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ABSTRACT
Although educators, policy-makers, business leaders, and the general public have become increasingly concerned about the "basic skills" crisis in American schools, research-based solutions have existed for over two decades in the form of measurably superior teaching methodologies: Precision Teaching and Direct Instruction. In federally validated research, each of these instructional technologies has been shown to produce far greater achievement and self-esteem among students than more traditional teaching practices, with favorable cost-benefit ratios when implemented in schools. These results have been obtained despite adverse socioeconomic influences on students so often blamed for failure in the classroom. These methods have not been widely adopted, partly due to political and philosophical resistance to measurably superior instructional technology among educators.

This article provides overviews of Precision Teaching and Direct Instruction, discusses their origins and research backgrounds, cites effectiveness data, and describes how they can complement one another when used together. It provides sufficient references to the literature and pointers to existing programs to enable interested readers to learn more about each of these measurably superior educational solutions.

Introduction

Although systematic, empirically derived instructional technology in many forms has existed for decades, mainstream educators have, by and large, resisted it. Such criterion-referenced approaches as the "Personalized System of Instruction" (PSI) or "Keller Plan" (Sherman, Ruskin, & Semb, 1982) have been rejected in many university settings, despite measurable improvements in students' learning, because many educators and administrators cannot accommodate systems that disturb the normal distribution of grades in the student population. An analysis of the contingencies that affect adoption of instructional methods in the educational establishment reveals forces that oppose change at all levels and which must be overcome in order for measurably effective instructional technology to take hold (Watkins, 1988).

In elementary and secondary schools, and in the university programs that prepare teachers for those schools, educational fads come and go. To an observer it often seems that "new" methods are valued *because* of their newness, and mature methods, including measurably effective ones, are rejected simply because they are no longer new. Unfortunately, some of the most mature and effective instructional methods fall into the "behavioral" category—a school of thought that is now very much out of vogue in mainstream education. Among the measurably effective instructional technologies that have been implemented in schools over the last 25 years are Precision Teaching and Direct Instruction. In fact, these two approaches to instruction may be the most thoroughly validated and consistently effective methods yet developed in English-speaking schools (Binder, 1988; Watkins, 1988). Decades of research and application suggest that Precision Teaching and Direct Instruction in regular and special classrooms may be capable of eliminating America's current "basic skills crisis," if broadly adopted. However, most educators and policy-makers are not aware of these methods. And when they are aware of them, there is often philosophical and political resistance to their use (Binder & Watkins, 1989).

An important message that performance technologists and systematic instructional developers can deliver to those concerned about America's educational failures is that the *keys to a solution lie in better instructional methods, not in the socio-economic and cultural factors that are so often blamed for the problem*. Results of effectiveness research demonstrate that with the implementation of superior instructional methods it is possible to overcome the effects of such variables as inner-city poverty, singleparent families, television overdose, and other influences outside the classroom (e.g., Watkins, 1988). Nonetheless, most educators and policy-makers continue to blame factors beyond teachers' control for failure in the classroom.

This article provides overviews of Precision Teaching and Direct Instruction, discusses their origins and research backgrounds, and describes how they can complement one another when used together. It provides sufficient references to the literature and pointers to existing programs to enable interested readers to learn more about each of these measurably superior instructional technologies.

The fact is that America now has the best basic skills instructional technology in the world, yet it is not being used. We hope that this article will help to inform educators, policy makers, and increasingly concerned business leaders that there are now mature, cost-effective solutions to America's educational crisis, ready to be implemented in a broad variety of educational settings, and able to produce results that are orders of magnitude greater than the results of mainstream educational practice.

Precision Teaching

Origins

During the 1960s, many of the students and colleagues of B. F. Skinner moved from basic research laboratories into applied settings. In fact, NSPI (originally the National Society for *Programmed Instruction*) was a part of this movement. Most of those who began to apply what had been learned in the laboratory to educational problems created processes and programs based on the *findings* of basic research. Using reinforcement schedules, behavior shaping, discrimination learning paradigms, stimulus fading, and other principles and procedures derived from laboratory research, these pioneers created teaching programs and revised them based on measured effects. However, when they moved into the classroom, most behaviorists discarded the measurement framework that had proven so useful in basic research laboratories (rate or frequency of response) in favor of the scale used in virtually all traditional educational evaluation—percentage correct (Lindsley, 1990). Despite Skinner's (1950) conclusion 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," *most behaviorally oriented instructional technologists opted to measure accuracy only, and generally ignored the temporal dimensions of behavior*, except in particular cases (e.g., typing speed and reading rate).

O. R. Lindsley, the founder of Precision Teaching (Lindsley, 1964, 1972, 1990), who with Skinner had first applied the method of free operant conditioning to humans (Lindsley & Skinner, 1954), had coined the term "behavior therapy" in his work with psychotics, and had made major methodological contributions in areas such as sleep research (Lindsley, 1957), behavioral pharmacology (Lindsley, 1962), and geriatric behavior prosthesis (Lindsley, 1964b), took a different approach. Instead of creating programs and "recipes" based on laboratory findings, he emphasized the *measurement framework* that had proven so powerful for Skinner and his associates in the laboratory. He created the "Standard Behavior Chart" (a.k.a. Standard Celeration Chart), a 6-cycle semi-logarithmic graph for charting behavior frequency (or rate) against calendar days, and he taught teachers and their students to count and time behaviors and accomplishments in the classroom (see Figure 1). He reasoned that by "putting science in the hands of teachers and students" it would be possible for them to discover, in the case of each individual learner, what procedures and materials produced greatest improvements in learning and performance. In effect, Lindsley emphasized the *evaluation* and *revision* components of systematic instruction by encouraging teachers and students to pinpoint behaviors, count, time and chart them every day, and "try, try again" when initial procedures did not produce the desired results (Lindsley, 1972).

The Standard Behavior Chart itself (Pennypacker, Koenig, & Lindsley, 1972; Kazdin, 1976; West, Young, & Spooner, 1990) proved to be an important contribution to the study of learning and performance. Its logarithmic or "multiply-divide" count per minute scale along the left axis enabled students and teachers to chart and directly assess ratios of correct and error frequencies, and to view and quantify progress in the

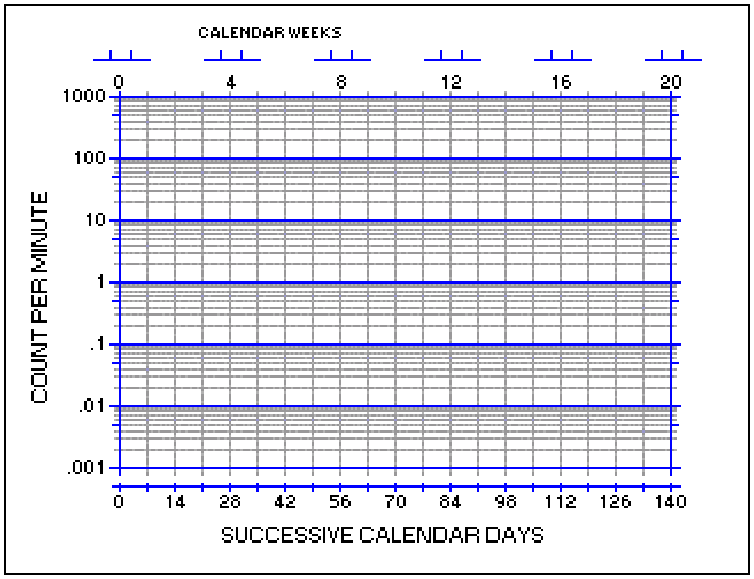

Figure 1: The Standard Celeration Chart (the vertical axis represents a frequency scale).

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Precision Teaching Philosophy and Strategies

At the beginning of the paper that represents his initial contribution to the educational literature, Lindsley (1964a) wrote: "Children are not retarded. Only their behavior in average environments is sometimes retarded. In fact, it is modern science's ability to design suitable environments for these children that is retarded" (p. 62).

A key element of Precision Teaching is the dictum that "the child knows best" (Lindsley, 1972). Based on Skinner's famous statement that "the organism is always right," Lindsley taught Precision Teachers to assume that learners respond in lawful ways to environmental variables and that if learners behave in an undesirable way it is the responsibility of teachers to alter those variables until they produce the desired result. This assumption, perhaps obvious to most current-day performance technologists flies in the face of traditional psycho-educational practice which tends to label and to blame *students* for failure, not instructional methods.

Daily measurement of performance was another important element of Precision Teaching from the beginning. As in the basic operant conditioning laboratory, where continuous cumulative response graphs allowed researchers to observe ongoing variability of performance, daily recording of students' performance enabled Precision Teachers and their students to identify and to take advantage of variables that cause changes in performance during the learning process.

Self-recording by students and sharing of results among teachers and students was another component of Precision Teaching that came from the methods practiced by laboratory behavior analysts who met frequently to share cumulative response records (Lindsley, 1990). The standard chart became a primary communication tool among thousands of Precision Teachers and their students, a means of sharing discoveries and cooperatively solving problems. As in the operant conditioning laboratory, Precision Teachers analyzed results and designed interventions for *individuals* while collecting and comparing individual records in the hope of identifying *general principles* of learning and performance. The Standard Celeration Chart (unlike conventional "stretch-to-fill" charts), because it allowed for direct graphic comparison among individuals and interventions, serves as an efficient tool for this purpose.

Early Precision Teachers used the categories of functional behavior analysis when analyzing and changing interventions. They distinguished between *operational* or *descriptive definitions* of events (antecedent events, movement cycles, and subsequent events) and *functional definitions* (stimuli, responses, and consequences), which could only be determined by changing events and continuing to measure behavior frequencies (Lindsley, 1964a) to determine functional relations among behavioral and environmental variables. Thus, for example, one would only call a subsequent event a "consequence" if measurement demonstrated that changing that event had an effect on the frequency of the behavior it was arranged to follow.

An extension of this functionalist approach, derived originally from the operant conditioning laboratory, was an emphasis on definition of behavior as *active*, and measurement of its *products* whenever possible. Precision Teachers applied the "dead man's test" to descriptions of behavior. "If a dead man can do it, then don't try to teach it." This rule helped teachers avoid setting teaching objectives such as "keeps eyes on paper" or "sits quietly in chair" which are *not* countable behaviors. Likewise, early Precision Teachers tried to measure "behavior tracks"—the results of behavior rather than the behavior itself—whenever possible. This principle was related to the recognition that automatic laboratory apparatus actually counted switch-closures caused by sufficiently robust movements on the part of laboratory subjects, and did not necessarily measure each of the subject's bar-presses. Precision Teachers, for example, could neither measure nor change the frequency of "feeling good." But they could certainly help students to increase their frequency of tallying "good feelings" during the day, a kind of behavior track. Gilbert (1978) expressed the same idea, perhaps more elegantly, by stressing accomplishments rather than behaviors as the proper subject of performance engineering.

Combining these principles and practices, Precision Teachers and their students have treated each project as an individual experiment, and for more than 25 years have continued to make discoveries about how to improve learning and performance in a broad range of student populations.

Research and Development of Precision Teaching

Early practitioners discovered that brief timed samples of academic performance (e.g., 1 minute per day) were sufficient for monitoring progress and making decisions, and that it is often unnecessary to record performance for longer periods, as had been the practice at the very beginning of the movement. Subsequently, most Precision Teachers began using daily 1-minute timed samples of performance for charting and decision-making (Kunzelmann, Cohen, Hulten, Martin, & Mingo, 1970; White & Haring, 1976).

One of the most significant contributions of Precision Teaching research was the use of *frequency aims* (Haughton, 1972; Wood, Burke, Kunzelmann, & Koenig, 1978; Koorland, Keel, & Ueberhorst, 1990). Because early practitioners were strongly influenced by operant conditioning and its applied offshoot known as "behavior modification," they initially viewed behavior frequency (response rate) as a "performance variable" to be arbitrarily increased or decreased through the use of consequences. However, when teachers began measuring behavior frequencies of academic skills (e.g., writing answers to simple arithmetic problems), they noticed that consequences were often not sufficient for increasing performance.

For example, while most students could achieve performances of 40 to 50 correctly written answers to addition problems per minute by engaging in daily practice, some seemed unable to move beyond 20 per minute. No matter what consequences teachers arranged for improving performance (e.g., tokens, praise, notes home, etc.), these low-rate performances remained below the desired levels. After discovering that these students' rates of writing and reading digits were considerably lower than the levels exhibited by successful students, Haughton and his associates found that by practicing the more elementary or "tool" skills (writing and reading digits) until they reached higher levels, students were able to attain higher rates of writing answers to problems.

The discovery that rate of correct responding in prerequisite skills, not merely the successful performance of prerequisites at any rate, is a limiting factor in the development of subsequent skills, became the driving force in curriculum-based decision-making among Precision Teachers. Later, Precision Teachers began using the term *fluency* to refer to accuracy plus speed of performance, a goal of Precision Teaching efforts at every level in a student's progress through any curriculum sequence (Binder, 1988). Precision Teachers have developed curriculum guides, assessment inventories, and decision-making strategies based on objectively determined aims or fluency standards established in many different curriculum areas (Starlin, 1972; White & Haring, 1976; Barrett, 1979). In discovering the importance of fluency, not mere accuracy, as a definition of true mastery, Precision Teachers confirmed findings from a broad array of other fields about the relationship between automaticity or "second nature" responding and improved retention, transfer of training, and "endurance" or resistance to distraction (Binder, 1987, 1988; Binder, Haughton, & Van Eyk, 1990). Going beyond mere confirmation of prior research about "overlearning" past 100% correct, Precision Teachers have been able to accurately measure required performance levels as count per minute frequencies and to explicitly plan for their differential effects on key outcome variables.

Another key development in Precision Teaching was the use of "learning screening" procedures for independently assessing performance levels and celerations (measures of learning as change in performance over repeated daily samples) on specific tasks to identify students at risk of failure in academic development. A massive project in Washington State (Child Service Demonstration Programs, 1974) collected approximately 150,000 daily performance frequencies of nearly 3,000 skills from 17,996 students in three school districts. Teachers charted 7 to 10 days of data per student per skill (3 to 5 skills per student) to determine median frequencies and celerations (measures of learning). Project staff defined problem learners as students with less than half the median class frequency or weekly celeration on a given skill. This procedure identified more than 70% of the students whom more costly and time-consuming procedures subsequently diagnosed as having learning problems. In a later study with preschool children (Magliocca, Rinaldi, Crew, & Kunzelmann, 1977), single "snapshot" measures of performance on a set of five elementary skills enabled teachers to identify 90% of the students who were subsequently referred for special services. Koenig and Kunzelmann (1981) showed that celeration, a direct measure of learning, is not racially discriminatory, while isolated performance frequency samples may correlate with racial or socio-economic factors since they represent levels of current achievement. Thus celeration may be the first truly unbiased measure of aptitude in the educational literature. A combination of performance frequency measures and celerations (change in performance per week of daily measures) may offer the most sensitive, cost-effective and culturally unbiased assessment framework, for defining performance standards and monitoring progress in schools—a subject of considerable debate among educators and policy-makers in recent years.

Precision Teachers have conducted extensive research on the process of instructional decision-making. In early practice (e.g., Freschi, 1974), teachers and students simply inspected charted data and made changes when frequencies of correct and/or incorrect performance were not changing in the desired direction. Liberty and her associates have conducted extensive research on the use of decision rules based on both levels and trends (celerations) of performance (Liberty & Haring, 1990). The use of projected trends on the standard chart (called *dynamic aims*) as guides for decision-making substantially increased the frequency with which teachers made instructionally effective program changes. The use of "learning pictures," named patterns formed by data on the chart used by students to decide if and how to change procedures, has been among the most powerful and effective strategies for decision-making in Precision Teaching classrooms (All, 1977; McGreevy, 1983; Lindsley, 1990).

Finally, Precision Teaching research and practice have revealed that the suppression of errors can often retard learning and that encouraging students to respond at very high rates from the beginning of their work on a given skill, even when most responses are incorrect, can significantly increase learning rates (Bower & Orgel, 1981; Lindsley, 1990). Thus, Precision Teachers call errors “learning opportunities” and often encourage students to take large “leap-ups” through curriculum sequences, making many errors and correcting the errors as an integral part of the learning process. McGreevy (1978) summarized this strategy with the slogan “Easy to do, hard to learn; hard to do, easy to learn.” Substantial published research supports the conclusion that placement on more difficult tasks can result in faster learning rates (Johnson, 1971; Neufeld & Lindsley, 1980; Scott, Wolking, Stoutimore, & Harris, 1990).

Effectiveness of Precision Teaching

Because data collection and analysis—the evaluation and revision cycle of systematic instruction—are inherent in the practice of Precision Teaching, every successful intervention adds to the Precision Teaching effectiveness database. Literally hundreds of thousands of charted instructional projects have demonstrated the effectiveness of this approach. Rather than attempting to demonstrate effectiveness per se, Precision Teachers are always striving to attain breakthroughs that improve on already impressive results. Lindsley (1990), for example, suggests that learning at the rate of doubling performance per week (a x 2.0 celeration on the daily chart) is a good benchmark for Precision Teachers. Steady progress at a x 2.0 celeration produces orders of magnitude greater net performance improvement than is typical in schools.

To confirm Precision Teaching effectiveness on measures that are commonly used and accepted in educational evaluation studies, the most widely cited demonstrations were conducted in Great Falls, Montana, during the early 1970s (Beck, 1979). Over a 4-year period students and teachers in the Sacajawea Elementary School engaged in 20 to 30 minutes per day of Precision Teaching, with curriculum and instruction that were otherwise similar to what was practiced elsewhere in the school district. Students advanced an average of 19 to 40 percentile points (depending on the subtest) on the Iowa Test of Basic Skills higher than comparable students elsewhere in the school district. These results were confirmed by the Joint Dissemination Review Panel of the U.S. Office of Education, and led to the Precision Teaching Project, a federally funded dissemination effort operated from Great Falls over a number of ensuing years. The improvements themselves are dramatic; but when cost/benefit is considered, they are staggering, since the time allocated to Precision Teaching was relatively small and the materials used (primarily standard charts and mimeographed practice sheets) were quite inexpensive. Improvements of two or more grade-levels per year of instruction are common in Precision Teaching classrooms (e.g., West, Young, & Spooner, 1990).

Current Efforts and Future Trends

Precision Teaching as a “movement” is still quite small in the context of mainstream education. One factor that may have prevented widespread adoption is that it has been developed primarily by practitioners, not by academics. Consequently, there have been relatively few publications about Precision Teaching because teachers, unlike academics, have neither the interest nor tangible incentives for publication. On the other hand, because it has been driven by classroom practice rather than by grant-supported or tenure-motivated research, Precision Teaching has advanced technically by leaps and bounds—based on daily practice and experimentation by thousands of teachers and their students. The result, after a quarter of a century, is a relatively mature and extremely potent set of discoveries and practices that are not widely acknowledged or accepted in the academic community.

Some states, districts and universities are Precision Teaching strongholds, (e.g., Utah, Great Falls, Montana, the Universities of Florida and Washington). A number of commercially available computer-based programs for instruction (e.g., Math Tutor marketed by Scholastic), for authoring and delivering instruction (Exemplar from BehaviorTech, Inc. in Irving, Texas), and for charting and decision-making (e.g., AC-CEL, developed at Utah State University and marketed by Precision Teaching Materials and Associates, Sarasota, FL) have been based on Precision Teaching principles and procedures. A small but active network of private schools and tutoring agencies (e.g., Morningside Academy in Seattle, Quinte Learning Centre in Ontario, Children’s Workshop in San Diego, Ben Bronz Academy in West Hartford, Evergreen Center in Milford, Massachusetts, Haughton Learning Center in Napa, California) exists for various student populations. The National Diffusion Network continues to support Precision Teaching, based on the Great Falls Precision Teaching Project. And a number of companies supply Precision Teaching materials and training (Precision Teaching Materials and Associates, Inc., in Sarasota, Florida; Behavior Research Company in Kansas City, Kansas). Precision Teachers gather annually for an international conference (most recently in Boston, November, 1990). And an increasing number of Precision Teachers are making an effort to communicate with a broader audience of educators, policy-makers, and business leaders. However, until there is greater demand for measurably effective methods in the public schools, this approach may continue to be a minority movement within the educational mainstream.

From the perspective of performance technology, Precision Teaching offers a critical set of tools for instructional planning, implementation, evaluation, and decision-making. Precision Teachers do not hesitate to experiment with a variety of different teaching methods and practice strategies, as long they can continue to measure and chart the effectiveness of such new approaches. Fluency aims represent a universal, objective standard for educational planning and evaluation. The practice of Precision Teaching is compatible with any other educational approach, given measurable objectives. There is reason to believe, therefore, that as educators and others become more desperate in the current mood of educational crisis, there may yet be an opening for greater use of this powerful, adaptable, and measurably effective instructional technology.

Direct Instruction

Direct Instruction (DI) is a research-based approach to instructional design and implementation based on over 25 years of development. It is an educational philosophy and a set of teaching procedures and programming principles derived from that philosophy. DI is best represented by over 50 commercially available teaching programs (the majority published by Science Research Associates) each of which has been field tested to ensure its effectiveness. In recent years some teachers and instructional designers have combined DI methods and materials with Precision Teaching. Like Precision Teaching, Direct Instruction encounters resistance among mainstream educators, often because of its detailed scripting of teacher's behavior. However, Direct Instruction has been consistently shown to support greater academic achievement, self-esteem and problem-solving abilities in children than any mainstream approach to teaching (Watkins, 1988).

Origins

With a background in philosophy, Siegfried Engelmann originally derived his approach to teaching basic academic skills to children from a *logical* analysis of concepts and operations followed by testing of teaching materials and procedures. The forerunner of Direct Instruction was the Bereiter Engelmann preschool program funded by the Carnegie Foundation during the 1960s at the University of Illinois at Urbana (Bereiter & Engelmann, 1966). This program produced dramatic effects with disadvantaged children (Engelmann, 1970) and a request for Engelmann and his associates to participate in Project Follow Through. Project Follow Through was a federally funded effort to identify effective teaching programs for students who are at high risk for failure. The approach to instruction developed in the Bereiter-Engelmann preschool was combined with the principles of behavior analysis to form Direct Instruction through Engelmann's collaboration with Wesley Becker at the University of Illinois. Engelmann and Becker later moved to the University of Oregon.

Strategies for Teaching More in Less Time

The Bereiter-Engelmann program was based on the assumption that disadvantaged children can "catch up" with their more affluent peers if they are provided with effective and efficient instruction. This "more in less time" notion is critical to the mission of Direct Instruction because even if students with academic deficits are taught with effective programs that result in their gaining at the *same* rate as more affluent peers, they will always remain behind. Only by teaching at a *faster* than average rate can the gap be closed.

Direct Instruction realizes the goal of teaching more in less time by using teaching procedures that maximize the time students spend in instruction and by developing materials that seek (whenever possible) to teach a "general case." A general case strategy is one that uses the smallest possible number of examples to produce the largest possible amount of learning. For example, by teaching 40 sounds and blending skills, Direct Instruction gives students a generalized decoding skill that is relevant to one-half of the more common English words (Gersten & Maggs, 1983). An important part of the analysis phase of developing a Direct Instruction program is identification of such general case strategies.

Direct Instruction Design Principles

According to Engelmann and Carnine (1982), designing instruction for cognitive learning requires three analyses: the analysis of behavior, the analysis of communications, and the analysis of knowledge systems.

The analysis of behavior seeks empirically-based laws or principles about how the environment influences behavior. This analysis concerns such factors as how to motivate students, how to present examples as part of instruction, how to prompt and reinforce responses and how to correct errors.

The analysis of communications seeks principles for the logical design of effective teaching sequences. These principles allow the designer to describe the range of generalization expected to occur when the learner receives specific sets of examples. The analysis of communications examines the samenesses and differences among sets of stimuli. It supports design of instructional sequences that prevent misrules, restricted generalization (failure to respond to appropriate examples), or overgeneralization (responding to inappropriate examples).

The analysis of knowledge systems seeks to logically organize or classify knowledge. In order for a classification system to have maximum utility for the instructional designer it must provide information about how to communicate skills to a learner. Because concepts that are structurally similar can be taught similarly, this analysis looks for similarities across seemingly different types of learning outcomes. The logical analysis of the structure of (knowledge forms) underlies Engelmann and Carnine’s theory of instruction (1982). They identify three major categories of cognitive knowledge which are presented in order from simple to complex: Basic Forms, Joining Forms, and Complex Forms.

Table 1

A Logical Classification of Knowledge Forms*

Knowledge Category	Type	Examples
Basic Forms (sensory-feature concepts)	Comparatives (one dimension)	louder, darker, longer
	Non-comparatives (one dimension)	• red, dark (object properties) • on, between (object relations)
	Nouns (multi-dimension)	truck, shoe, boy, pony
Joining Forms (logical or empirical relations between sensory-feature concepts)	Response transformations	• changing any adjective to an adverb by adding “ly” • add 1 to any number to get the next number

	Correlated features relationships (facts): • Concrete example—give feature • Label a set—give feature • Name substitution (synonym) • Given a class, tie to higher-order class	 • Hot air rises. This air is hot. Will it rise? Why? (It's hot.) • Mammals are hairy, warm-blooded, etc. Are these mammals? Why? (Name identifying features.) • When it's sunny I feel lazy? Say it with another word for "lazy." (When it's sunny I feel indolent.) • All cars are vehicles. Is this [car] a vehicle?
Complex Forms	Communications about events (fact systems)	• Describing the workings of the heart • Describing a baseball game
	Cognitive problem-solving routines (behavior chains)	• Long division • Applying any algorithm

*(from Engelmann & Carnine, 1982)

Classifying knowledge forms provides Direct Instruction programmers with a basis for designing instructional strategies that can be used repeatedly with similar forms of knowledge. In other words, it results in rules for teaching skills in each category. The specific program design principles are described in detail by Engelmann and Carnine (1982).

Juxtaposition Principles for Teaching Basic Concepts

An important consideration in teaching basic concepts is the selection and sequencing of examples and non-examples. The five juxtaposition principles for sequencing and presenting examples and non-examples illustrate the precision with which Direct Instruction programming principles guide the design and implementation of instruction (Engelmann & Carnine, 1982). Table 2 contains a script reflecting application of these principles. This 12-step instructional sequence is designed for initial teaching and testing of the concept "voiced sound." A similar sequence can be applied in the initial teaching and testing of virtually any single-dimension noncompartitive concept or operation.

Table 2

A Script for Teaching the Concept "Voiced Sound"

Step	Word	Type	What the Teacher Says
1	Mack	Non-example	"I'll say some words. Then I'll tell you if each word ends in a voiced sound. Mack. It doesn't end in a voiced sound."
2	Mass	Non-example	"Mass. It doesn't end in a voiced sound."
3	Maz	Example	"Maz. It ends in a voiced sound."
4	Mag	Example	"Mag. It ends in a voiced sound."

5	Mad	Example	"Mad. It ends in a voiced sound."
6	Mat	Non-example	"Mat. Does it end in a voiced sound?" (student responds)
7	Mass	Non-example	"Mass. Does it end in a voiced sound?" (student responds)
8	Mab	Example	"Mab. Does it end in a voiced sound?" (student responds)
9	Maff	Non-example	"Maff. Does it end in a voiced sound?" (student responds)
10	Mal	Example	"Mal. Does it end in a voiced sound?" (student responds)
11	Mat	Non-example	"Mat. Does it end in a voiced sound?" (student responds)
12	Mav	Example	"Mav. Does it end in a voiced sound?" (student responds)

Note: This table does not include procedures for reinforcing or correcting student responses.

We can summarize the five juxtaposition principles as follows.

1. *The wording principle* states that the teacher's wording should be as similar as possible across examples and non-examples. This helps focus students' attention on the details of the examples by reducing distraction or confusion that may be caused by variations in the teacher's language. Note in Table 2 the consistency in what the teacher says.

2. *The setup principle* is based on the logical assumption that anything that is the same across examples and non-examples rules out a possible incorrect interpretation. Therefore, examples and non-examples selected for the initial teaching of a concept should share the greatest possible number of irrelevant features. In Table 2 all examples and non-examples are words of similar length that have the same first two sounds. This eliminates the length of the word or the initial sounds as possible interpretations of "voiced sound."

Engelmann and Carnine (1982) maintain that using these first two principles in the initial sequence is most efficient. Later sequences introduce systematic changes in wording and setup to promote maximum generalization.

3. *The difference principle* states that in order to show the limits of a concept, we should juxtapose examples and non-examples that are similar to one another, and indicate that they are different. This sequence facilitates discrimination of concept examples and non-examples. Steps 5 and 6 in Table 2 illustrate the difference principle.

4. *The sameness principle* states that to show the range of the concept we should juxtapose examples of the concept that differ from one another as much as possible and indicate that they are the same. This sequence is intended to foster generalization to unfamiliar concept examples. Steps 3, 4, and 5 illustrate the sameness principle.

5. *The testing principle* calls for random presentation of new examples and non-examples to see if the concept has been learned. Steps 6 through 12 illustrate this principle and would in practice be followed by appropriate reinforcement or correction procedures, depending on students' responses.

Direct Instruction principles include similar principles for programming sequences to teach other types of knowledge and for teaching sets of related concepts (e.g., geometric shapes).

Direct Instruction Teaching Procedures

Certain features of the practice of Direct Instruction distinguish it from more traditional approaches. Some of the more salient features are described next.

1. *Scripted presentations*. Lesson scripts specify what the teacher says and does for each task. Scripted presentations support quality control of instruction. The particular examples and sequences in Direct Instruction programs have been pretested and empirically established as effective, ensuring the success of students who have mastered essential prerequisite skills. Most teachers lack training in instructional design and therefore are not likely to select and sequence teaching examples effectively without explicit directions. Without guidance, teachers may use language that students do not understand or that distracts students' attention from examples. Like Precision Teaching, Direct Instruction assumes that students learn or fail to learn because of effective or ineffective instruction. Direct Instruction places responsibility for learning in the hands of teachers and instructional developers, and does not "blame students for failure—as is so common in mainstream psychoeducational practice. Teachers are more likely to use effective instructional sequences when given explicit scripts for using field-tested procedures.

An additional advantage of scripted presentations is that they make it possible for supervisors to readily evaluate instruction and to provide immediate assistance to teachers, when needed. Scripts allow aides, parents, and other paraprofessionals to assume teaching responsibilities, resulting in increased quality instructional time.

2. *Small groups*. Direct Instruction lessons are typically taught with groups of 5 to 10 students. Small group instruction is more efficient than one-to-one instruction and provides the opportunity for more adult direction, attention, feedback, and individualization than large group instruction.

3. *Unison responding*. One of the goals of Direct Instruction is to generate high rates of responding by *all* students. If individual students are asked to respond to the teacher's questions, problems can arise. First, while the teacher is interacting with one student, other students may not be paying attention. Thus, students might only be learning some fraction of the time that they are actually in the learning situation. This is a waste of time that could be spent acquiring academic skills. A second problem is that when students respond in sequence rather than in unison, one student may copy the response of the preceding student The teacher has no way of knowing whether the second student has actually learned the answer or is merely imitating another student. These problems disappear when all students respond at the same time to each question posed by the teacher. Unison responding permits the greatest amount of practice for each student and provides the teacher with the maximum amount of information about each student's performance.

4. *Signals.* Teachers ensure simultaneous responding from all students by preteaching the entire group to answer on a particular cue or signal and then managing signaled unison responding throughout lessons. Some signals are visual (hand movements) while others are auditory (e.g., hand claps). The teacher's manual specifies how and when to signal for a given task. The signal is an evaluation tool: By having students respond in unison while listening to the responses of all students, the teacher can determine whether or not each student in the small group has truly mastered a particular skill. Signals make it possible to combine the benefits of one-to-one teaching with the efficiency of group instruction.

5. *Pacing*. Rapid pacing of instruction is important because it allows the teacher to present more material during each instructional period. This results in increased opportunity to learn, a variable that is clearly related to student achievement (Brophy & Good, 1986). In addition, brisk pacing helps to maintain students' attention to the task which may result in increased learning and fewer behavior management problems. In the process, it is also a way of encouraging fluent performance.

6. *Correction procedures*. While Direct Instruction materials are programmed to minimize student errors, some errors are inevitable. Errors provide the teacher with valuable information about the difficulties students are having. Errors tell the teacher that students need more practice applying certain skills, and corrections provide those additional teaching trials. Effective instruction includes effective correction procedures. Different types of errors call for different types of corrections. The procedures specified in the Direct Instruction teacher's script provide effective correction for each type of mistake. An

important part of the analysis, design, field-testing, and revision of Direct Instruction is the identification of error types and of appropriate correction procedures.

Shifting Aspects of Task Design

Because of its specificity and teacher scripting, some critics fault Direct Instruction as too rote, too artificial, or too teacher-directed, and, therefore, unlikely to produce generalized conceptual and problem-solving skills able to be applied by students without teacher prompting in novel situations. *In fact, students taught with Direct Instruction exhibit superior problem solving abilities* (Watkins, 1988). Design principles used by Direct Instruction developers for systematically shifting the characteristics of instructional tasks in the course of complete teaching programs prevent the problems anticipated by critics. Becker and Carnine (1981) describe six "shifts" that should occur in any well-designed teaching program.

The first shift is *from overtized to covertized problem-solving strategies*. Initially, teachers require overt responding at each step in the instructional sequence so that they can identify particular skills with which students have difficulty and apply appropriate reinforcement and correction procedures. Later, teachers may only require overt responding in some of the steps in a problem-solving sequence, perhaps only the last step. This shift facilitates transition from teacher-directed to independent problem-solving.

The second shift is from *simplified contexts to complex contexts*. In simplified contexts the teacher emphasizes the relevant features of a task, while in complex contexts students must apply knowledge under conditions that vary in irrelevant detail, thereby mimicking everyday problem solving situations.

The third shift is *from providing prompts to removing prompts*. Early in instruction supplemental stimuli, which are later removed, may be added to focus the learner's attention to relevant details of the presentation.

The fourth shift is *from massed practice (to encourage acquisition) to distributed practice (to facilitate retention).*

The fifth shift is *from immediate feedback to delayed feedback*, another condition that mimics everyday situations.

The sixth shift is *from an emphasis on the teacher's role as a source of information to an emphasis on the learner's role as a source of information*. Like the other shifts, this one enhances independent performance. Taken together, these instructional strategies help move students from fixed lessons to more generalized, independent, and real-world application of strategies and skills.

Taken together, these instructional strategies help move students from fixed lessons to more generalized, independent, and real-world application of strategies and skills.

Direct Instruction Research Background

Direct Instruction principles and procedures are supported by general principles derived from basic behavioral research as well as by the literature of effective teaching practices. In addition, a multitude of controlled research studies provide empirical support for the specific design principles and teaching practices used in Direct Instruction. These studies are summarized by Engelmann and Carnine (1982), and are also reviewed by Becker (1984), Becker and Carnine (1980) and Weisberg, Packer, and Weisberg (1981).

However, the most important research basis for Direct Instruction is field-testing of programs and analysis of errors. Logical analyses of what is to be taught and how to teach it guide the development of lesson scripts, which are then tested on students to see if they are effective. Effectiveness is measured in terms of whether the procedures produce the intended learning. Programs are systematically revised based on data from field tests. Most of the commercially available programs have gone through three revision cycles. Most Direct Instruction teacher-training manuals have been revamped four times (Becker & Carnine, 1981).

Effectiveness of Direct Instruction
Perhaps the most compelling evidence for the effectiveness of Direct Instruction is the evaluation of Project Follow Through (Watkins, 1988). A national evaluation compared the performance of children in over 20 different instructional models which represented the broad range of current educational practice. Although the evaluation has been controversial (see for example, House, Glass, McLean, & Walker's 1978 critique of the method of data analysis), it is generally acknowledged that the Direct Instruction model was clearly the most effective of all programs on measures of basic skills achievement, cognitive skills, and self-concept. (Many of the non-DI programs tested were actually *less* effective than typical public school programs used with control groups, yet some of these ineffective programs continue to receive funding at *higher* levels than Direct Instruction.) Other publications provide detailed descriptions of the findings for all of the Follow Through models (e.g., Stebbins, St. Pierre, Proper, Anderson, & Cerva, 1977), as well as for the Direct Instruction model in particular (e.g., Becker, 1977; Becker & Carnine, 1980).

Some researchers have tried to assess the stability of the effects of the Follow Through Direct Instruction model. For example, Becker and Gersten (1982) compared the scores of fifth- and sixth- grade students who had participated in Direct Instruction programs during earlier grades with the performance of similar non-Follow Through children. Direct Instruction students scored significantly higher on measures of reading and math in 50% of the comparisons made. In other studies, students who had participated in Direct Instruction programs during their first three grades were compared with similar students who did not participate. Results indicate that Direct Instruction students are more likely to receive high school diplomas, less likely to be retained in any grade, and less likely to drop out (Gersten, 1982; Gersten & Carnine, 1983; Gersten & Keating, 1983).

More than any other commercially available instructional programs, Direct Instruction is supported by controlled research studies. While it is not possible to summarize all of the research demonstrating the effectiveness of Direct Instruction, interested readers are referred to Becker's (1984) review of research with broadly divergent populations, in a variety of settings, in numerous content areas. The approach is also supported by studies conducted in Australia. Lockery and Maggs (1982) reviewed more than 30 studies conducted in Australia over a 10-year period. The impressive results of these studies provided the basis for changes in the way both normal and retarded children are taught in Australia.

Current Status and Future Directions
Advances in Direct Instruction program development continue to occur. Englemann-Becker Corporation (Eugene, OR) has developed DIAL (Direct Instruction Authoring Language), a computer-based training authoring system that incorporates DI design principles. Vachon and Carnine (1984) published criteria based on Direct Instruction for evaluating computer-based training programs. Programs are being designed that will apply Direct Instruction to math and science for high school and college students using videodisc technology.

Becker (1984) estimated that at least 5 million children in the English speaking world are currently learning with Direct Instruction programs. In addition, Direct Instruction has been introduced in seven African countries and there are adaptations of the programs operating in other non-English speaking countries. The Association for Direct Instruction (P.O. Box 10252, Eugene, OR 97440) publishes a newsletter, offers training on DI programs, and operates a state-funded preschool. Engelmann-Becker Corporation continues to develop commercial Direct Instruction programs and publish books, and research continues at the University of Oregon and elsewhere.

In spite of these advances and evidence suggesting the superior effectiveness of DI, educators continue to resist adopting Direct Instruction programs. Recently, Engelmann won a suit in the state of California directing the state curriculum board to base textbook adoptions on "learner validation"—a policy that had been legally mandated but not enforced (Binder & Watkins, 1989). Engelmann filed the suit when Direct Instruction programs, perhaps the most thoroughly tested of any commercially published teaching materials, were rejected for inclusion on the state approved textbook list. Engelmann plans further efforts in the courts while continuing to develop and refine Direct Instruction programs.

Combining Precision Teaching with Direct Instruction

More and more practitioners are combining the two technologies. While Direct Instruction is a powerful skill and knowledge acquisition technology, Precision Teaching offers superior tools for practice to the point of fluency, criterion-referenced assessment, and decision-making. The strengths of these methods complement one another. Teachers use Direct Instruction for initial teaching of skills and concepts, then use Precision Teaching materials and procedures to help students achieve high levels of fluency, beyond the acquisition criteria specified in Direct Instruction programs. Educators in public and private settings in Florida, California, Ontario, Seattle, and numerous other locations have used the principles and procedures of these two technologies to produce unprecedented academic achievement in their students. The Morningside Academy in Seattle, for example, reports that students who had previously progressed by only 2 to 3 months of academic achievement per year of public school instruction, as measured on standard tests, routinely improve by two full grade levels on two skills per month using a combination of Precision Teaching and Direct Instruction methods and materials (Johnson, 1989).

Conclusion

Precision Teaching and Direct Instruction are mature and extremely powerful instructional technologies that are fully capable of erasing America's "basic skills crisis" if widely adopted. Based on systematic methods and extensive research, these technologies are perhaps the most fully validated teaching tools ever implemented in American schools. At this time, very few educators or policy makers are aware of these methods, or of their measured effectiveness. Those who know about them often resist adoption for philosophical or political reasons. We believe that policy-makers, corporate and cultural leaders, and the general public will opt for measurably effective instructional methods, *if* they know of their existence. Hopefully this article will help to make a wide audience aware of these cost-effective educational solutions.

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