Precision Teaching

An Introduction

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Eliza is a fourth-grade student at the Valley Dale School. For a few minutes during her various academic periods each day, Eliza works with a classmate on exercises in reading, mathematics, and spelling. For the first few minutes, she reads aloud, answers arithmetic problems, and spells words dictated to her as her peer tutor times her work. After each exercise, the two students look at Eliza's work, correct it, count the number of correct and incorrect responses, and enter the scores into a computer. Then they practice the academic skills together. A few minutes later, Eliza and her classmate exchange roles; Eliza now becomes the tutor and her classmate the learner.

Each exercise the students complete is designed to help them develop fluency, or *automaticity*, in the performance of important academic skills. They use the computer to analyze their daily performance and suggest practice, instructional, and motivational strategies that should help them perform fluently. Fluent performance is accurate as well as relatively effortless.

Eliza and her classmates have found that developing fluency helps them learn quickly and retain their learning much longer. The exercises they complete provide them with many opportunities to respond, be corrected, and help one another. They all have learned a great deal during this year of school.

Eliza has a severe language disorder, is bilingual, and was seriously behind her expected grade level at the beginning of the year. Now, at the end of the year, Eliza is performing near grade level in reading, spelling, mathematics, and language skills. She has accomplished nearly 2 years of growth, and her percentile score on the California Test of Basic Skills (CTBS) (1978) has improved by 21 points. Her classmate-tutor, Jorge, also improved by nearly two grade levels. He was performing nearly 2 years below his expected grade level at the outset and his percentile score improved by 23 points on the CTBS.

Similar achievements were accomplished by the other class members. The average improvement in percentile rank was more than 17 points (de Ayora, 1988; West, Young, & de Ayora, 1988). However, since students who previously have scored well below the norm on this test are likely to make more improvement in percentile rank, the percentile scores were converted to normal curve equivalents or NCEs (Tallmadge & Wood, 1980). The

average improvement in NCEs for Eliza's classmates (18 points) was even greater than their improvement in percentile rank (West, Young, & de Ayora, 1988).

Eliza and her classmates used the AC-CEL Computer Program (West, Young, West, Johnson, & Freston, 1985) to evaluate their own academic progress, which saved teacher time and involved the students in the learning process. This curriculum-based assessment system was used by the fourth-grade students at Valley Dale every day to enter and display their scores and every sixth day to analyze the scores. Based on this analysis, AC-CEL recommended strategies the students could employ during their peer tutoring sessions throughout the next 6 days. Every 6 days, the students conducted another analysis and adjusted their tutoring according to the recommendations of the software. Using this system, students learned effective peer tutoring techniques that significantly improved the learning of their partners.

Overview of Precision Teaching

The experimental approach used by Eliza's teacher at the Valley Dale School was built largely upon the principles of precision teaching, a method of measuring student performance regularly and frequently and using an analysis of the measurements to suggest instructional and motivational strategies capable of correcting failures to learn. Using precision teaching procedures, educators become students "of the pupil's behavior, carefully analyzing how the behavior changes from day to day and adjusting the instructional plan as necessary to facilitate continued learning" (White, 1986, p. 522). Precision teaching is not so much a method of instruction as it is a precise and systematic method of evaluating instructional tactics and curricula. In naming this approach, Ogden Lindsley, its originator, noted that "what was really new in [the] procedure was precision, [so] we decided to use that as an adjective in front of whatever it was one was doing; hence in our case, 'precision teaching'" (Lindsley, 1972, p. 9).

Lindsley, a former student of B. F. Skinner, built precision teaching around a framework of operant conditioning and the methods of experimental analysis of behavior developed by Skinner. This framework consisted of the following seven basic elements:

1. The principle that the student knows best, or in other words, the student's behavior can tell us better than anything else whether or not instruction has been effective.
2. An emphasis on the direct measurement of behavior and continuous monitoring (daily performance assessment).
3. The use of rate of response (e.g., number of correct answers per minute) as a universal measure of behavior.
4. A standard chart format or visual display that can be used to study performance patterns.
5. The use of descriptive and functional definitions of behavior and processes.
6. Ongoing analytical investigations of the impact of environmental influences (teaching tactics) on individual behavior (student learning).
7. An emphasis on building appropriate and useful behavior, rather than focusing exclusively on eliminating undesired or inappropriate behavior.

Precision teaching is effective in providing information to teachers that can help them help students learn, even if their past learning history has been unspectacular. It provides a great number of response opportunities because it promotes fluency (increasing responses per unit of time). Greenwood, Delquadri, and Hall (1984) have concluded that the number of opportunities to respond is consistently associated with gains in academic achievement. Other researchers have found that fluency produces greater retention and generalization (Chomsky, 1978; Howell & Morehead, 1987; Jenkins, Barksdale, & Clinton, 1978; Young, West, Howard, & Whitney, 1986).

Applications

The articles in this special issue of *TEACHING Exceptional Children* describe various applications of precision teaching. Each application transforms the fundamental principles of precision teaching into practice.

Be Aware of the Relationship Between Teaching and Learning

Learning is the objective of teaching, or at least that seems to be a logical proposition. However, teachers sometimes neglect to determine whether or not their teaching has had any effect on the learning of their students. Teachers who are truly interested in ensuring that teaching has had the intended effect will certainly be interested in precise measurements of learning. More important, however, they will want to adjust their teaching practices when the measurements indicate that prior instruction has failed to accomplish its objective. Therefore, measuring learning is one of the most important of all instructional acts.

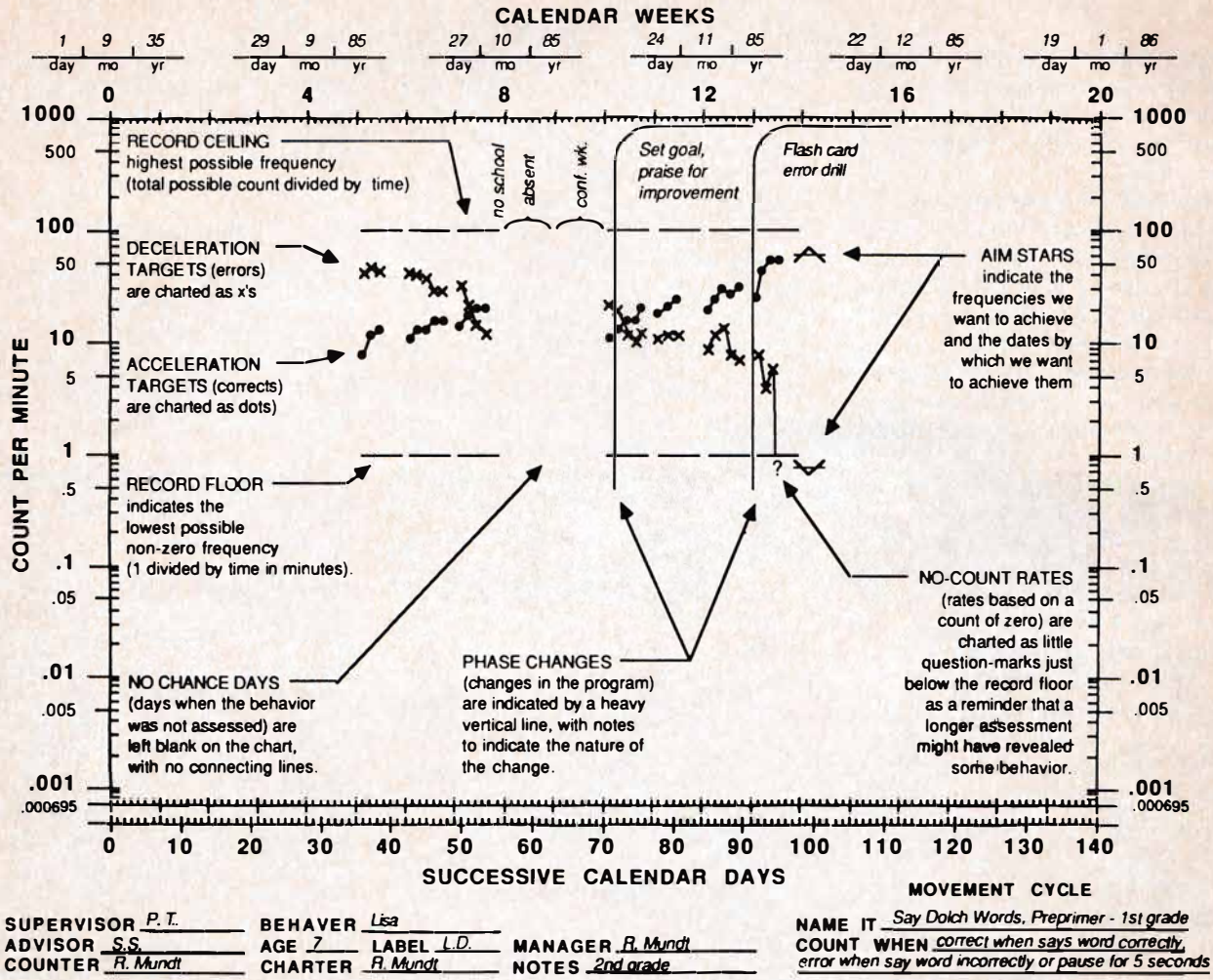
Measure Frequently

The first thing that must be decided in order to measure learning is what the phenomenon is that is to be quantified. What is learning? Are learning and knowing the same? Coming to an agreement on the definition of these terms is prerequisite to a discussion of how learning ought to be quantified. While they are not the same, learning and knowing are certainly related: *Learning* is the process of acquiring knowledge; *knowing* is the condition that results from the process of learning.

Learning is a continuous process; it can be compared to a motion picture that gives a continuous study of an event or series of events. Assessing a student's performance is like taking a

Figure 1

STANDARD CELERATION CHART AND CHARTING CONVENTIONS



From "Precision Teaching—Precision Learning" by O. R. White, 1986, *Exceptional Children, 52,* p. 529. Copyright 1986 by The Council for Exceptional Children. Reprinted by permission.

single frame from the motion picture. At that particular point in time, the student "did this" or "knew X." Knowledge, in this sense, is a static property, something that is inferred from the student's performance on a particular occasion, under particular circumstances. Learning, on the other hand, requires more than a single instance of measurement. In fact, the more instances of measurement we have to inspect, the more accurate and representative will be our interpretation of learning. If we can study many frames from the motion picture, we will have a much better idea of the continuous process the motion picture represents.

One frame in a motion picture differs little from frames that are adjacent to it. Similarly, we do not need to measure "knowing" constantly in order to detect significant changes in what is known. However, just as it is difficult to determine the story reflected in a motion picture if we see only the first and last frames, measurement must be frequent enough to permit an inspection of the process of "coming to know" or learning. Therefore, measurement of learning should be frequent enough to detect changes in knowing, and it should relate to specific skills the instructor considers to be important, presumably those which are the objects of instruction. Generally speaking, each student's performance should be assessed at least once during each instructional session or class period. Changes in the student's performance from one assessment to the next may be thought of as learning.

Most academic skills can improve slightly in a single day's time. There-

fore, timed observations of performance should be conducted each day, or four to five times per week. The more frequently assessments are made, the more often decisions can be made about the effectiveness of instruction. A minimum of three data points (resulting from three assessments) is required before a picture of learning emerges. If performance assessments were conducted only once a week, it would take 3 weeks or more to accumulate enough data to evaluate teaching effectiveness. Too much valuable instructional time is lost when assessments are as infrequent as this.

Each timing should (a) be essentially the same from day to day; (b) be free from constraints that inhibit responding; (c) provide sufficient opportunities to respond; and (d) provide time for repeated occurrences of the response. This consistent format reduces the possibility that a detected change in performance is the result of a change in the assessment environment rather than in the performance or ability of the student.

Use Rate of Response as a Way to Measure Performance

An adequate definition of learning specifies the units that should be used in the measurement. It may be clear that learning is a change in performance, but what dimension of the performance must change in order to say that learning has occurred? We say that learning occurs when something is done that could not or was not done before, under similar circumstances, *or* that something can now be done better than it could be done before. But in what way is the performance better: accuracy, fluency, or a combination of accuracy and fluency?

Generally speaking, educators emphasize accuracy when they are concerned with learning; correctness of the response receives the most attention. At the beginning of the term, for example, Sally was able to answer correctly only 5 of the 25 questions on a quiz. Today, she answered 23 of the questions correctly. Obviously, her performance has improved and she has learned something, but what has she learned, and how much has she learned? It may be said that Sally answered only 20% of the questions correctly at the beginning of the term and that she can now answer 92% correctly—an improvement of 72% in the accuracy of her performance.

Percent scores also mask the incorrect responses by treating everything that is not scored as correct as an error (e.g. "skips," or those items not attempted). Accuracy (percent correct) is subtracted from the "total possible" (100%); everything that is left is treated the same even though the percent wrong consists of incorrect responses and skips. Any teacher knows that skips and incorrect responses (also known in precision teaching as "learning opportunities") are not the same. If a student responds incorrectly to an item on an exercise, the teacher has been given important information concerning the nature of the incorrect response (and any associated learning problem) and can help the student to correct his performance in the future. The error represents an "opportunity to learn" to perform the skill correctly. Skips, on the other hand, can be the result of carelessness, boredom, avoidance of punishment, or other factors. Additional information must be obtained for the teacher to adjust instruction. For these reasons, precision teachers record information on both corrects and errors (some even record "skips"), and make decisions about the impact of their instruction based upon a careful analysis of both characteristics of accuracy.

However, Sally has improved not only in accuracy but also in fluency, or rate of responding; her performance is much more efficient now than in the past. At the beginning of the term, she took 50 minutes to answer 5 questions correctly, a rate of .1 correct answer per minute (5 answers/50 minutes). At the close of the term, Sally took only 10 minutes to answer 23 questions correctly, a rate of 2.3 correct answers per minute. This is an improvement of 23 times (a "×23" or "times 23" improvement). Sally's performance at the end of the term is 23 times better than her performance at the beginning of the term. By combining measures of rate and accuracy, we have a more complete picture of learning than with either measure alone.

Rate of response may be the most important consideration in quantifying performance. Accuracy measures can only describe gross improvements in quality; they reveal nothing about quantity. Therefore, if teachers are interested in quantifying changes in performance of learning, they must use rate measures rather than accuracy measures. Skinner (1972) contended that "rate of responding appears to be the only datum which varies significantly and in the expected direction under conditions which are relevant to the 'learning process'" (p. 75).

Use a Graphic Display

Changes in performance can be studied more easily when scores are plotted on a graph and inspected visually, especially when many performance scores are obtained for each of several students. Graphs enable teachers to inspect and compare many data points without having to sort through pages of tabularized data and raw performance scores. Use of a standard scale and format can help teachers avoid the potential misinterpretations that may result from using many different formats and permits them to make consistent and reliable interpretations of instructional effectiveness.

One scale that spans a wide range of performance values without requiring tremendous space is a ratio or logarithmic scale. Figure 1 is an example of a graph with a logarithmic scale on the *y*-axis. This graph is referred to as the *standard celeration chart* because the logarithmic scale and other aspects of the chart are standardized. The logarithmic scale permits the display of performance values (recorded as number of responses per minute) ranging from 1 response per day (1 ÷ 1440 min. = .0007) to 1,000 responses per minute. The scale encompasses virtually all performance values of interest to educators (White, 1986).

The logarithmic scale is important for reasons other than its ability to display widely varying scores. When the Standard Celeration Chart is the medium through which the data will be charted, analyzed, and interpreted, attention is usually focused on both errors frequencies (# of errors/unit of time) and correct frequencies (# of corrects/unit of time), concurrently. These frequencies are arranged in an accuracy pair (corrects and errors).

When correct and error scores are plotted on the standard celeration chart, teachers have a picture of learning that is easy to interpret. When data are plotted on the standard celeration chart, learning is generally represented by a straight or nearly straight line.

The value of the slope of the line that best fits the distribution of values plotted on the logarithmic scale is considered an index of learning. The steeper the slope, the faster the learning is; the flatter the slope, the slower the learning is.

Because learning (change in performance scores) appears to grow like compound interest, or by multiplying, it is analogous to acceleration. Change is measured in terms of the number of responses per minute per week. Theoretically, the change in performance scores can be either up or down, meaning that performance scores can either increase or decrease. With this method of measurement, *celeration*, the root of acceleration, has come to mean "learning," with *ac*celeration, or *times* (×) celeration, representing "up learning," or an increase in performance scores, while *de*celeration, or *divide by* (÷)), celeration means that scores are declining in value.

The index of learning (celeration), which is represented by the slope of the line best fitting the performance scores, can be estimated with a simple calculation. Data are generally obtained from daily timings; therefore, the most representative scores from the week would probably be the median of the five daily scores. The celeration score (which is always 1.0 or greater) can be thought of as a factor by which the more representative score from the five scores in the first week is either multiplied or divided to obtain the most representative score in the second week. Thus, if the median of the scores in week 10 is 40 correct responses per minute and the median of the score in week 11 is 50 correct responses, the celeration score is 1.25, or 25% improvement, because 40 responses $\times 1.25 = 50$ responses.

The logarithmic scale employed by the standard celeration chart is also useful in studying the variability of scores, or relative change in the values, as opposed to absolute change. Equal distance on the logarithmic scale corresponds to equal ratios. In other words, the distance from a score of 10 per minute to a score of 20 is the same as the distance from 100 to 200 per minute. In these two cases, improvement from the first to the second score would be "times × 2," meaning that performance had doubled in 1 week.

Adjust Instruction According to Analysis of Learning

An ambitious, conscientiously applied program of collecting and displaying performance scores cannot ensure effective instruction. This will not occur until the learning is inspected regularly and instruction is adjusted according to the analysis. A given instructional strategy is presumed to be effective if the learning slopes (or best-fitting lines) are steeper in the desired direction when the strategy is used than when the strategy is not used. When a learning slope is nearly flat or is going in the wrong direction, different teaching strategies must be tried until one is found that reverses the trend. An effective teaching strategy is retained until the student reaches a performance standard, or *aim*. The aim represents the teacher's fluency criterion for a particular skill. Decisions to change instruction are made for each student, thus individualizing each instructional program. The rate of a student's response is very sensitive to changes in instruction, so the effects of a new teaching strategy are immediately obvious.

Conclusion

Teachers are more effective if they clearly specify what they want to teach, provide opportunities for their students to learn, frequently measure the performance of critical skills, regularly analyze the performance data, and adjust instruction according to the analysis. The picture of learning that results from this type of program is convincing evidence of the teacher's commitment and dedication to a program of effective instruction (Beck, 1981; Beck, & Clement, 1976; Burney & Shores, 1979; de Ayora, 1988; West, Young & de Ayora, 1988).

The articles in this special issue represent theoretical discussions and descriptions of precision teaching applications. The first was written by Ogden Lindsley, who is considered the founder of precision teaching. He refers to the work of many teachers who helped him refine precision teaching practices. Next is an article by Lovitt and his colleagues describing an application of precision teaching combined with learning strategies. There are three articles by Howell and Lorson-Howell; Binder, Haughton, and Van Eyk; and Downs and Morin that emphasize the importance of focusing on fluent, as well as accurate, performance. There are three articles by Scott, Stoutimore, Wolking, & Harris; Peterson, Scott, & Sroka; and Williams, White, Haring, Cohen, & Rudsit that describe precision teaching applications with students who have learning difficulties. The articles in the *TEC* Departments also focus on precision teaching issues (Koorland, Keel, & Ueberhorst—Research into Practice) and applications (Mounsteven—Teacher Idea Exchange and Liberty & Paeth—Teacher Notebook).

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