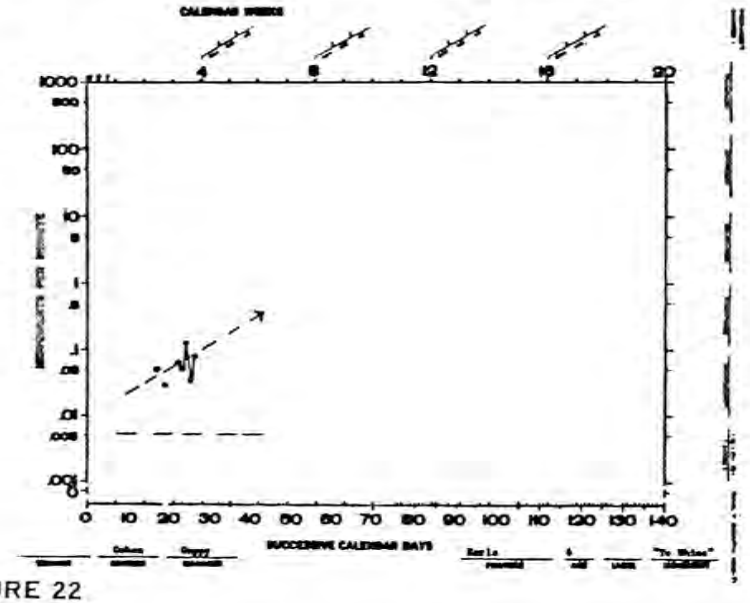



FIGURE 22

The teacher decided to use a countoon. A countoon is simply a picture sequence depicting the child engaging in his problem behavior, with a count column for the child to mark each time he has completed one movement cycle.[5] The teacher placed the countoon on Karla's desk and instructed her that each time she whined, she was to mark the countoon. The teacher then continued to keep data on Karla on her own separate data sheet. After 10 days, Karla still was whining; however, the data do show some change.

[5]For further information on countoons, see PRECISION TEACHING-AN INITIAL TRAINING SEQUENCE. Seattle: Special Child Publications, 1970.

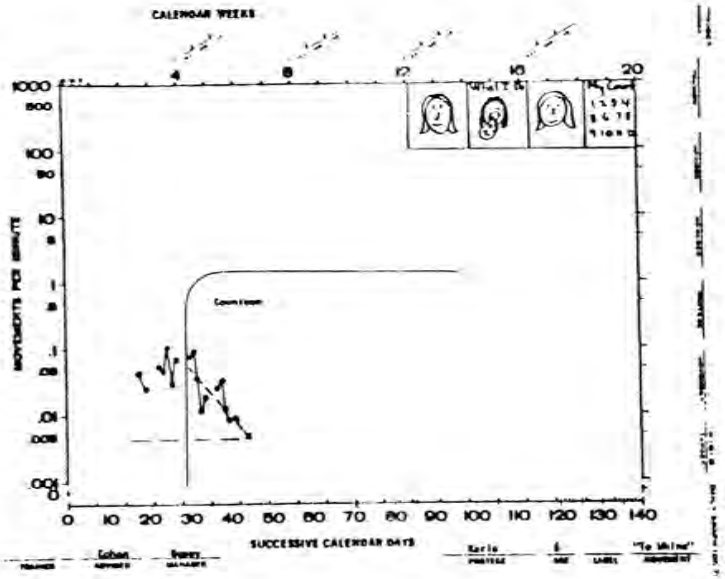



FIGURE 23

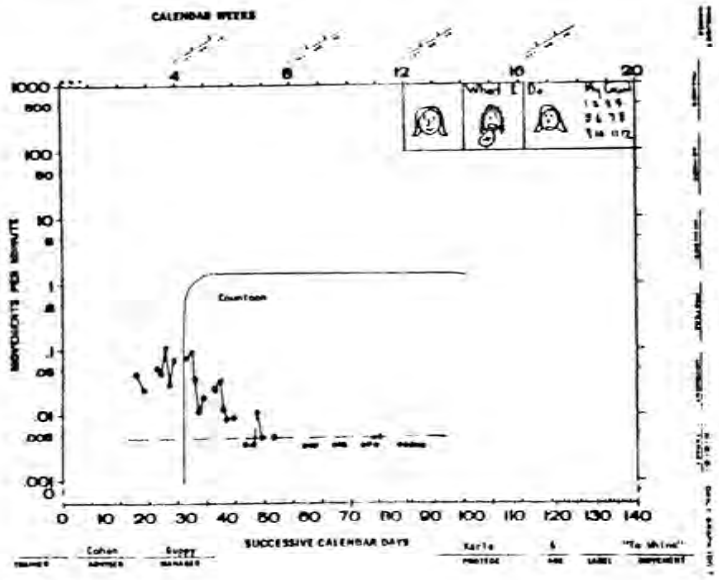



FIGURE 24



The data plots indicate that Karla's whining was decelerating at a rate of ÷ 2.6 whines per week, so that in the third week, the teacher could predict from the data that she would eventually achieve her goal for Karla–0.0 whines each day. As the data in Figure 24 show, the teacher was correct in her prediction.

Predictive statements have been made and will continue to be made by the various professionals who are concerned with a child's academic and social performance. These statements will continue to carry tremendous weight in determining the child's future. It is our obligation, then, as professionals, to be certain that our statements about children are accurate. In all fairness to the child, we must be certain that we have viewed his performance objectively and that our predictions concerning his educational future are based upon more than simply one or two observations or "tests." Counting Karla's whines for 2 days (see Figure 25a) would certainly have given us a misleading view of the future. Seven days later (see Figure 25b), our prediction looked quite different. One must avoid making predictions based on limited data!

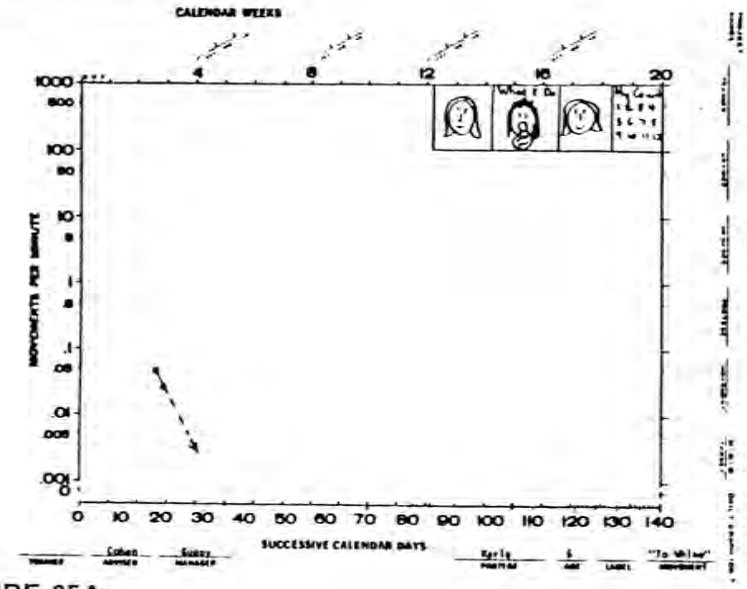



FIGURE 25A

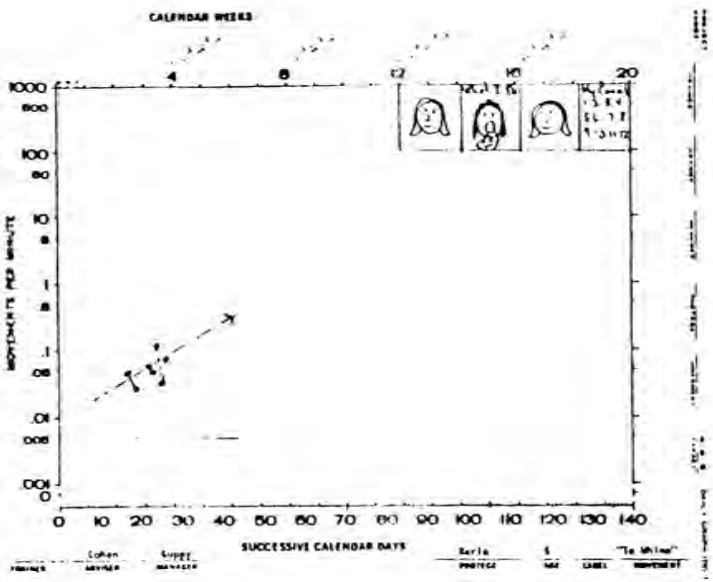



FIGURE 25B

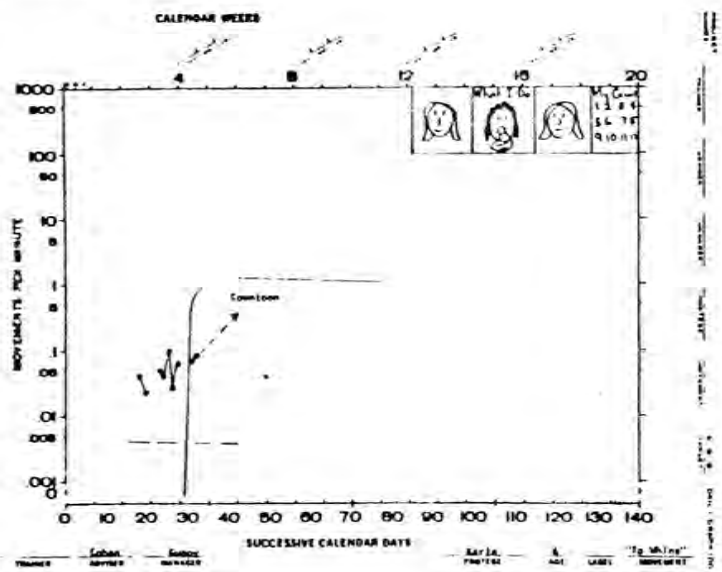



FIGURE 25C



Again, when the countoon was introduced, 2 days' data could have led to some false assumptions about the outcome of this plan. (Figure 25c)

Predictive statements have proved extremely useful in looking at academic performance to determine whether the student will reach the educational objectives set for him. In this particular example, the teacher's educational objective for Jimmy was 30 correct responses per minute with 0.0 errors at the end of a 9-week period on randomly presented, single-column addition facts, sums 0-9. Jimmy was given 1 minute at the start of each math period to work on a sheet of problems with these particular combinations.

Over the first 3 weeks, Jimmy's responses decelerated at a rate of ÷ 1.05. The teacher predicted that Jimmy would not reach her objective for him unless a change in plan was initiated. Jimmy had been receiving 1 point for every 5 problems done correctly. These points were to be used to "buy" different activities during the day, such as art, music, and surprises. (Figure 26)

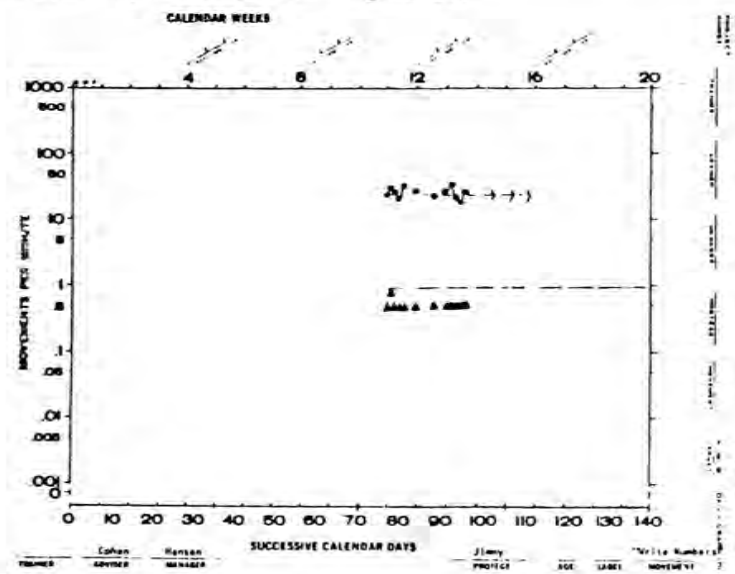



FIGURE 26

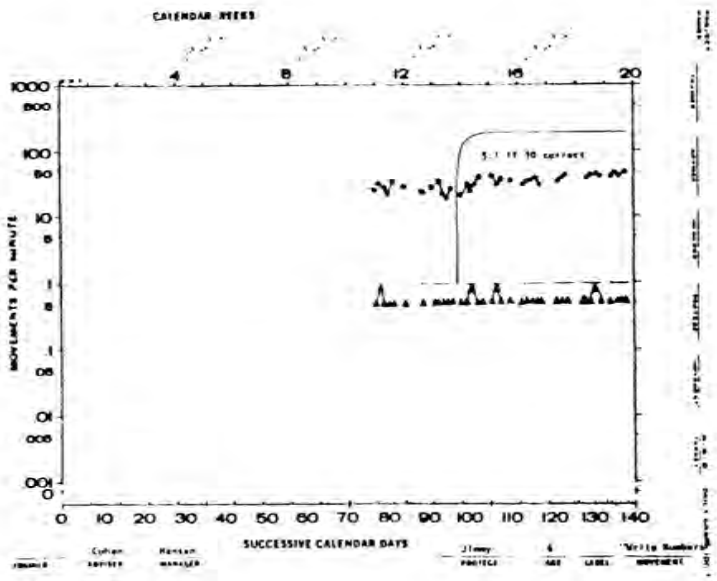



FIGURE 27

The teacher now informed Jimmy that he would receive his 1 point for every 5 problems only if he did at least 30 correct problems on the page. If he did fewer than 30 problems, he would receive no points. With this change in plan came a change in Jimmy's math. Jimmy not only achieved but even surpassed his objective in the 9-week period. (Figure 27)

We have an obligation to the children in our charge to make predictive statements about their futures based upon that which *has* happened and *is* actually hapening. Haphazard speculation is dangerous when the education of children is at stake. Rate as a measure not only allows a careful look at the different dimensions of performance—accuracy, speed or frequency, endurance, and improvement—but also makes possible a meaninglul predictive statement about future growth.



## SUMMARY AND DISCUSSION

Figure 28 utilizes and summarizes the previously discussed dimensions of classroom measurement. The chart describes the progress of a teenage girl who is learning cursive writing.

The first phase of the chart shows a rather poor performance. First, the median correct response rate was only 3.2 letters per minute. The error rate, on the other hand, was .75 responses a minute or a little over 7 responses in 10 minutes.

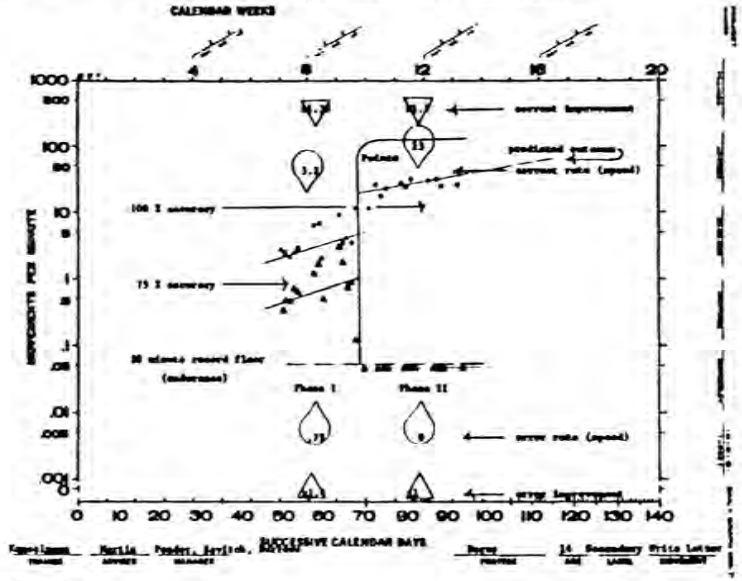



FIGURE 28

After a comparison between correct and error rates, we find that the student was initially working at about 75% accuracy.

One can see the added dimension of improvement when a trend of x1.35 for correct responses and a x1.4 error trend are noted. In other words, both correct and error responses were increasing so that even though the student was writing more and more letters, the errors were also very high.

Finally, the record floor for the entire project was 20 minutes. Few statements about endurance can be made from these data other than that the student was working for 20 minutes, and that a student working continuously for 20 minutes probably has more opportunity to acquire competency than a student working for any period less than 20 minutes.

The major phase change came with the addition of contingent free time points. In other words, after the beginning of Phase 2, indicated by the straight vertical line on the graph, the student received 1 minute of free time for every 40 correct responses she made. This free time could be taken whenever the student chose. The effect of this change was rather significant and immediate. First of all, the correct median for the second phase was 23 responses a minute as contrasted to slightly more than 3 responses a minute in the first phase. The median error rate, on the other hand, was 0.0 for the second phase compared to .75 errors per minute in the initial phase.

The line of progress or trend for correct responses was x1.2 movements per minute per week. The error rate was 0.0; it continued at that level, and had a trend of x1.0.

The accuracy dimension during the second phase was as good as could be expected; 100% accuracy was maintained from the initial change day throughout the balance of the chart.

On the basis of these dimensions—speed, accuracy, endurance, and improvement—the teacher felt very confident that an appropriate management change had been made. Accuracy was increased as well as speed of performance. It seemed that the student continued to improve in correct responses, so that the outcome predicted—the continuation of the line of progress—was that the student would increase to a median of 50 or more in the following weeks if all of the conditions remained relatively constant.



We hope that the reader can see from this example how all of the dimensions discussed in this chapter can be used in the classroom environment. The most sensitive instructional decisions require complete and accurate information about all these dimensions; rate of performance provides the teacher with this information.

## REFERENCES

Bijou, S. W., Peterson, R. F., & Ault, M. H. A method to integrate descriptive and experimental field studies at the level of data and empirical concepts. JOURNAL OF APPLIED BEHAVIOR ANALYSIS, 1968, 1, 175-191.

Graphs that look funny but tell you a lot. CHANGING TIMES, Nov., 1970, 34-37.

Haughton, Eric. Counting together: precision teaching rationale—69 (Monograph). Eugene, Oregon: Instructional Materials Center, University of Oregon, 1969.

Kunzelmann, H. P., Cohen, M. A., Hulten, W. J., Martin, G. L., & Mingo, A. R. PRECISION TEACHING-AN INITIAL TRAINING SEQUENCE. Seattle: Special Child Publications, 1970.

Skinner, B. F. Some contributions of an experimental analysis of behavior to psychology as a whole. AMERICAN PSYCHOLOGIST, 1953, 8, 69-78.

Skinner, B. F. Are theories of learning necessary? CUMULATIVE RECORD. New York: Appleton-Century-Crofts, 1961.

Skinner, B. F. Operant behavior. In W. K. Honig (Ed.), **OPERANT BEHAVIOR: AREAS OF RESEARCH AND APPLICATION**. New York: Appleton-Century-Crofts, 1966.

Skinner, B. F. What is the experimental analysis of behavior? **JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR**, 1968, 9:3, 213-218.