Precision Teaching:

By Teachers for Children

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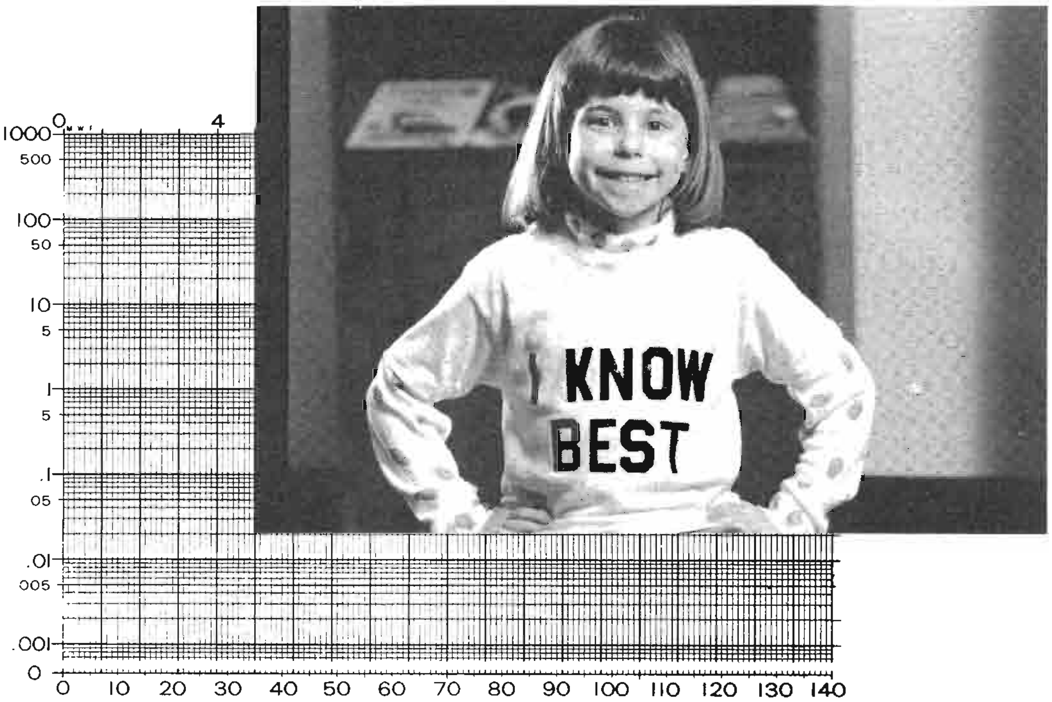


People often state that I developed precision teaching. This is incorrect. I did not develop it. It would be more accurate to say that I founded and coached it. Teachers developed it at my urging by following its founding policies. I still urge teachers to use the powerful methods of free-operant conditioning (often referred to as *behavioral psychology*) in their classrooms. This refers to a process of learning in which students are free to respond at their own pace without having restraints placed on them by the limits of the materials or the instructional procedures of the teachers. In following these procedures, teachers went beyond the use of teaching trials to develop the methods of precision teaching.

Founding Policies of Precision Teaching

I learned, adopted, and committed to the methods of free-operant conditioning as a student of B. F. Skinner at Harvard University during the 1950s. I successfully applied these methods to the study of psychotic behavior in adults and children at the Behavior Research Laboratory at Metropolitan State Hospital, Waltham, Massachusetts, under the supervision of Skinner and Harry C. Solomon, Massachusetts Commissioner of Mental Health. Visitors to the laboratory went back to their universities, agencies, and schools to apply our methods in their settings. But when they applied these methods to children in their classrooms, they typically neglected to use rate of response, self-recording, and standard recording—the hallmarks of free-operant conditioning. Instead, they adopted reward and token economy systems and continued to record the percentage correct of the children's academic work, the time-honored educational measure.

Unfortunately, percentage ignores speed and fluency. Sole attention to percentage correct often produces highly accurate, painfully slow learners who have very low tolerance for error-filled, courageous learning. When the primary type of feedback students receive is percentage correct, with accuracy usually falling between 60% and 90%, students often become fearful of making errors, which in turn can stifle creativity and exploration.

Policy 1: Monitor Frequency Daily

My laboratory research (Lindsley, 1960) has shown frequency to be 10 to 100 times more sensitive than percentage correct in recording the effects of drugs and different reinforcers on the behavior of psychotic and normal children and adults. However, no amount of urging from me would get visiting experts to standardize the use of frequency of response in their classrooms. I knew that the real power of learning enhanced by free-operant conditioning lay in frequency of responding (by allowing the student to be both accurate and fluent) and standard self-recording. When educators would not heed my caution and could not see my vision for dramatic learning opportunities, I decided the ethical thing to do was to close my hospital laboratory and devote myself to education.

As a professor in teacher training in a midwestern university, I began teaching teachers how to teach their pupils to efficiently self-record their own academic frequencies on standardized charts. When children's charts were collected, we summarized their learning and found that frequency and standard self-recording were far superior to traditional educational monitoring. This proved that the superior sensitivity of frequency found in my hospital laboratory experiences also held for pupils in public school classrooms (Lindsley, 1971a).

Policy 2: Use Self-Recording

Students in precision teaching classrooms keep records of their own academic and nonacademic performance and use these records to guide their performance. Students might correct their own assignments and count the number of problems they have answered correctly or words they have read correctly, or count the number of times they praised the work of other students in the class. These records can indicate changes in performance over time as well as telling each student the level of today's performance. When a student charts these "counts" on the standard celeration chart, performance changes, or learning can be seen readily. Using the chart, the student has a visual display of past performance and can see how performance must be changed to meet current aims or standards. Many teachers have found that behavior changes are much greater when students take such an active role.

Policy 3: Use Standard Charts to Display Major Changes

Skinner often urged his graduate students to look for important variables that produced major changes in behavior. He cautioned against wasting time measuring unimportant, small changes in behavior. At the time, I was aware that our cumulative response recorders forced us to look at major changes in response frequency in our laboratories. However, it was not until 1969, after 4 years of charting on standard multiply scales, that I understood why. I noted that in all cases the cumulative response recorders were built to display *doublings* in frequency on their charts. This doubling forced laboratory researchers to search for powerful interventions that produced at least a doubling in response frequency.

In the Harvard Medical School Behavior Research Laboratory at Metropolitan State Hospital, the patients' response rates were automatically recorded on cumulative response recorders throughout each daily session. These cumulative response records displayed changes in their behavior frequencies within experimental sessions. Changes in behavior frequencies between and across sessions from week to week and month to month were charted by hand on 8 1/2- by 11-inch, 10-squares-to-the-inch chart paper. This paper was limited in the number of changes it could record, and as behavior frequencies increased we had to rechart two or three times.

However, it was not until I was training teachers at the University of Kansas Children's Rehabilitation Unit that I was compelled to have a custom chart printed. The teachers met once a week for a 3-hour class. I required that they improve a behavior of one of their pupils and also one of their own behaviors. The teachers shared their progress on these behavior change projects by showing charts in class each week. It took 20 to 30 minutes to share one behavior project because most of this time was spent describing each teacher's unique charting and recording system.

In desperation, I had a standard chart printed with the full range of behavior frequencies, from 1 per day to 1,000 per minute, on a multiply (or logarithmic) scale up from the left, or short, side of the paper. The long side had 140 calendar days, or 20 weeks, which is about 1 school semester. This chart had several advantages.

First, by accommodating the full range of behavior frequencies on one chart, a teacher could record any behavior of interest. Behaviors with low frequencies (e.g., a student getting into one or two fights per day) and those with high frequencies (e.g., a student reading several hundred words per minute) could be recorded on the same type of chart, eliminating the need for interpretation.

Second, student performance data from an entire semester could be recorded on one chart.

Third, the logarithmic scale also made it possible to measure the rate of learning or celeration.

Fourth, later we learned that the chart could be used to accurately predict future performance, which helped in making decisions. For example, if learning was slow and the prediction was that several weeks would be required to master an objective, a teacher could try something else and accelerate learning.

In order to standardize the interpretation of rate of learning and accurate prediction and to promote major changes in student performance, I designed the chart so that a line from the lower left corner to the upper right corner of the grid represented a doubling in frequency every week (celeration period). This angle of about 33 degrees was the most sensitive part of the slope of the chart. If the central slope of the chart was a doubling, it should prompt our teachers to produce doublings of their pupils' frequencies each week. In the same way that the doubling cumulative response recorder grids prompted the early laboratory free-operant conditioners to search for major variables, I hoped that the standard chart doubling would prompt our precision teachers to discover major classroom variables that would accelerate learning.

Because the standard celeration chart forces us to look for at least doublings in pupil performance frequency, it blinds us to very small changes. For this reason many researchers avoid the standard celeration chart because it makes the small changes they may have produced (e.g., changes from 11 to 13 responses per minute) look trivial. In fact, when changes from 11 to 100 responses per minute can be produced easily, a change from 11 to 13 *is* trivial and should be seen as such.

Policy 4: The Child Knows Best

When I was a graduate student, I trained a rat whose behavior did not extinguish exactly as the charts in Skinner's (1938) book had shown. My rat had at first responded much more rapidly when his responding was no longer reinforced. This rapid responding went on for about 30 minutes, at which time the rat stopped abruptly. I took the cumulative record of the rat's unusual extinction to Dr. Skinner and asked him how this happened. How could the rat do this when the book showed a very different gradual extinction curve? Skinner answered, "In this case, the book is wrong! The rat knows best! That's why we still have him in the experiment!"

Skinner's easy acceptance of possible error in his book's generalizations impressed me. Here was an empiricist at work! His charming way of admitting that the scientist did not know everything yet, that the rat knew rat behavior best, was the clearest way I had yet found to describe the inductive approach to behavioral research. For this reason I made "the child knows best" a policy and slogan for precision teachers to use in their discoveries (Lindsley, 1971b).

Often in workshops a teacher will ask, "Dr. Lindsley, what is the best way to help a child improve his oral reading to a frequency above 40 words per minute?" I always reply, "What is the child's name?" If the teacher replies, "Brent," I answer, "What did Brent suggest?" The teacher usually replies, "I didn't ask him!" And I answer, "Then please go back and ask him, because, after all, the child knows best."

Contributions of Precision Teachers

Applying these founding policies of precision teaching has enabled many teachers to discover effective teaching techniques. Some of these discoveries are mentioned here.

Academic performance can be accelerated by chart display. In 1965, Lois Cox, supervised by Thomas Caldwell, found that pupil academic performance frequencies increased when pupils displayed their charts. Lois also found that fourth-grade children enjoyed computing and charting their own daily performance frequencies.

Self-recording is simplified with wrist tally cards. In 1966, Jean Stables cut 3- by 5-inch blank cards in half and held the 2 1/2- by 3-inch card to her wrist with a watch strap. She used this wrist tally card to record six or seven different behaviors. At the end of the day, the tallies were counted and charted and the dated cards were filed in a card box.

Pupils can count academic and nonacademic behaviors and display their performance on the standard celeration chart. In 1967, Carl Koenig, under my supervision, taught a special class of six 9- to 11-year-old boys classified as emotionally disturbed. The pupils timed and counted their own arithmetic and both silent and oral reading frequencies. Each pupil also counted one nonacademic behavior (Koenig, 1967). Koenig's master's thesis at the U. of Kansas was the first to use the term *precision teaching* and the first to include standard celeration charts. The chart was called six-cycle semilog graph paper at the time, and was later called the standard behavior chart (Pennypacker, Koenig, & Lindsley, 1972). Still later, the chart was correctly named *standard celeration chart*, because what is standard on the chart is the angle of the celeration lines. A line from the lower left corner to the upper right corner represents a learning in which performance doubles every celeration period (i.e., times 2.0 per week, per month, per 6 months, or every 5 years, depending on the version of the chart that is employed). A line from the upper left corner to the lower right corner represents unlearning, or deceleration, in which performance halves each celeration period (i.e., divide by 2.0 per week, per month, per 6 months, or every 5 years).

Self-selected competencies are more effective than teacher-selected. In 1969, Karen A. Curtis, supervised by Tom Lovitt, found that higher academic response frequencies occurred when the pupils selected their own reward contingencies than when the teacher selected them (Lovitt & Curtis, 1969).

Pupils with orthopedic handicaps can chart their own behaviors. In 1969, Sally Slezak, under my supervision, taught two different classes of children with orthopedic handicaps. The first year she taught 8 primary pupils: 4 paraplegic cerebral palsied, 3 spina bifida, and 1 brain damaged. Of these, 4 were severe and 4 were mobile. The second year she taught 7 intermediate pupils: 3 paraplegic cerebral palsied, 2 spina bifida, 1 muscular dystrophy, and 1 choronic health disorder. Of these, 1 was severe and 6 were ambulatory. All the children used wrist counters, which they purchased with points they earned, to count their own nonacademic behaviors. Wrist tally boards were used to count up to six or seven behaviors on the same tally card. The daily tally cards were dated and kept by the children.

Sally discovered that they could use masking tape strips (better known as "stickies") to record behaviors. The best size was 1 inch wide cut 3 to 4 inches long. Each morning the children would tear off a piece of tape and write the date and the behavior they were recording on it. These stickies were placed on wheelchair arms, crutch legs, comb cases, shorts, or wrists. At the end of the day, the children placed their stickies under their names on the "stickie chart."

In 2 weeks or less, Sally taught her children to use the standard chart paper. She used the performance charts as report cards for parents. Hers was the first thesis to use the term *daily behavior chart* to report acceleration as movements per minute per week and to use an acceleration finder (Slezak, 1969).

Regular second graders can keep 19 academic charts each. In 1970, Elizabeth Freeman, supervised by Eric Haughton, taught an entire class of second graders at Whitaker School, Eugene, Oregon, to time, correct, count, and chart their own academic behaviors. The children posted their own charts on room dividers that were set up along the wall. The children and parents loved this demonstration of self-recording.

Young children can learn standard charting. In 1971, 5-year-old Stephanie Bates, supervised by her father, Douglas Bates, not only taught her kindergarten class to chart, but also taught her teacher. Stephanie's chart-teaching method was made into an 18-minute color slide presentation that dispelled the common educational fear that using semilogarithmic charts was difficult to learn (Bates & Bates, 1971).

Instructional procedures can be compared using precision teaching methods. In 1971, Nina Young, supervised by Nancy Johnson, found that inner-city high school students successfully tutored elementary school pupils who were one to four grade levels behind in their reading. The pupils were tutored by the same tutor 45 minutes a day, 5 days a week. The project, called Operation Upgrade, lasted several years during which several graded readers, several vocabulary lists, the local newspaper, and pupil written stories were used as curricula from which the pupils read aloud each day. No one curriculum produced the best learning for a majority of the pupils, once again proving "different strokes for different folks." If one had to pick a best it was the newspaper.

For any given two-week period each pupil was reading from three different materials in three separate one-minute timings each day. For example, the SRA graded reader, the Kansas City Star, and the pupil written "our stories." If over that two-week period the pupil showed the steepest learning (not the highest performance) on the Kansas City Star, the Star would be kept as one of the three curricula for the next two-week practice period and the graded reader and our stories discarded and two other curricula tried in attempts to get even better learning producers. In this way, three different curricula can be tried at once. The worst can be discarded, and three more tried again.

More important for precision teaching methods was the discovery that if three different curricula are tried for 1 minute each day, the performances and learnings (frequencies and celerations) for each curriculum stay independent and projectable. This means that three different procedures can be compared at once in the same pupil with the same tutor in the same calendar time (Johnson, 1971).

Countoons are useful for self-recording. In 1972, Marilyn Cohen, supervised by Harold Kunzelmann, designed "countoons." These were cartoon-like drawings in sequenced frames that described a behavior pinpoint to accelerate and another to decelerate. Each time a pupil emitted one of these target behaviors, he or she made a tally under the picture on the countoon. These countoons were very effective in helping students record their own behavior frequencies.

Charting can help predict student performance. In 1974, Sally Macmillan, supervised by Donna Boykin and Ray Beck and teaching a regular first-grade classroom in Great Falls, Montana, had all the children writing numbers in sequence. She found that a trendline through 2 weeks (10 daily scores) of student data plotted on standard celeration charts could be used to predict performance 2 weeks into the future.

Naming their "learning pictures" can help students monitor progress. In 1977, Pat All, under my supervision, taught her regular seventh-grade students to count and chart the words they spelled correctly. She had them sort their charts according to the patterns of data, called *learning pictures*. She asked them to name the pictures by their patterns. Figure 1 illustrates the learning pictures named.

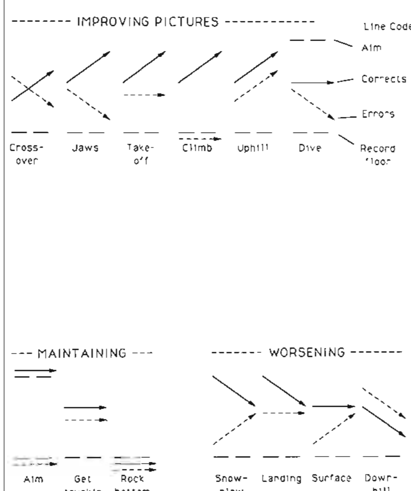
The code in Figure 1 shows the correct celeration or learning line as solid line with an arrow at its left end. It would have been drawn through the daily correct frequencies that had been charted. It is moving as on the chart from left to right. It should be considered as a vector in motion, the arrow pointing to where the performance is going. The error learning line is short dashes with an arrow pointing in its direction. The record floor (the lowest frequency that can occur) is shown as two horizontal long dashes at the bottom of each picture. These floor lines indicate that each picture is about two weeks long. The floor lines also show how far the frequencies are above the floor. Note that in the Aim picture the errors are below the floor, showing zero errors are being made.

The students named Jaws after the wide-open jaws of the shark famous in a thriller movie the prior summer. Snowplow, Uphill, and Downhill came from the positions of snow skis while skiing. In climb, Takeoff and Landing the correct celeration line is the flight of an airplane and its related error line is the surface of the ground. In Surface and Dive the correct line is the surface of the sea, and the error line is the path of a submarine. Note that all the names describe motion, showing that the students knew their learning is dynamic and has direction and that their performance is almost always changing–for better or for worse. These relationships are useful as memory aids in sharing these learning picture names with other students.

The students saw pictures with corrects maintaining and errors maintaining not as one picture, but as three very different pictures. One picture on which both frequencies were very low was known as the "Rock-Bottom." Another picture, with both frequen-

Figure 1

THIRTEEN LEARNING PICTURES



cies in the middle of the chart, was "Get-Truckin'." The last picture, with the corrects above the aim and the errors below the floor, became known as the "Aim." This showed the advantages of inductive over deductive development and also demonstrated that the child knows best (All, 1977).

Daily practice produces more learning than practicing every other day. In 1978, Suellen Gabriel, supervised by Dick Clement and Ray Beck, taught her 26 regular fourth-grade pupils to locate and abbreviate the names of the states on a blank United States map. She found that the learning from 1-minute practice sessions every day was greater than that from 2 minutes practice every other day. She learned that daily practice is more effective than alternate day practice when the same time is spent.

Using two channels at once can help students learn. In 1978, David Keller, supervised by Linda Haines, Dave Freschi, and Ann Duncan, taught boys who were diagnosed as emotionally disturbed and autistic at Spaulding Youth Center in Tilton, New Hampshire. He taught spatial relationships in more than one channel each day. (*Channels* refer to the pathways by which the student receives information and produces a response; for example see and write, see and say, and hear and write.) David found not only that correct learning and error learning were independent, but also that the learning in one channel ("See the name"/"Point to the picture") was independent from the learning in another channel ("Hear the name"/ "Place your hand in the position"). Just as Young and Johnson had found that three curricula can be tried at once because their learning is independent, Keller found that two or more channels can be tried at once each day because their learning is also independent.

A leap-up in curriculum improves learning and motivation. In 1979, Marilyn Chappel, supervised by her principal, Gene Stromberg, taught her second-grade class at Garfield School, Ottawa, Kansas, basic mathematics facts. Figure 2 is a copy of Hollie's mathematics chart for the fall semester. She looked at basic mathematics problems and wrote the answers on precision teaching practice sheets during 1-minute timings (see/write). The dots on the chart represent her frequency of correct additions during her best timing each day. The small x's are her error frequencies per minute each day. Learning (celeration) lines are drawn through the dots and x's to show the slopes of the correct and error learning in each curriculum phase.

Note that the +5 and +6 addition problem phases produced correct learning, but little error learning. When +5 and +6 addition problems were mixed on the same practice sheet (the next two phases), error learning did not occur either. However, when all basic addition facts and all basic subtraction facts were mixed with basic multiplication facts and practiced *without* prior instruction (+, -, ×) Hollie had both high correct (×1.6) and higher error (/10.0) learning!

Essentially the same beneficial effect of the curriculum leap-up on Hollie's correct learning (advancing well ahead in the curriculum to a new instructional objective) was seen on all the other children's learning. Their median correct frequency jumped down from 120 to 4 per minute from the last day of "mixed +5 and +6" to the first day of "mixed add, subtract, and multiply facts." This showed that the leap-up was 30 times harder to do (120/4). Their median correct learning turned up from ×1.60 to ×1.90, with a range of ×1.40 to ×3.0 per week. This showed their correct learning had improved by ×1.19 or 19% (1.90/1.60).

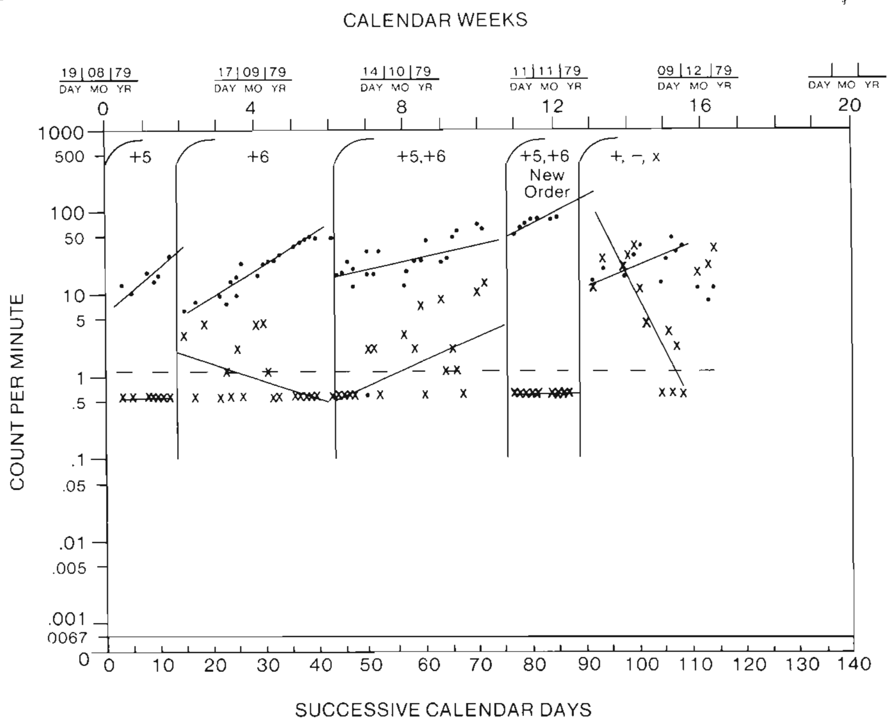
A similar beneficial effect similar to that of the curriculum leap-up on Hollie's error learning was seen on all the other children's error learning. Their median error frequency jumped up from 0 to 20 per minute. This showed that the leap-up produced over 20 times more errors. Their median error learning turned down from ÷1.00 to ÷2.50, with a range of ÷1.50 to ÷10.0 per week. This showed that their error learning was 2.5 times better.

In summary, the leap-up in the curriculum to mixed addition, subtraction, and multiplication facts *without instruction* made the pupils' basic mathematics 30 times harder to do with 20 times more errors, but over all their learning was doubled. After their leap-up, most of the students were in cross-over learning, with the error frequencies five times higher than their corrects. All the students enjoyed the challenging error-filled curriculum much more than their prior accuracy-addictive curriculum. With these challenges, the students made more improvement in less time in both correct and error performance than would have been expected using traditional curricular sequence steps.

The learning of most students is held back by traditional lockstep, slow-paced public school curricula. However, Marilyn's class results suggest that *all* students are capable of doubling their frequencies every week if given an appropriate and proper curriculum challenge. The results also show that the traditional instruction-before-practice educationalal sequence may be unnecessary and therefore wastes valuable educational time. Even more important, Hollie and Marilyn's other pupils have shown that accuracy addiction, or perfectionism, and its desired opposite, curricular courage, are not properties of children. Rather, they are both clearly properties of the curriculum.

Figure 2

HOLLIE'S MATHEMATICS CHART



Conclusion

The list of bench-mark contributions to precision teaching presented here is not complete. Many more teacher-supervisor teams have made significant contributions. However, the list demonstrates the nature of the contributions that practicing teachers have made to precision teaching. It should be clear by now that precision teaching was built by a large number of practicing teachers in their classrooms, not in an academic, grant, or administrative office. It was not deductive, not the classroom testing of academic hypotheses. Rather, it was inductive, coming from classroom discoveries, made by teachers in their daily efforts to improve the amount, quality, and precision of their pupils' learning.

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