Fluency-Building™

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Fluency increases retention of knowledge, lengthens attention span, and ensures application of new learning. Here are the roots of this new approach, created by the author at Boston-based PT/MS.

Summary

Fluency is accurate, quick performance. It is what we recognize in the work of experts: doing, saying, or thinking the correct things without hesitation. PT/MS Fluency-building™ technology is a systematic approach to instructional design and evaluation aimed at producing fluency as efficiently as possible.

PT/MS Fluency-building technology is based on research from a variety of fields in education and psychology. This review surveys some of the most important contributions to that research and provides a brief history of precision teaching, the measurement-based instructional approach which gave rise to Fluency-building techniques.

Verbal learning and precision teaching research has shown that when people attain fluency in skills or knowledge they don't forget what they learn. In other words, fluency ensures "retention" of skills and knowledge.

Research by human information processing theorists, human factors engineers, and precision teachers has demonstrated that when people attain fluent skills or knowledge they can use what they learn for extended periods of time without fatigue, loss of attention, frustration, or distractibility. In other words, fluency increases "endurance" or attention span.

Research in reading, perceptual-motor learning and precision teaching has shown that when people attain fluent preskills or prerequisite knowledge they can easily become fluent in more complex or advanced skills or knowledge. When people do not learn to the point of fluency, they often cannot easily use what they have learned. In other words, fluency ensures the "application" of skills and knowledge.

Training without Fluency-building techniques may not be cost effective. Fluency-building bridges the gap between learning and truly useful performance.

Carl Binder founded Precision Teaching and Management Systems, Inc. in 1982 to develop Fluency-building technology for corporate training and development.

Fluency-building: Research Background

Introduction

Behavioral fluency is the combination of accuracy plus appropriate speed of performance which defines true mastery of any skill or human information process. Fluency is the same as "automaticity" or "second-nature knowledge." It represents the most easeful, efficient, and expert level of human performance and, as such, is the most desirable outcome of every training program or performance intervention.

However, to a large extent training and educational research has ignored the time or "speed" dimension of expertise, with a few notable exceptions. In studies of reading, Morse code, typing, and other so-called "performance" tasks, both researchers and practitioners stress the importance of speed. But in general, most curriculum and instructional design efforts for both children and adults ignore the time dimension, and therefore generally fail to produce fluency, or true mastery.

Though largely ignored,

there are clear results in various traditions of academic and applied research which indicate that speed (or pace) is an important dimension of every performance or learning outcome. This document reviews a few reports of those results, both published and unpublished, which have contributed to our understanding of fluency and to the development of PT/MS Fluency-building technology.

Multiple Sources

Our Fluency-building technology is based on research from different fields in psychology and education, including:

- Reading
- Operant conditioning
- Verbal learning
- Perceptual-motor learning
- Human information processing
- Human factors
- Precision teaching

Prior to the advent of precision teaching as an educational technology in 1965, no single field provided a context for applying what is known about fluency in a systematic way. In fact, as is common in academe, researchers and practitioners in any one of these fields often remain largely unaware of work conducted in the others.

As a discipline and field of research, precision teaching has repeatedly confirmed and extended what is known about aspects of human learning and performance studied by researchers in other fields. Precision teaching has also contributed a range of practical new developments and research findings which provide a foundation for PT/MS Fluency-building technology.

Precision teaching is based on daily measurement and charting of performance speed and accuracy in individualized learning projects. It has given us a set of measurement tools for studying the effects of instructional procedures on behavioral fluency in human learners. Thus, precision teaching has integrated and advanced our understanding of fluency, leading to the development of a practical technology based on that understanding.

Overview

The remainder of this review falls into two sections:

I. A survey of selected research, organized according to three critical learning outcomes: retention, endurance, and application.

II. A brief history of precision teaching research and development.

I: Retention, Endurance, and Application

Training and management efforts represent investments in human performance. In order to reap a reasonable return on that investment, we would like to be able to ensure at least three critical learning outcomes, no matter what performance we seek to create or improve.

First, we want people to retain, or remember what they have learned. A common result in both school education and adult training is that learners forget much of what they have supposedly learned. A 50% loss of information a few weeks after training is not unusual (Bower and Orgel, 1984). A satisfactory return on training investment demands better retention than this.

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Second, we'd like trainees to emerge from training with a sufficient level of skill or knowledge to continue to perform at acceptable levels for extended, useful periods of time. We call this outcome endurance. It is related to "attention span" and distractibility. The common experience is that until people reach a certain level of skill or knowledge mastery, they may experience mental or physical fatigue, or frustration, after only short work periods. In order to put new learning to use, people must emerge from training with sufficient endurance or resistance to distraction to use new skills or information without undue fatigue.

Third, for training to be worthwhile, people must be able to apply what they learn. Typically, individuals emerge from training programs with an "understanding" or "comprehension" of the course content; but often they cannot really apply what they have learned to more complex situations, problem-solving, etc. Any investment in performance must result in efficient application of skills.

Precision teachers have defined performance criteria, sometimes known as "REAPS" (Retention-Endurance-Application Performance Standards), which ensure these critical outcomes (Haughton, 1980). Research supports the conclusion that performance criteria in training programs must include the time or speed dimension, not merely accuracy or quality measures. Only by defining what we call fluency standards can we ensure Retention, Endurance, and Application of new learning.

Retention

How well do you recall information about a given topic (e.g., features of a particular product), or remember how to perform a given skill (e.g., formatting a document in your word processor)? Your answer depends to a large extent on how well you learned it in the first place and how much practice you've actually done.

Studies of retention in verbal learning were among the earliest systematic research in experimental psychology. Even before the turn of the century, laboratory psychologists taught people arbitrary associations between words or nonsense syllables and then tested to see how accurately they could recall the associations later. The general findings were that people could retain more of what they had learned with "overlearning," or added practice, beyond the point of 100% accuracy.

However, because they only tested for accuracy (percentage correct), these scientists were unable to directly measure performance improvements beyond the point of 100% correct—even though they knew that practice beyond that point produced greater retention. Charles Osgood (1946) conducted several verbal learning studies in which he tested for speed as well as accuracy. He presented a printed word or syllable and measured the time until the person responded with the correct (or incorrect) word. With more sensitive timing devices than his predecessors he was able to accurately measure very short periods of time between verbal stimuli and responses—fractions of a second. He found that with so-called "overlearning" practice beyond the point of 100% accuracy, people increased the speed with which they were able to respond. Already knowing that overlearning produces better retention, he was the first verbal learning researcher able to say that greater retention is associated with faster responding.

More recently, Bower and Orgel (1984) conducted research with students at Wayne State University. They compared teaching methods which required students to meet both speed and accuracy criteria with more conventional methods requiring only accurate responding. Not surprisingly, this research showed that 5 weeks after the end of the term, students who had met fluency criteria could accurately recall nearly twice as much of the course content as the others.

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These results confirm what is already our common experience. The skills or information which we retain best are those which have become fluent, automatic, able to be used quickly and without hesitation.

Endurance

How easily can you continue to perform a skill or use information for an extended period of time without becoming distracted, frustrated, or fatigued? Again, the intuitively obvious answer is that we are most comfortable and can maintain our attention best with fluent skills or information

Think about your initial experiences with accounting, playing a musical instrument, or perhaps using a word processor. When you merely learn to do something correctly, before you have attained appropriate speed, you are highly susceptible to distraction—easily taken away from the task by the slightest interruption. In fact, continuing to perform a skill or to use information which is not yet fluent can become downright unpleasant after an extended period. This is the dimension of endurance, addressed by studies in human information processing and precision teaching.

LaBerge and Samuels (1974) reported studies of what they called "automaticity" in reading—another name for fluency. They were working in the context of Human Information Processing theory, discussing their results in the language of computer metaphors for thinking and behavior. They hypothesized that when verbal associations become "automatic," practiced to the point where the learner no longer needs to think (or "pay attention") before responding, they should become highly resistant to distraction while requiring less time for processing. They found that after sufficient amounts of practice beyond the point of 100% accuracy, people could respond quickly and accurately, without being distracted or slowed down by unexpected events arranged by the experimenters. They concluded that "training beyond the accuracy criterion must be provided if the association is to occur without attention"—automatically (p. 307).

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Related findings in Human Factors Engineering suggest that when the the environment (e.g., slow computer operation) prevents people from working at an optimal pace, they experience frustration and fatigue (Spencer, 1987). In other words, when procedures or other environmental factors impose a "ceiling" on performance, people experience endurance problems. Fluency research indicates that when a lack of fluency in prerequisite skills or knowledge imposes a ceiling on an individual's performance, this dysfluency may cause a negative experience and distractibility, similar to when external factors limit performance levels (Binder, 1978).

Binder (1979) explored the relationship between fluency and distractibility in a series of laboratory and classroom studies. In one experiment, subjects learned to say specific numbers when presented with arbitrary printed Hebrew characters. They then performed "addition" problems by stating the "sums" of pairs of these Hebrew characters as quickly as possible. They wore audio headphones as they performed the addition task, and sometimes heard a voice saying random digits as they attempted to maintain the pace of "adding" the Hebrew characters. At first, when they had merely learned the associations to the point of 100% accuracy, the distracting auditory number-reading almost completely disrupted the addition, slowing it down nearly to a stand still. As they continued to practice the basic associations between Hebrew characters and numbers, gaining fluency, they became capable of performing the addition task at a constant pace, despite distracting input from the headphones. In short, fluency in the basic associations produced resistance to distraction during the more complex task. This finding conforms to our everyday experience. For example, we can watch TV without disruption while using fluent skills or information, but not when doing something that is still new and difficult.

In classroom studies, Binder (1980) measured the relationship between fluency and the ability to maintain a given performance level for an extended period of time. He found that students who could perform simple math skills relatively quickly and accurately for short periods could maintain their performance levels for longer periods. On the other hand, those who performed accurately but with hesitation for short periods experienced difficulty, including negative emotional states, when required to continue working for long periods without interruption. The message is that repeated short practice periods may be better than long ones in the beginning of any learning process. With added fluency comes increased endurance.

Application

Early experiments in perceptual-motor learning (e.g.,Gagne and Foster, 1949) demonstrated that when learners become fluent on parts of a task, they can more easily become fluent when combining those parts into more complex tasks.

Haughton (1972), one of the founders of precision teaching, made a major instructional design breakthrough in field studies of children's learning in the classroom. He found that simply knowing "how to do" a prerequisite or component skill correctly or accurately was not sufficient preparation for mastering more advanced or complex skills. For example, students who were unable to write answers to simple arithmetic problems as quickly and accurately as their more competent peers did not improve when teachers used a variety of reward systems or required extensive practice on the arithmetic skills themselves. When teachers assessed more elementary or "tool" skills, such as reading numbers and writing digits, they found that the students could perform them accurately, but far less quickly or fluently, than their peers. With added practice, these students were able to attain fluency on the elementary skills with relative ease, and then proceed to apply them to more complex problems.

Fluency on product knowledge facts improved sales performance by 20% while cutting training time in half.

Repetitions of this basic procedure in a range of skill areas—ensuring fluency on prerequisites before expecting fluency on advanced skills or information—has produced remarkable results for thousands of students previously thought to have "learning problems." Binder (1979) taught severely retarded people to follow written directions by providing fluency practice on elementary sight reading and spoken instruction- following. Pollard (1978) taught previously "unteachable" multiply handicapped students to perform a range of self-care and work skills by providing fluency practice on components before expecting fluency on more advanced skills.

Daniels-Blakeslee (1985) demonstrated that fluency in typing simple computer keyboard patterns supported the development of fluency on more complex keyboard operations. Orgel (1984) showed that fluency on product knowledge facts could improve sales performance by 20% while reducing training time by half. Orgel (1984) demonstrated that University students could learn to solve complex calculus problems more easily when they had attained fluency on basic formulas and rules.

Haughton (1982) developed an analogy based on chemistry to help communicate this relationship between fluency on component skills or information and the application of components to more complex tasks. He likened the components to chemical "elements" which combine to form "compounds." The idea is that skill or knowledge elements combine in ever-increasing complexity to form compound skills or information. Fluency in elements supports their combination, or application to compounds.

All of these results conform to our common experience. Whenever you learn a complex skill or information process—whether using computer software, learning martial arts, playing a musical instrument, or any other complex skill or information process—you'll do best if you master the elements first. If you do not attain fluency on the elements you'll face increasing difficulties when applying those elements in more complex situations.

Thus, fluency bridges the gap between learning and acceptable performance. It allows what we learn to become useful. In attaining a useful level of skill or knowledge, we increase the likelihood that we will continue to apply what we have learned and consequently maintain the skill or knowledge over time.

II: A Brief History of Precision Teaching

Precision Teaching traces its origins to the methods of "free operant conditioning" developed by Skinner (1938) in the first half of this century. The key to his methodology, also called "an experimental analysis of behavior," was the use of rate or frequency measures of behavior. He used automated laboratory equipment to count and time behaviors. His standard measure of performance was response rate per minute.

After years of laboratory research with animals of many species, Skinner and his graduate student, O.R. Lindsley, opened a laboratory at the Harvard Medical School to study the behavior of chronic psychotics, the first full-scale human operant conditioning laboratory in the world (Lindsley & Skinner, 1954). For over ten years Lindsley conducted hundreds of experiments with both psychotic and normal human subjects, and published dozens of research articles in medical and psychiatric journals. He developed such refined methods for monitoring and predicting the rate of human behaviors that he could, for example, measure the effects of two aspirins on performance. He made contributions to behavioral pharmacology (the study of drug effects on behavior), advertising research, the analysis of psychiatric symptoms, and many other fields and sub-fields—all based on response rate measures of behavior.

In 1964 Lindsley left the psychiatric field at Harvard to apply rate measures in special education classrooms at the University of Kansas (Lindsley 1964,1972). He trained graduate students and teachers to measure behavior rates, or frequencies, in the classroom and to use daily measurement and charting as a tool for individualized educational decision-making. He called this new endeavor "Precision Teaching," and worked with a small number of colleagues and students to disseminate the method throughout the country. Haughton (1972), one of Lindsley's first graduate students, made his breakthrough discovery about fluency and application of skills while working with teachers in Washington, Oregon, and California. Trained in the tradition of "behavior modification" and operant conditioning, these pioneers originally believed that rates of behavior, including such behavior as reading, writing, and arithmetic, could best be changed by altering their consequences. Give Johnny a hug or a piece of candy when he works faster. Give Mary a gold star or a nickel when she increases her rate of correctly spelling words. What they did not yet realize is that factors other than consequences (rewards and punishments) affect changes in behavior frequencies. They didn't yet understand that changes in the frequency—degree of proficiency—of one skill or information process could alter learning rates for other skills or information.

The big discovery, as outlined in the first section of this review, was that the rate at which a person can perform a given skill is limited by the rate at which he or she can perform its components or prerequisites.

Moreover, it became clear that we can identify fluency standards, (or "aims") which define expert levels (or ranges) of performance for each skill. With this discovery, the real power of precision teaching emerged. It became very important to measure fluency (expert performance) in order to know how to teach or attain it. By adding the time dimension to traditional criterion-referenced instruction, precision teaching provided the means for defining and achieving true mastery of skills and information.

Teachers and therapists throughout North America devised curriculum sequences based on the principle that fluency at each step requires fluency at each previous step (Starlin, 1972). Thousands of students timed and charted their own performance on hundreds of different skills on a daily basis. Administrators and researchers developed assessment techniques which could sensitively predict students' success or failure, based on only a few one-minute timings of the performance of selected skills (Magliocca, Rinaldi, Crew, & Kunzelmann, 1977). Barrett (1979) showed that only by monitoring performance speed, in addition to accuracy, was it possible to measure differences between normal professional adults and severely retarded institutional residents on a range of simple pre-academic and prevocational skills. There were large differences in speed of performance, but both normal and severely retarded people were able to perform with 100% accuracy. The implications for assessing skills and information, in general, were profound. The conclusion was that without attention to speed, it would be impossible to detect critical differences in proficiency.

Having discovered this powerful new set of tools and principles, teachers and administrators began to see remarkable improvements in their students' learning rates and performance levels. Perhaps the most thorough study of instructional programs based on fluency practice and daily measurement was the Precision Teaching Project in Great Falls, Montana (Beck, 1979). At the Sacajawea School, students in all grades performed fluency practice and measurement each day for a total of 20 to 30 minutes in a variety of skill areas. At the end of 4 years their average Iowa Test of Basic Skills Achievement scores had risen between 20 and 40 percentile points as compared with those at all the other schools in the district. The magnitude of this effect is unheard-of in the educational literature. A Federal study validated these results and a federally funded training program introduced precision teaching to teachers and administrators throughout the country. However, very few schools or school districts adopted precision teaching methods as more than a passing trend. The message seemed to be that the public education system does not place a high priority on results.

The bulk of this pioneering work went unpublished since most of it occurred in classrooms in the process of day-to-day teaching activities. For about 6 years, the Data-Sharing Newsletter (Binder, 1977-83) served a communication function for several hundred precision teachers around the world. The Journal of Precision Teaching arose in 1980 and precision teachers met at various national and regional conferences. But mostly they shared charted data, not written reports. Lindsley sometimes described precision teaching as "putting science in the hands of the practitioners," most of whom had little interest in publishing.

During the late 1970's, Lindsley and a few of his colleagues began seeking other areas to apply the principles of precision teaching. In part because the human services and public education establishments seemed so unresponsive to demonstrated improvements in learning and performance, a few precision teachers became interested in corporate training. Because the measurement system underlying precision teaching applies to performance of all kinds—not just in instructional settings—this move seemed natural and inevitable (Binder, 1980). Having already extended precision teaching into college and graduate school classrooms (e.g., Merbitz & Olander, 1980; Bower & Orgel, 1981), precision teachers reasoned that the next step might be to teach adults in the workplace.

Binder, who had published the "Data-sharing Newsletter" and studied or worked with Skinner, Lindsley, Barrett and Haughton over the course of a decade, had a broad overview of the field and its various aspects and applications. In 1982 he founded Precision Teaching and Management Systems, Inc., to bring the methods of precision teaching, and a range of related performance technologies, into the corporate environment.

Unprecedented improvements in learning and performance are possible...

PT/MS continues to develop this approach...

Remarkable results are our expectation for the future.

The PT/MS Fluency-building technology has been an outgrowth of years of research and development, combining both precision-teaching and research from other fields, some of which was reviewed in Section I. Aimed at producing fluent skills and knowledge as efficiently as possible, it uses Haughton's (1977) "Learning Channel Matrix" approach to curriculum design and a broad range of principles from both laboratory and classroom research.

Although the emphasis so far has been on technical training ("hard" skills and knowledge), the principles of fluency apply equally well to so-called "soft" skills development. Being able to "respond with feeling" without hesitation, for example, is as amenable to a Fluency-building approach as is a more easily definable technical skill. The challenge is to find applications and markets in which the technology can be expanded and refined.

Conclusion

The guiding principle for all fluency research and development is measurement. Fluency-building methods evolve as we discover new ways to produce the desired result: fluency, or true mastery of skills and information, defined as accuracy (or quality) plus appropriate speed (or pace) of performance. Not wedded to any theory, this approach offers a context in which to improve all of our efforts to produce productive, satisfied learners and performers in both industry and in the educational system.

We know from such studies as the Precision Teaching Project (Beck, 1979) that unprecedented improvements in learning and performance are possible with the systematic application of these principles. PT/MS continues to develop this systematic approach in the context of business and industry. Remarkable results are our expectation for the future.

Dr. Carl Binder is President of Precision Teaching and Management Systems, Inc. (PT/MS), of Newton, Massachusetts, a human performance consulting firm. He is also President of the Massachusetts Chapter of the National Society for Performance and Instruction (NSPI). He studied with B.F. Skinner at Harvard University, was Associate Director of a university-affiliated human learning research lab for 10 years, and founded PT/MS in 1982.

PT/MS develops both "high tech" and "low tech" solutions to learning and performance problems in a range of industries and organizations, with measurable results. Call Dr. Binder at (617)332-2656, or write to him at PT/MS, Inc., P.O. Box 169, Nonantum, MA 02195.

Glossary

Aims: A term used by Haughton to describe fluency standards, count per minute performance levels (or ranges) which serve as goals for students using precision teaching to manage their own learning.

Application: The ability to apply what one has learned to learn or perform more complex or advanced skills or information processes. Known as "transfer of training" in the traditional learning literature.

Automaticity: A term used by Human Information Processing theorists to describe the level of performance at which attention is no longer required to perform, and distractibility is at a minimum. Equivalent to fluency.

Behavioral fluency: The level of performance exhibited by experts which combines high accuracy or correctness plus appropriate speed or pace. Supports retention, endurance, and application of skills or information.

Endurance: The ability to maintain a level of performance for an extended period of time, without distraction, fatigue, or negative emotional states. Related to what has traditionally been called "attention span." Associated with fluency.

Experimental Analysis of Behavior: The method, developed by B.F. Skinner, which uses response rate measures of behavior and single-subject experimental design (rather than statistical groups design) to study functional relations between the behavior of organisms and environmental events. The experimenter learns about behavior by systematically varying environmental events and continuously measuring behavior to identify causal relationships.

Fluency-building™ technology: A systematic approach developed by Precision Teaching and Management Systems, Inc. for measuring and producing behavioral fluency.

Fluency Cards™ learning materials: A trademark held by Precision Teaching and Management Systems, Inc., referring to a type of practice cards and the method for using them as one aspect of its Fluency-building technology. Used according to a specific set of procedures with daily measurement and a fluency standard.

Fluency standards: Count per minute performance levels (or ranges) which serve as goals for Fluency-building activities, and which define behavioral fluency for a given exercise. Also known as "aims." Human Factors (Engineering): The study how humans interact efficiently with the environment. Related to ergonomics.

Human Information Processing Theory: A theoretical framework in psychology and education which uses computer information processing models to represent human behavior and nervous system operations.

Information process: Any behavior involving what is conventionally called "information" such as reading, thinking, problem-solving, etc. An imprecise reference to covert verbal behavior.

Learning: A change in performance over time.

Operant conditioning: The process, defined and investigated by B.F. Skinner, whereby the probability of behavior is governed by its consequences, e.g., reinforcements and punishments. Skinner used rate per minute of behavior as the measure of probability.

Perceptual-motor learning: Leaning, and the study of learning, which combines complex visual or auditory stimuli with motor responses.

Performance: Count per unit time of behavior or accomplishments, e.g., words written per minute, dollars earned per month.

Precision Teaching: Use of count per minute measures and the Standard Celeration Chart for instructional evaluation and decision-making. Originated by Ogden Lindsley in 1965 in collaboration with Beatrice Barrett, Eric Haughton, Harold Kunzelmann, Ann Duncan, et al.

Retention: Remembering, or the ability to perform a skill or recall information at a later time. The opposite of forgetting.

Second-nature knowledge: Knowledge (or skill) which is so well- learned that it is virtually automatic, capable of being used without thinking or hesitation. The same as fluent knowledge or skill.

True mastery: The level of performance (skill or knowledge) which defines a true expert. Without specifying a time dimension (pace or speed of performance), in addition to accuracy or quality, it is impossible to define true mastery.

Verbal learning: The study of learning "verbal" associations or series. One of the oldest branches of experimental psychology.

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