A COMPARISON OF
PRECISION TEACHING METHODS WITH AND WITHOUT ERROR URGING

BY

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ABSTRACT

Previous research has shown that students will not make errors in math freely. If students were encouraged to make errors, would there be an increase in learning? Would students remember the material longer? Would they feel any different about what was learned?

Forty-five ninth grade general math students were the subjects of this study. The purpose of the study was to compare the effectiveness of precision teaching—encouraging errors, with precision teaching, discouraging errors.

The study was divided into three phases. Phase I (regular math) used math at grade level and compared two timings for each student each day. Only correct answers were counted in one timing (exact) but answers within 5 were counted in the other timing (close). Phase II (step-up) involved math that was one grade level more difficult and was graded by counting answers plus each digit correct in one timing compared with answers plus digits correct to the first mistake in the other timing. Phase III (leap-up) involved math problems two to three levels above grade level. The students were not given instructions as to how to solve the problems. This phase was graded by using exact compared with close scoring.

At the end of the study, 84% of the students were making errors in the challenging (leap-up) curriculum with error encouragement as opposed to 2% making errors with error discouragement. This difference was statistically significant at the 6×10^{-17} level.

The results of this study clearly demonstrate that the greatest amount of learning takes place when students are both _challenged_ and _encouraged_ to make errors.

ACKNOWLEDGEMENTS

I am grateful for the opportunity to express my sincere appreciation to Dr. Ogden Lindsley, for his patient assistance throughout this study. His generous support, encouragement, and dedication to education were a real source of inspiration.

My gratitude is also extended to my husband Tom, for his moral support, and to my son Courtney for his delightful distractions.

V.L.P.

There is only one person with whom you can profitably compare yourself, and this person is yourself, yesterday.

---Unknown

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Introduction

The effective teacher must be continually engaged in a process of assessing where we are, looking back at what has been learned, and anticipating future needs. The awesome responsibility that is the teacher's is never clearer than this bit of elementary arithmetic--the child of age 15 will be at a productive peak in say twenty years. Can I possibly predict about the specific educational needs of the next millenium? I don't know. But this is exactly the point. Our job must be to prepare our students for the non-routine, for the unforeseen, the unfamiliar, and the uncertain. Lists of highly specific skills and knowledge will not suffice as objectives.

Neither is it enough to say that we must teach problem solving. The development of problem solvers has always been an implicit goal of education, though no generation can be particularly prideful of its record in attainment. What is important to recognize is that not only do problems change over time, but so do the methods, tools, and knowledge required for their solutions. We cannot be satisfied to teach routines and formulas for the solution of today's problems and hope such routines will apply to tomorrow's.

Students must learn to learn, and to go on learning independently; to be experimental and flexible. They must be encouraged to hazard a guess and a try, to select and test alternatives, to be both reflective and tenacious. Thoughtful conceptualization of problems should be more highly valued than just correct answers obtained by memorized techniques.

Are present math programs producing students who are challenged by the unfamiliar, turned on by the chance to leap in and grapple with a new unstructured situation? Or are they producing rigid, formula obsessed mock-calculators who are immobilized unless they know a rule, and who will not tackle a problem unless they have seen a solution to one like it?

Too much evidence points to the latter. The 1979 publication of the results of the National Assessment of Educational Progress indicated that while students are doing well in routine computational skills, their abilities to apply these skills are woefully deficient. Where thinking and reasoning were called for, the students all too often appeared to be, to put it bluntly, "out to lunch."

How do we teach a child to think? To explore? I'm not so brash as to suggest that I have the answer. But I am convinced of this—children will not develop their potentials in higher order mental processes unless they are rewarded for, encouraged to, and given ample opportunity to do their own thinking. The mind must explore, experiment, and expand.

In talking to Dr. Lindsley about precision teaching, I was very eager to try and show that students actually learn more when they are allowed and encouraged to make mistakes. I didn't realize at the time how difficult it would be to get students to make errors in math. However, Cryss Clark (1979) showed this to be true even at the kindergarten level.

In my review of related literature, I investigated research involving studies of precision teaching, errorfull and errorless learning, and methods of teaching math concepts.

Review of Literature

Precision teaching research springs from the animal research done by B. F. Skinner (1938). His major contribution to operant conditioning is the use of frequency of response as a behavioral measure (1968).

Psychiatric wards presented the first major opportunity for the behavioral scientists to try modifying the behavior of humans (Lindsley, 1956, 1959, Isaacs, Thomas and Goldiamond, 1960). These researchers soon discovered that not only the behavior of adults, but also that of children, fell under the same rubric governing other animals' behavior.

Lindsley (1964) following Bijou's (1962) lead in applying reinforcement theory to classrooms moved from using frequency to record the behavior of institutionalized adults to using behavior frequencies in the classroom. Three major rationales prompted this move:

1. Prevention and remediation of adult psychosis begins with providing sound, healthy environments for children.

2. The classroom and/or the home afforded the most realistic setting for implementing management procedures designed for this purpose (Lindsley, 1967).

3. The classroom applications were not using frequency of response as a behavior measure. Lindsley wanted to correct this neglect of the greatest contribution of operant conditioning and to test frequency advantages in the classroom (Bijou, 1962, 1963).

First teacher reports clearly indicated that the major concern centered around decelerating pupils' disruptive behaviors. Talking out,

out of seat, pushing in line, hitting, etc., headed the list of behaviors with which they needed help (Lindsley, 1966). Maintenance of discipline, and not development of more efficient and effective instructional methods, received more teacher attention than it deserved. Behavior modification research conducted in classroom settings also reflected this concern.

Warren (1967) found that "talk-outs" decelerated when Kathy, a normal third grade girl self-applied and wore a surgical mask 5 minutes after each inappropriate talk-out. Edwards (1969) developed effective deceleration procedures; eliminating both talk-outs and out of seat in a class of learning disabled pupils. Forfeiture of points, telecoaching, withdrawn teacher attention also effectively decelerated inappropriate behaviors: talking out, jerking, and making animal noises (Koenig, 1967). Free time from schoolwork contingent upon remaining seated in the classroom decelerated out-of-seat behavior (Osborne, 1969). Token reinforcement programs also proved successful in reducing disruptive behaviors (O'Leary and Becker, 1967, 1969).

Other researchers also reported effective disruptive behavior modification in classroom settings (Madsen, Becker, and Thomas, 1968; Ward and Baker, 1968; Hall, Panyan, Rabon, and Broden, 1968; Wasik, 1969; Schmidt and Ulrich, 1969).

During the same period, researchers in the laboratory showed that manipulation of reinforcement conditions produced characteristic changes in reading rate (Staats, et al., 1962, 1964, 1965; Whitlock and Bushell, 1966; Whitlock, 1966). Schutz (1968) demonstrated that fixed interval reinforcement created highly stable reading rates. Other schedules, variable-interval and variable-ratio, produced and maintained steadily accelerating reading rates.

However, just as the modification of deviant and inappropriate behaviors moved from psychiatric wards into special education and public school classrooms, measurement and modification of curriculum-oriented behaviors moved from the laboratory into these more characteristic settings.

Academic performance rates showed the effects of booths, teacher planning, and a bad day for the teacher upon the pupils in a class for the emotionally disturbed (Johnson and Lindsley, 1965). They provided an excellent measure of student teacher effectiveness (Johnson, 1967; Caldwell, 1967; Koenig, 1967). Lovitt and Curtis (1969) showed that higher academic response rate occurred when the pupil selected the contingency requirements than when the teacher selected them.

Lovitt and Curtis (1969) demonstrated that a pupil's arithmetic rate correct accelerated and his rate wrong decelerated when he verbalized the problem before making a written response. Daily arithmetic rates proved sensitive indicators of the effectiveness of the motivational "first-aid" program designed by the classroom teacher (Schroer and Johnson, 1968). They also served as the basis, when compared with standardized IQ and achievement test results, for the statement that teachers attend more to test results than to daily performance when selecting gifted pupils (Johnson, 1967).

Edinger (1969) used pupil reading rates (correct and wrong) as his major tool for evaluating the Sullivan reading program. He found diagnostic test performance rates reliably different from program rendered performance rates. He also found placement-test performance an unreliable index for placement of the child in the program.

Edinger found that when presented with an accelerating consequence for correct responses, the pupils' programmed reader rate to correct accelerated. When this consequence was withdrawn following each incorrect response, the rate wrong decelerated (Edinger, 1969).

Johnson (1971) showed in an after-school program that students benefitted substantially from the remedial effort of an acceleration comparison program. Not only did they gain, on the average, a full year's advancement in their achievement level; they also gained an additional one-half year in their previously accumulated deficit.

Today, precision teaching can be defined as a system of monitoring weekly learning (i.e. the change in the growth of a particular performance). It is a unique system in that it measures not only performance, but also improvement in performance: learning. The system involves charting performance in terms of its learning characteristics, and adjusting the learning environment in accordance with information gained from the charts. These data-based decisions to improve teaching are the products of Precision Teaching.

The first requirement of the system is that an academic or social performance be functionally defined. In Precision Teaching, the process of specifying objectives is called "pinpointing" and the objectives pinpointed are functional "movement cycles." An objective that is defined as a movement cycle will be countable, contain action, and be repeatable.

For example, "saying words" is a movement cycle which is the source of an objective that may be stated as: "to accelerate saying words from 10/minute to 90/minute by March 10."

Movement cycles are measured in terms of their frequency, i.e. occurrence per minute. Frequency is used for many reasons. One reason is that frequency is something all performances have in common and therefore can be used as a universal measure. A second is that frequency is sensitive to changes in the environment. A third is that when frequency is charted properly, both speed (frequency) and accuracy (percent) are retained.

For the purposes of communication and analysis, data are usually recorded as a standard chart (Figure 1). This chart is designed so that frequencies are plotted in terms of their proportional relationships to each other. Since Precision teachers usually use the same chart and similar charting conventions, communication is increased both within and between schools. Most important, however, are the features of the standard chart that allow accurate data analysis in terms of both frequency (performance) and celeration (learning). The design of the chart assures that relative changes in frequencies are displayed such that "... you can project the future course of behavior by drawing a straight line through the middle of the daily frequencies you've charted. The direction of this line shows whether the frequency of performance is increasing, decreasing, or remaining the same." (Lindsley, 1971).

The Standard Celeration Chart is a graphic measuring device with an equal add scale across the bottom and an equal-multiply scale up the left.

The lines running horizontally from the bottom to the top of the chart are arranged the same distance apart as the C and D scales on a slide rule. The C and D scales are used to multiply and divide. These distances between the horizontal lines can be understood only in a multiply-divide dimension (Pennypacker, Koenig, Lindsley, 1971).

The vertical lines numbered from 1 through 140 are lines representing calendar days. The heavy vertical lines represent Sundays and separate the weeks. The lighter printed vertical lines represent the other six days of the week.

The distance between the lines is standard. The two dimensions that standardize the chart can be defined as frequency distances and time distances. These two dimensions can be abbreviated by number/minute, number/day or number/week. Since both coordinates are standard, the slope or celeration is also standard. Any line parallel with a line from the lower left to the upper right corner is times 2 or doubling every celeration period. The lines from the upper left to the lower right is divided by 2 or halving every celeration period. This is why it is called the "standard celeration chart."

Celeration refers to the direction of the line. Acceleration (/) refers to performances multiplying, and deceleartion (\) to performances dividing. As an example, a learner's performance on "saying multiplication facts on Monday is 10 correct/minute and a week later, on Monday, the performance is 20 correct/minute. The celeration is described as a times 2 change: 2 times 10/minute is 20/minute. The frequency was multiplied by 2. Individual celerations are measured over

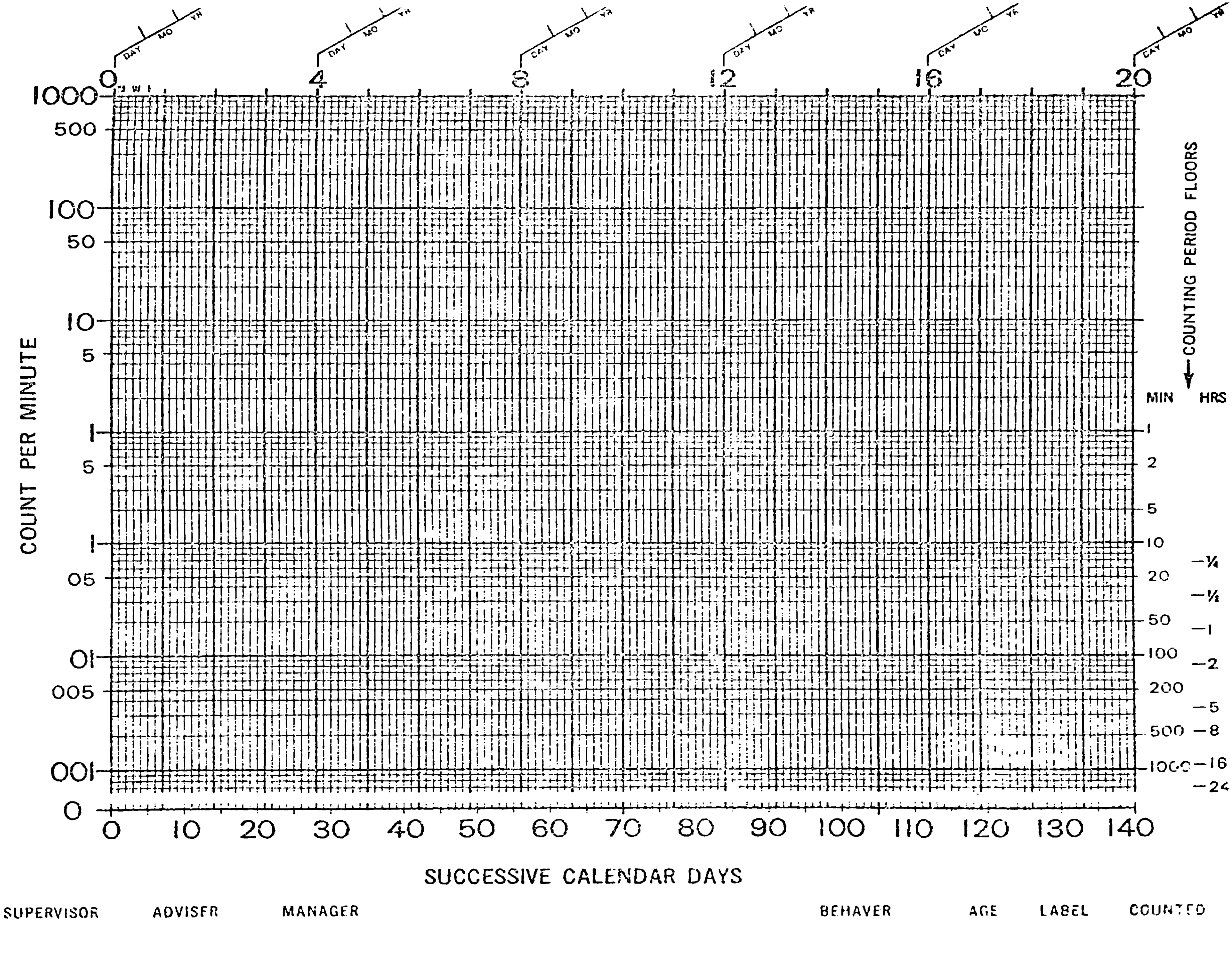

COUNT PER MINUTE
SUCCESSIVE CALENDAR DAYS
COUNTING PERIOD FLOORS
MIN
HRS
DAY MO YR
0 4 8 12 16 20
1000 500 100 50 10 5 1 5 1 05 01 005 001 0
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
1 2 5 10 20 50 100 200 500 1000
¼ ½ 1 2 5 8 16 24
SUPERVISOR
ADVISER
MANAGER
BEHAVER
AGE
LABEL
COUNTED
DEPOSITOR
AGENCY
TIMER
COUNTER
CHARTER

Figure 1

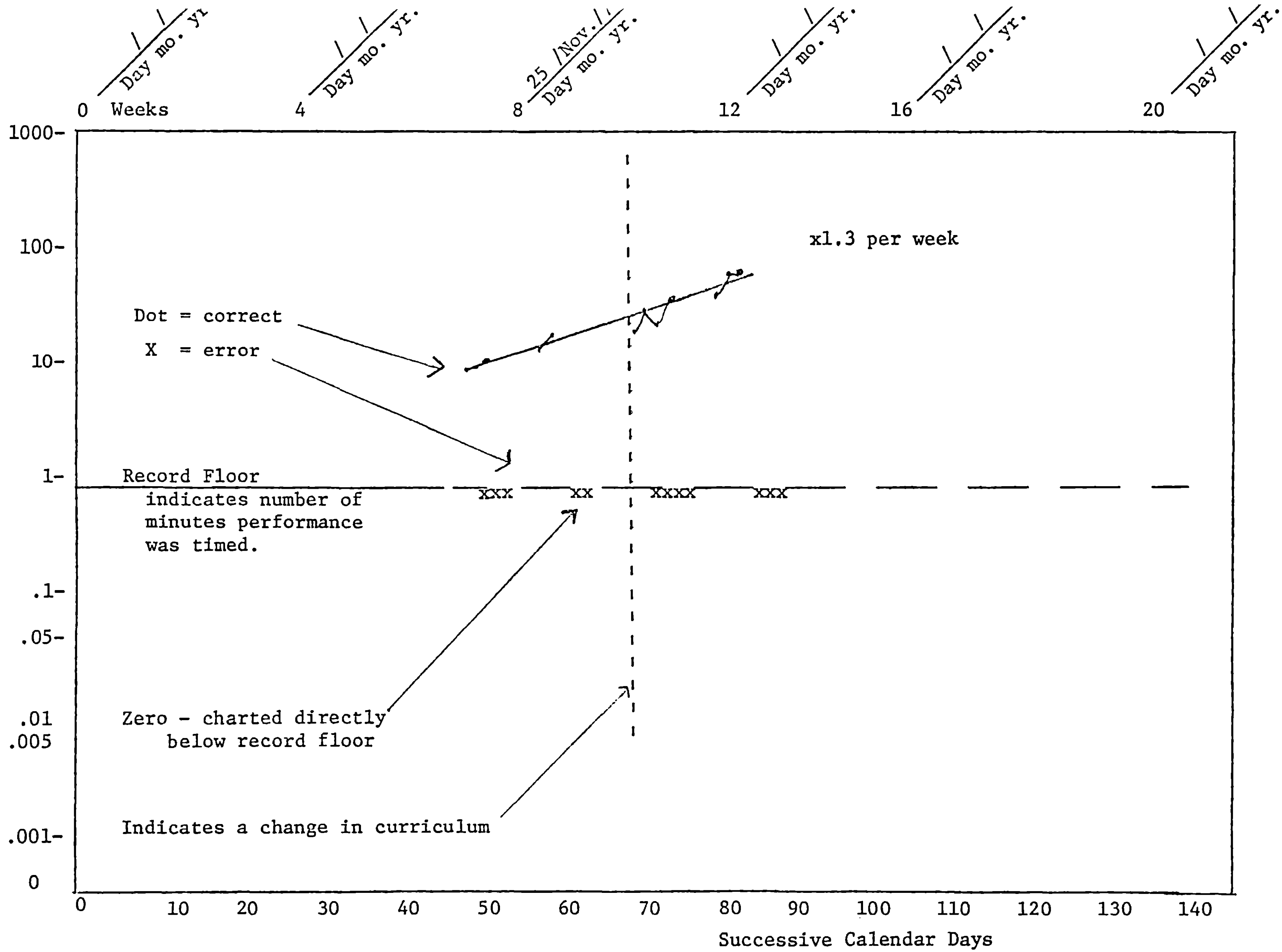


Figure 2: A simplified version of the Standard Chart

a period of one week and can be used as a standard measure to compare different periods of time, different objectives, and cross-cultural performances.

The celeration path is extremely important to the teacher. It provides convenient information for decision-making. The teacher knows a learner's starting performance level, current performance status, and projected learning outcome.

Another important aspect of a precision teaching system is evaluation. Empirical measurements are necessary to determine if the goals of the performance objectives are being accomplished. If the specified consequences and contingencies are not having the intended effect, the precision teaching system must be redesigned to reach its intended goal.

In order to cut down on teacher hours spent charting, one creative teacher taught her students to do their own charting. The student self-charting was so successful that an 18 minute color slide presentation was written and narrated by Stephanie Bates, a 5 year old kindergarten student. Stephanie illustrated how easy it is to learn to use the chart (Bates, 1971).

So now in Precision Teaching, each student records his daily behavior on the chart. After charting about ten daily frequencies, the teacher and student can see the learning picture on the chart. Dr. Eric Haughton suggests that students can go a step father and plan how to change their own behavior (Haughton, 1971). A "count" of daily performance is true accountability. The use of appropriate instructional and management techniques coupled with precision teaching provides us with an extremely, flexible, creative and humanistic approach to education (Starlin, 1971).

This learning chart (standard celeration chart) which the student keeps has acquired the name of "learning picture." Pat All was the first teacher to use two-line learning pictures in her 7th grade spelling classes (All, 1977). This means that every two weeks the children looked at their daily charts of correct and error frequencies together as a unit. They decided what form or "picture" their learning had taken and found other children in the class with the same picture. That is, if their corrects were accelerating and errors decelerating, they made a picture they called "Jaws"--the best learning picture. If their corrects were accelerating and errors were high and maintaining, they were in a "TR-7" and needed to work on their errors. If their corrects were decelerating and errors accelerating, they were in a "snow-plow" picture and needed to work on both corrects and errors, or more idealistically, step back to a simpler stage in the curriculum.

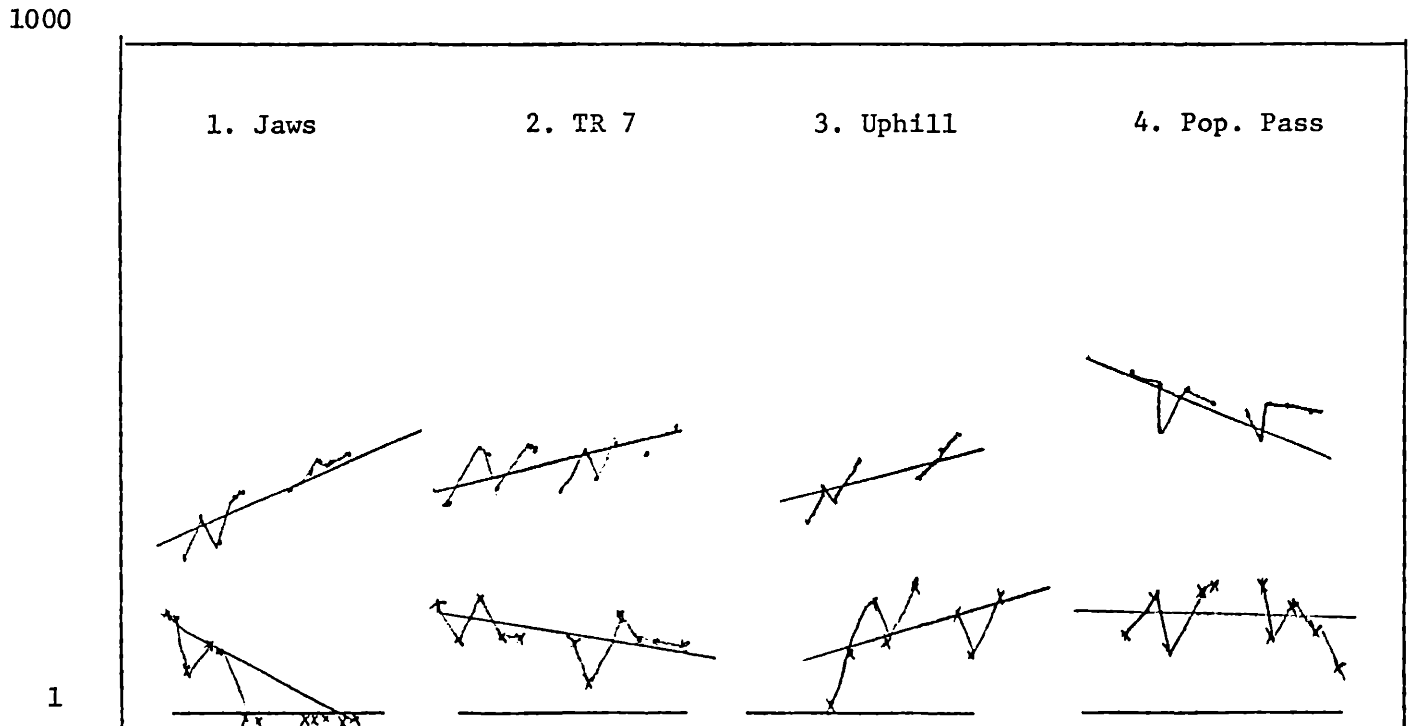
Of her 119 students using two-line learning pictures to help individualize instruction, 69 percent were improving, 28 percent were remaining about the same and only 2 percent worsening at the end of the year. These eleven types of learning pictures fell into three broader categories; improving, maintaining, and worsening. (See Figures 3, 4 & 5).

In an 8th grade math class, students used two-line learning pictures to help improve instruction and got 78 percent improving in the 21 students who participated. Twelve percent remained the same and 10 percent were worse at the end of the year (White, 1977).

Paul Getto (1978) had used the charts in his 9th grade reading class to see if he could get any improvement over a 36-week period. The students involved worked with books that were on a 4th to 6th grade level. They read to each other for one-minute time periods and recorded the number of words read correctly and the number of words missed. From this, a two-line learning picture helped the teacher individualize his instruction. At the end of the 36-week period, 60 percent of his 16 students were improving, 33 percent were staying the same, and 7 percent were worsening.

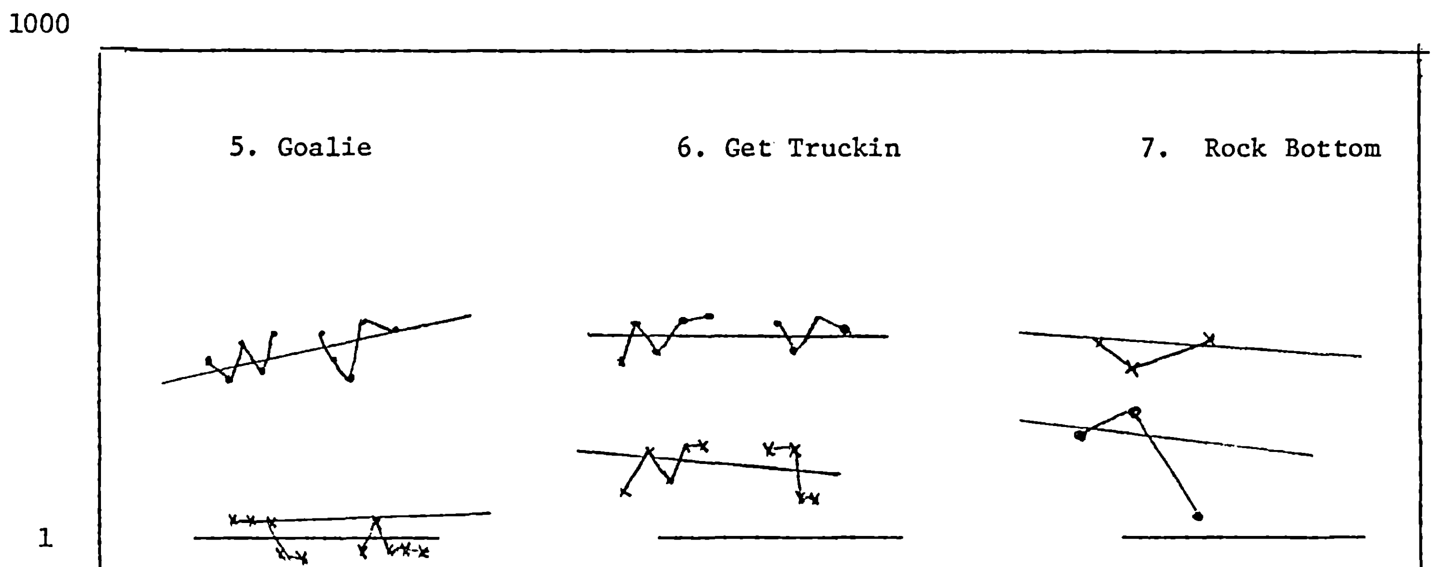
In The Accelerator, a news letter published by the Shawnee Mission Public School System, Henri Sokolove, working on an E.S.E.A. Title III project, found that during the 1975-76 school year, 1900 students charting their learning had an average of x1.21 learning or 21 percent increase in performance each week over the material being covered. During the 1976-77 school year, the average celeration or learning for 3600 students was x1.23 per week, or 23 percent increase each week.

In September of 1977 both teacher and student interpreted their charts using the two-line learning picture approach. Partial summaries and teacher reports showed learning to be increased as a x1.50 per week (Sokolove, 1978). This is a gain of 1.50/1.23 or x1.22 per week in learning as a result of the learning picture approach. However the teachers did not seek the "Jaws" picture with corrects accelerating and errors decelerating, but also accepted "climb" as an ideal picture. If they had not accepted "climb" as an ideal picture, they would have produced even better learning with their learning pictures. (Bailey, 1979).



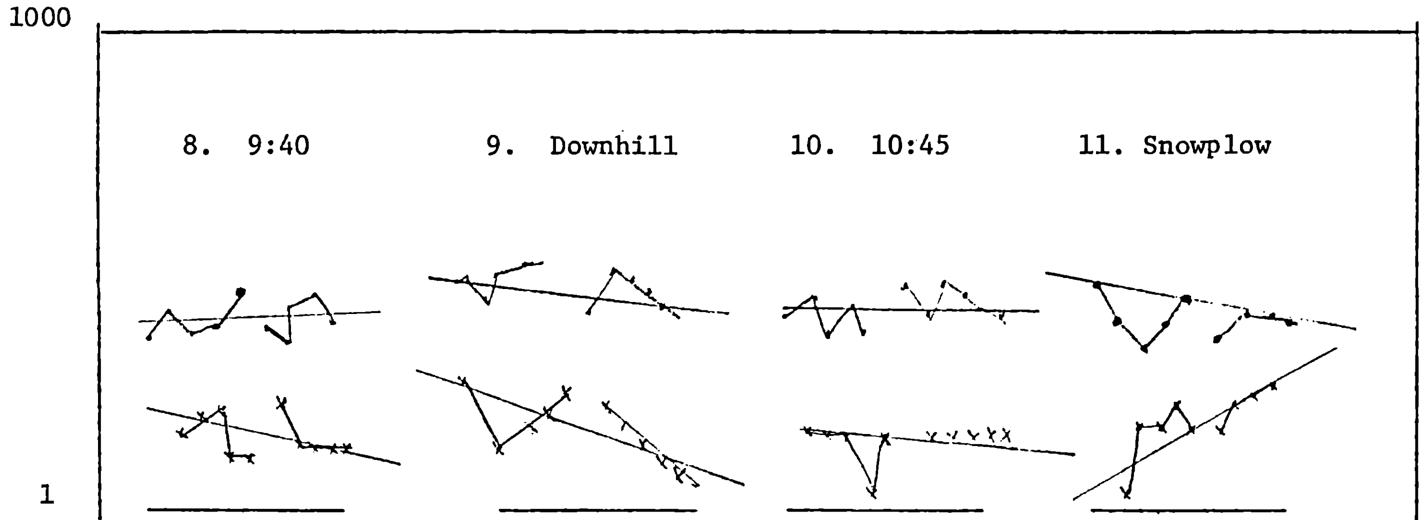
	1. Jaws	2. TR 7	3. Uphill	4. Pop. Pass
9th grade April 21, 1976 Not individualized	15	7	0	4
9th grade May 12, 1976 Individualized	24	2	0	6
7th grade November 16, 1976 Individualized	51	2	2	2
7th grade Feb. 18, 1977 Individualized	38	4	3	4

Figure 3. Improving Pictures



9th grade April 21, 1976 Not individualized	13	9	5
9th grade May 12, 1976 Individualized	14	2	8
7th grade November 16, 1976 Individualized	1	4	1
7th grade Feb. 18, 1977 Individualized	3	4	3

Figure 4. Maintaining Pictures



9th grade April 21, 1976 Not individualized	0	0	0	1
9th grade May 12, 1976 Individualized	0	1	0	0
7th grade November 16, 1976 Individualized	0	0	1	0
7th grade Feb. 18, 1977 Individualized	1	1	0	1

Figure 5 Worsening Pictures

Bailey (1979) charted, along with the number correct and the number wrong, the number skipped (three-line learning picture). So along with trying to keep the number of right answers going up and the wrong answers going down, he could also work on decreasing the number of skips.

He concluded that with some students who are afraid to make errors, it is useful to prevent skipping and to count them separately from errors. He also concludes that both the two- and three-line learning pictures provide a useful tool for the teacher when trying to measure a student's progress and improve instruction.

Gattegno, (1969, 1970) states "Naturally not all pupils follow the same path. Often it is very difficult to know how they have succeeded since success is the least revealing of events. Errors, on the other hand, help by revealing the problems encountered and are made the more valuable since we cannot force our pupils to be right or wrong to please us. In particular, mistakes are not symptoms of a deliberate reflection on the part of the writer, not of haphazard responses. Bearing this in mind, teachers will treat errors as indicating what exercises remain to be gone through so that inner criteria may be induced to function properly to provide correct images.

Jim White concludes "More work needs to be done to help students welcome errors, because through errors more learning opportunities are created. Students are brain-washed from kindergarten on that it is evil to make an error. So over their school years, children lose a good part of their creativity and almost all of their desire to take a chance. A deep fear of making an error has been instilled in their minds, probably by a well-intending teacher who had no idea what the end result would be." (White, 1977).

Pat All addresses the subject of perfect papers and error making: "Sometimes, these students used to getting A's or perfect papers want to achieve goals immediately and then stay there. It bothers them to make errors, and they prefer to maintain no improves rather than risk increasing their errors by trying more difficult words (any work) they do not already know. These are students used to a curriculum that is much too easy for them."

"One of my greatest problems is convincing the students that they must find work hard enough for them to make errors and, thereby, have opportunities to learn something new. Part of the discussion is convincing them that an error is not a mark against them. Learning occurs when an error is corrected or improved. By junior high, students are already conditioned to view an error as something bad, and a perfect paper as good." (All, 1977).

Conclusions drawn by Patrick McGreevy that relate to error making and error learning:

1. In terms of all projects, more than one of every three had no errors ("No Guts or Goalie"); phase changes to more difficult curricula were needed so that "Jaws" learning would be possible.

2. In terms of math projects, almost 6 of every 10 phases had no errors; again, phase changes to more difficult curricula were needed so that "Jaws" learning would be possible.

3. Almost one of every two phases supervised by teacher G and 2 of ever 5 phases supervised by teacher C had no errors; both teachers needed to make phase changes to more difficult curricula to enhance the chances of obtaining "Jaws" learning. (McGreevy, 1978).

Neely's conclusions resulted in these strategies for improving pupil learning:

1. Have teachers and children treat errors as something to make more of to get rapidly rid of rather than as something to stay away from.

2. Choose curricula that start with low correct frequencies making room for high learning of both (Neely, 1978).

Before attempting any research to try and verify these suppositions, I decided to see what some other researchers had to say about error-free and trial-and-error learning.

Error-free and Trial-and-error learning

Educators and trainers are continually seeking more efficient and beneficial methods of learning. To this end, modern technology has facilitated the development of programmed learning packages, both texts and machines. Content is ordered so that students are led from the simple to the more complex. The material is arranged to minimize or to delete errors during the learning process. Through the use of prompts, cueing, and feedback no part of the learner's experience is left to chance.

However, this error-free technique of learning is in direct contrast to a trial-and-error learning, or problem-solving approach. In the latter situation, the learner is encouraged to respond more freely to the learning situation. Through random but purposeful behavior, correct response patterns are developed and strengthened.

However, more is often at stake than the mere acquisition of specific information and skills. It is necessary for the learner to use his knowledge and capabilities in a variety of situations. That which he has learned must be transferred and applied to the solution or other similar problems. It has been pointed out that students must learn to learn; to transfer general methods of attack and techniques of acquisition from one situation to another. The question then arises: Does one of these methods of learning, error-free or trial-and-error, promote greater transfer of knowledge and skill than does the other?

Certain industrial and military skills may need to be highly prompted, for safety reasons. Generally, however, most skills are taught in a group process, with some degree of teacher guidance, but where the learner attempts to learn from his mistakes in order to attain personal goals.

To get the feel of the right response, one should know how it is to respond incorrectly. It would appear that many skill learning situations involve a process containing much trial-and-error, for whatever the reason. Even though it might be expected that a high degree of prompting and guiding will lead to the immediate mastery of a task, what of the proactive transfer effects on other similar learning tasks? Will these effects be any different from those following a learning experience involving problem solving and trial-and-error processes? In the learning of a perceptual skill needed by airplane pilots, Prather (1971) called attention to the need for learner involvement. He suggested that when cueing and/or prompting are too powerful they may decrease the involvement of the learner in acquiring the task, leading to learner passivity. It further appears that a highly controlled learning situation in which errors are non-existent may also deprive the learner of knowledge of alternatives needed to develop accurate discrimination for a later learning task (Holding, 1969).

Although researchers (Holding, 1969; Kersh, 1958; Prather, 1971) are supportive of trial-and-error learning, this error-full type of learning has also been criticized. Those who are critical of this approach have suggested that learning through trial and error methods encourages the learning of incorrect responses as well as correct patterns of behavior. And, while this may be true, Holding (1970) has found that errors committed early and late in the learning process bore a small and nonspecific relationship to each other.

Statement of Problem

Research done by others has shown that even with a stepped-up curriculum where there is room for errors, students make few. This is probably because they have been punished for making errors and therefore avoid them.

To counteract the fear of making errors in this study, we wish to reward errors by grading problems correct that are within five of the correct answer.

By combining curriculum 1 or 2 grades above grade level which would make room for errors with grading correct for close answers, we hope to produce high correct and high error learning.

Each student will serve as his own control and 2 timings each day will be done. The exact grading in which close errors are not rewarded and the grading where it is rewarded will be charted and graded each day.

Design and Time Sequence of Research

I. Introduction to Charting

  A. Time lapse: 1 week

  B. Procedure

  C. Results

II. Phase I: Math at level of difficulty

  A. Time lapse: 3 weeks

  B. Timings: 4 digits ÷ 2 digits

  C. Scoring: exact vs. close answer (within + or - 5)

  D. Results

III. Phase II: Math step-up

  A. Time lapse: 8 weeks

  B. Timings: 9 digits ÷ 3 digits

  C. Scoring: Up to 1st error vs. all of work in answers plus digits

  D. Results

IV. Phase III: Math leap-up

  A. Time lapse: 5 weeks

  B. Timings: permutation and combination problems

  C. Scoring: exact vs. close answer

  D. Results

Curriculum level	Pre - Instruction	Skill	Scoring			Time
			Comparison *		Unit	
			ED	EE		
Introduction to Charting	Yes	3 digit add.	None		Answers Correct	1 week
Level of Difficulty	Yes	4 digits ÷ 2 digits	Exact	Close	Answers Correct	3 weeks
"Step-up"	Yes	9 digits ÷ 3 digits	Up to 1st error	All of work	Answers Plus Digits Correct	8 weeks
"Leap-up"	No	Permutation & Combination Problems	Exact	Close	Answers Correct	5 weeks

* The study consisted of 2 comparison timings daily.
During one timimg, there was error discouragement. (ED).
During the other timing, there was error encouragement. (EE).

Table 1. Diagram of research design

Method

Forty-five ninth grade general math students were the participants in this study. The students were in either the third or seventh period class. Their math skills ranged from 6th through 9th grade level.

The study was divided into three phases which became necessary as my understanding of the research grew. The first phase lasted for three weeks, the second phase for eight weeks and the third phase for five weeks.

In order to foster some interest as well as understanding of precision teaching, my first step was to give both classes a general overview of this system of monitoring daily improvement.

I showed them charts done by students in other schools and also flash cards of different types of learning pictures. I asked the students what they thought the learning pictures meant and surprisingly enough, they were right on target with their answers. After discussing the pictures, we decided "Jaws" was the best learning picture and was the one we would strive for.

The next day I had a transparency made of the celeration chart and explained charting as Stephanie Bates had done in the spring, 1971 issue of Teaching Exceptional Children. The students were then given data to chart. I collected the papers and checked for mistakes.

On day three, the papers were returned with corrections made and explanations given. Only nine people had all of the information correct. So we went through the whole process again. This time 31 of the 45 students got everything correct.

On day four, the classes were divided into groups. Students still making errors were placed in groups with students who understood charting. This time everyone charted correctly.

On day five, students were given 10, one-minute timings using 3 digit addition problems. I did this so that each student could graph his own data.

Table 2

	DAY				
	1	2	3	4	5
Corrects recorded incorrectly*	-	20	11	0	0
Errors recorded incorrectly	-	20	11	0	0
Dates recorded incorrectly	-	6	0	0	0
Used same symbol for corrects & errors	-	4	0	0	0
Record floor on wrong line	-	7	2	0	0
Did not connect dots or dashes to draw pictures	-	7	3	0	0

Table 2. Common Errors in Learning to Chart

*Since students were accustomed to graphing with spaces between numbers equal add distance apart, most ignored the marked numbers in the chart and wrote in their own new numbers with equal add distance between them.

Phase I: Instruction at level of difficulty

During the first three weeks of the research, students were given two timings daily. Both timings were done using two digits divided into four digits, division problems. Students were given full credit for problems if they were within + or - five units of the correct answer in the first timing (error encouragement). While during the second timing, they were given credit only if every digit in the problem was correct. Even with such a generous offer, students made only one or two errors. 30 students had improving pictures and 15 had maintaining pictures with close scoring (error encouragement). 26 students had improving pictures and 19 had maintaining pictures with exact scoring (error discouragement). Although no one had worsening pictures, no one had maximum learning pictures either. (See Figure 12) Tables 2 and 4 compare this part of the research with other research; and Figures 5 and 6 show typical learning pictures for Phase I.

The median acceleration with error encouragement was x1.3 and x1.2 with error discouragement.

Phase II: Instruction step-up

In one of the timings, students received credit for any digit in the problem that was correct. While in the second timing, once the student made a mistake, no additional digits were counted. This process lasted for eight weeks and still there were very few errors being made using either method. (See Table 3).

Name	Pre-Instruction	Math Level	Units Correct	Required for Correct	Yr.	Grade	Making Errors %			Total making errors %	Total not making errors %	Level of Statistical Significance
McGreevy,P	Yes	Remedial	Answers	Exact	78	Sp.Ed.	28%	6%	6%	41%	59%	
White, J.F	Yes	On level	Answers	Exact	77	8	13%	8%	17%	36%	64%	
Johnson,J.	Yes	Remedial	Digits	Exact	78	Adult Rem.	9%	3%	3%	15%	85%	
Clark,C.	Yes	On level	Answers	Exact	79	7	3%	0%	0%	3%	97%	$7x10^{-2}$(.07)
Clark,C.	No	"Leap-up"	Answers	Exact	79	7	0%	17%	0%	17%	83%	
Phillips,V	Yes	On level (e)	Answers	+or-5	79	7	11%	0%	9%	20%	80%	$6x10^{-2}$(.06)
		On level (d)	Answers	Exact			7%	0%	0%	7%	93%	
Phillips,V	Yes	Step-up (e)	Digits	+ Exact	79	7	29%	4%	16%	49%	51%	$4x10^{-4}$(.0004)
		Step-up (d)	Digits	Exact	79	7	11%	2%	0%	13%	87%	
Phillips, V.	No	"Leap-up" (e)	Answers	+or-5	80	9	44%	13%	27%	84%	16%	$6x10^{-17}$ (.0000000000000000006)
		"Leap-up" (d)	Answers	Exact	80	9	2%	0%	0%	2%	98%	

(e) - errors encouraged
(d) - errors discouraged
* - answers counted plus work up to first error
+ - answers plus work through out all done

Table 3. Comparison with Related Research

Twenty-three students were in maintaining pictures (51%), and twenty-two students were in improving pictures (49%) with error discouragement. Nineteen students were in maintaining pictures (42%) and twenty-six students were in improving pictures (58%) with error encouragement. (See Table 4 and Figure 12).

Phase III: Instruction "leap-up"

During Phase III the students were given probability problems, more specifically, permutation and combination problems to solve. No explanation was given as to how to solve them. Close vs. exact scoring was again used.

Students continued to make very few errorswith error discouragement. Several students didn't even attempt to work the problems. (See Table 3). However, with error encouragement, we were able to get twenty students to achieve maximum learning pictures--maximum learning being either jaws or cross over.

The median acceleration for this phase was x1.1 with error discouragement and x1.45 with error encouragement. Table 3 shows the results to be significant at the 6×10^{-17} level.

To summarize the results, all the students' learning pictures were graphed into three categories. The three categories were improving pictures, maintaining pictures, and worsening pictures. The most common pictures in each category are illustrated in Figure 12.

In Tables 3 & 4 this research is compared with related research.

You can see that learning took place in each phase of the study; however there was only maximum learning in Phase III.

Name	Subject	Yr.	Grade	Max	Imp	Mtn	Wsn	Total	Imp Wsn	Max Imp WSN
McGreevy,P.	Math	78	Sp.Ed	41	91	28	11	171	x 12	x 4
White,J.F.	Math	77	8	25	168	30	26	249	x 7.4	x .96
Johnson,J.	Math	78	Adult M.R.	11	81	167	24	238	x 3.8	x .46
Clark,C.	Reg. Math	79	7	1	17	18	1	37	x 18	x 1
Clark,C.	Mega Math	79	7	0	0	27	0	27	x 0	x 0
Phillips,V.	Reg. Math	79	9	0	30(e) 26(d)	15(e) 19(d)	0 0	45 45	x 30 x 26	x 0
Phillips,V.	Step-up Math	79	9	0	22(e) 26(d)	23(e) 19(d)	0 0	45 45	x 22 x 26	x 0
Phillips,V.	Leap-up Math	79	9	20 0	16(e) 4(d)	6(e) 38(d)	3 3	45 45	x 12 x 1.3	x 6.7* x 0

* This table shows the increase in maximum learning with error encouragement.

e - error encouragement
d - error discouragement

Table 4. Comparison of Related Research Learning Picture Results

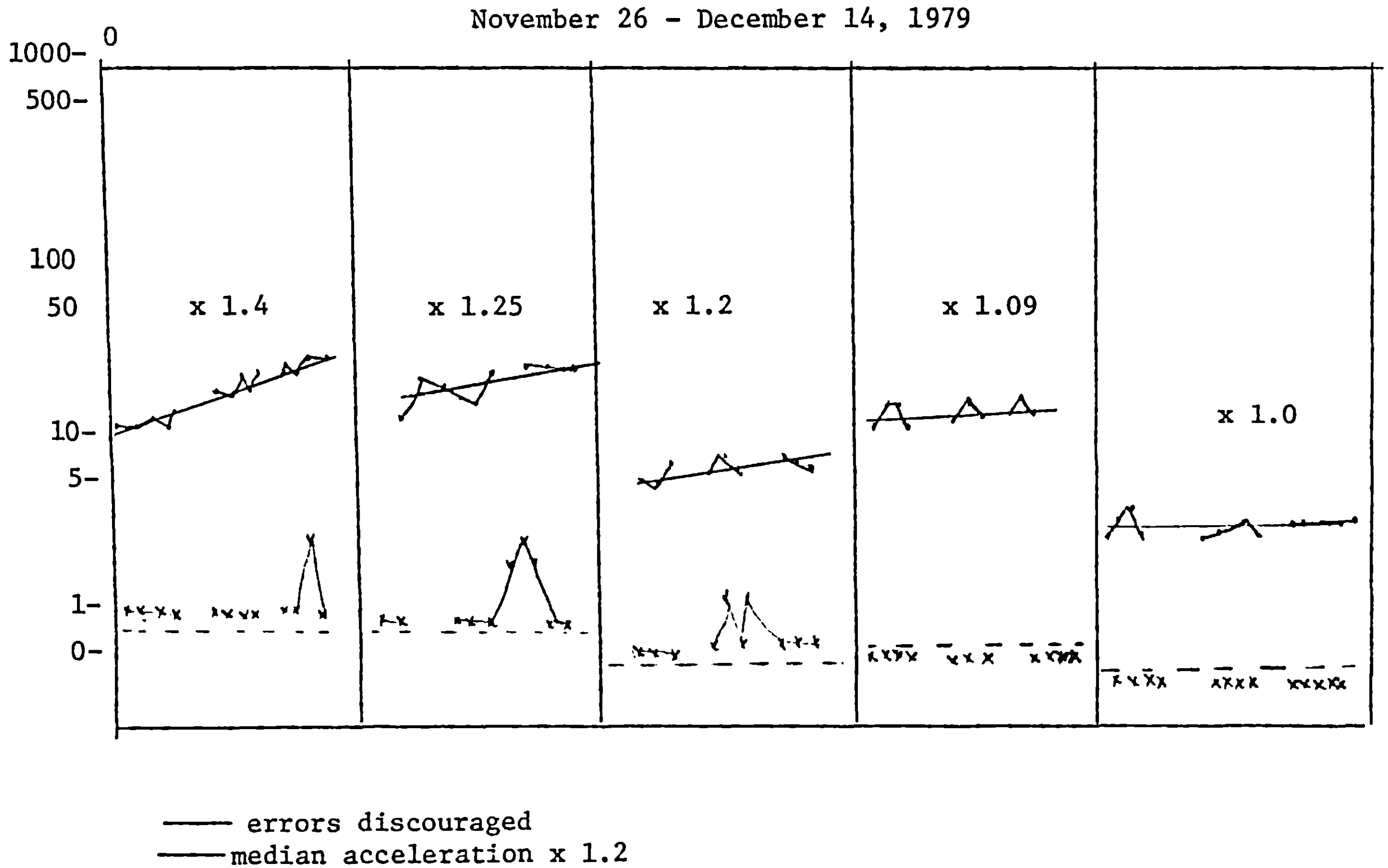


Figure 6. Sample of learning pictures for Reg. Math Phase I (3 weeks)

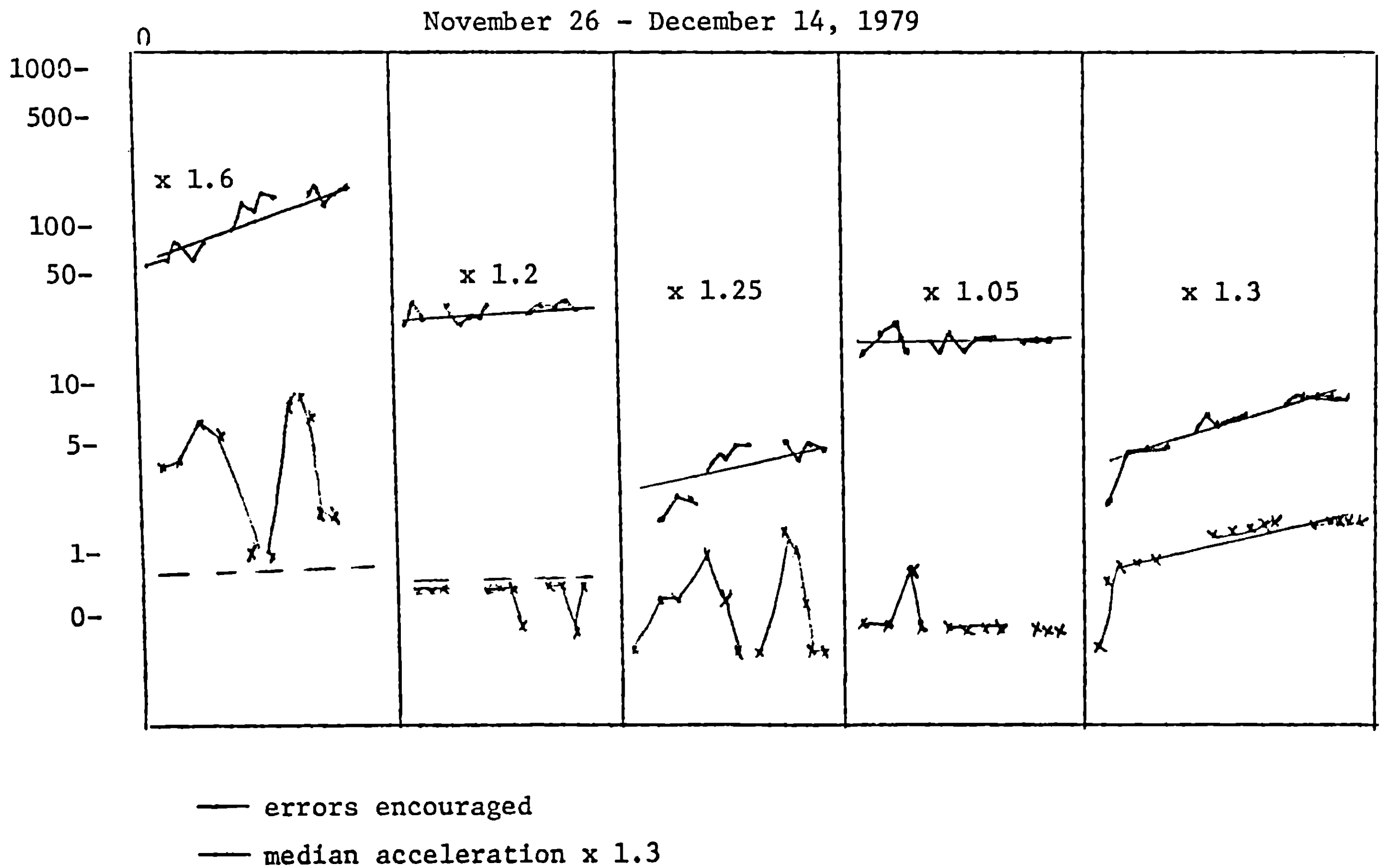


Figure 7. Sample of learning pictures for Reg. Math Phase I (3 weeks)

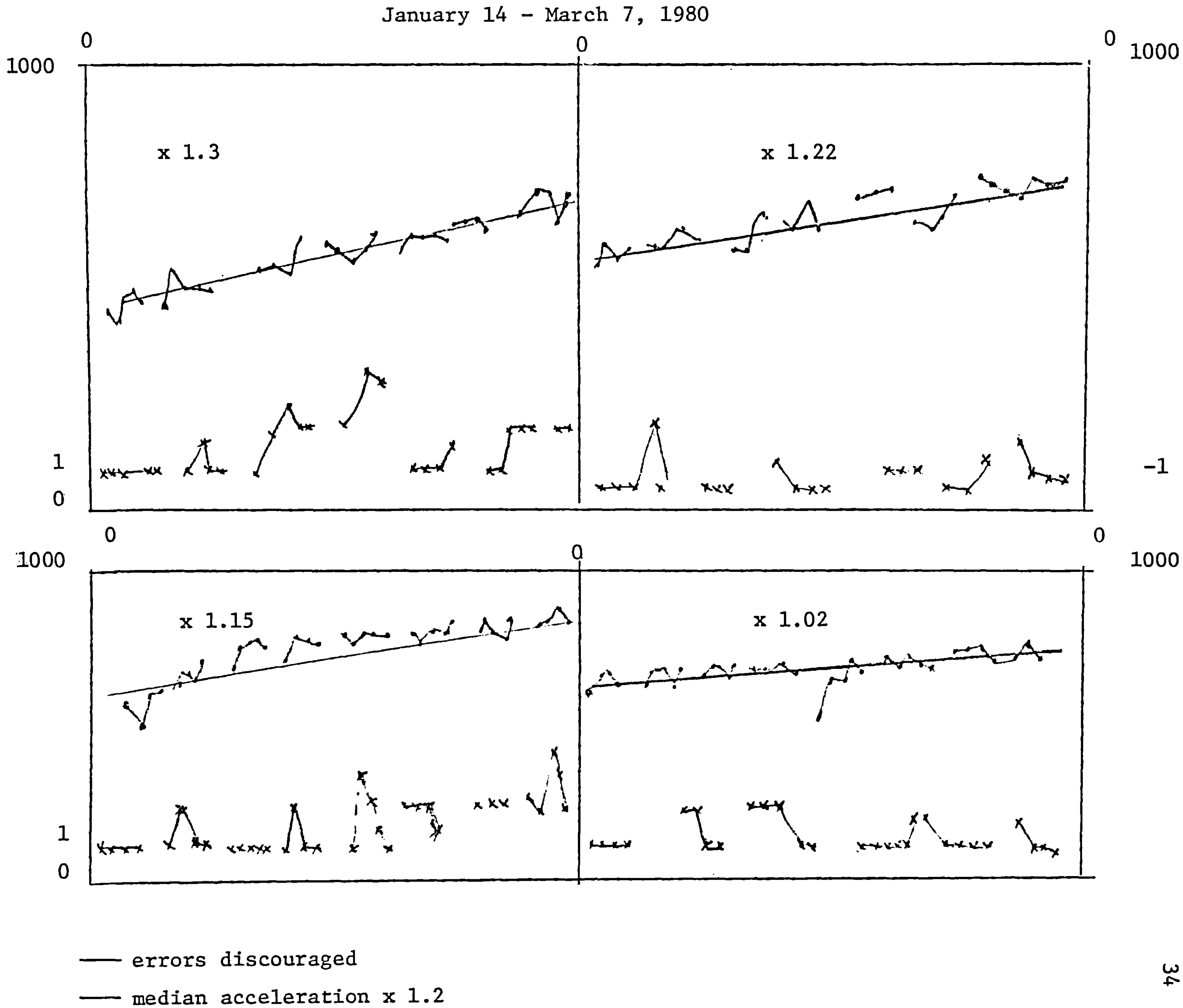
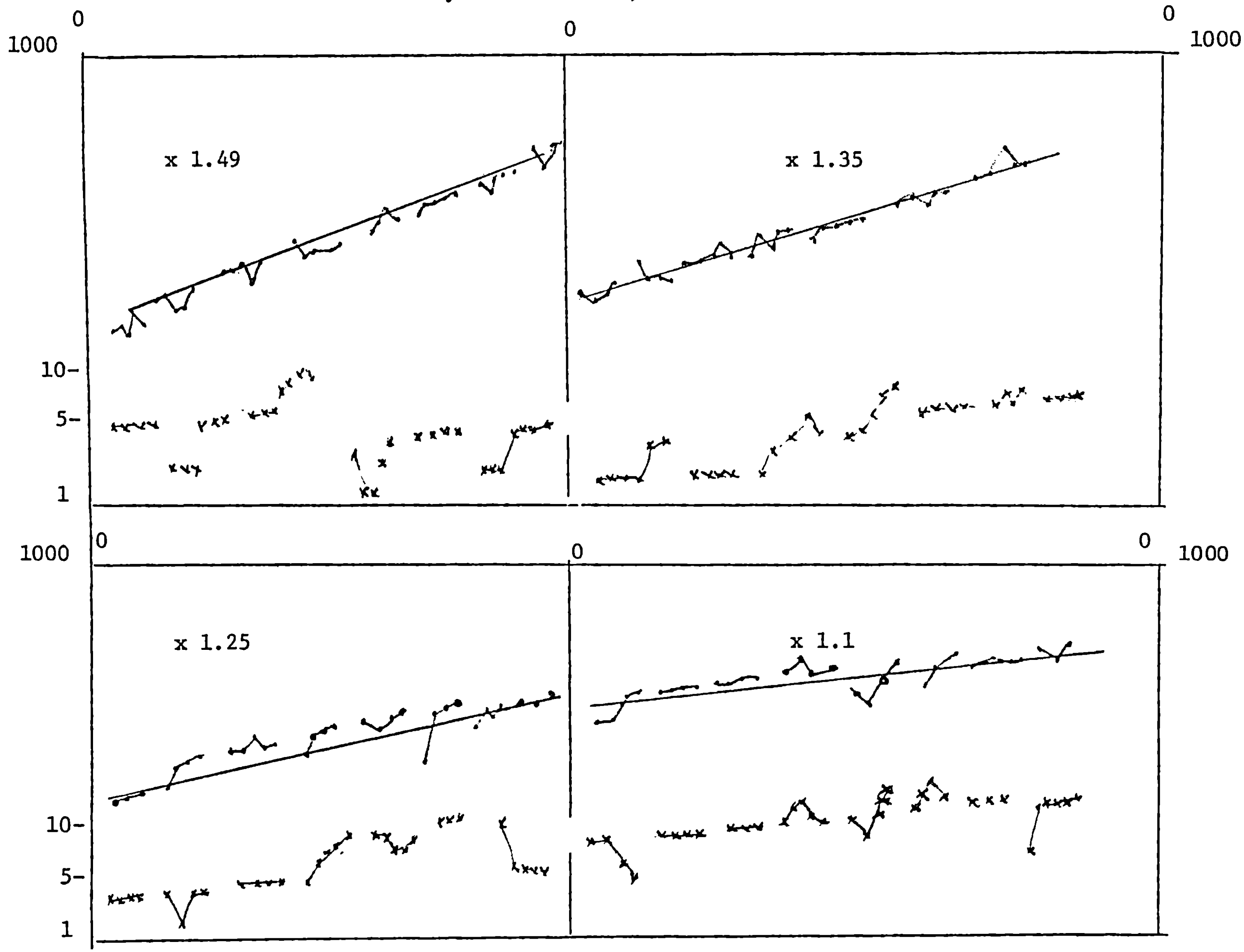


Figure 8. Sample of learning pictures for step-up (Phase II) (8 weeks)

January 14 - March 7, 1980

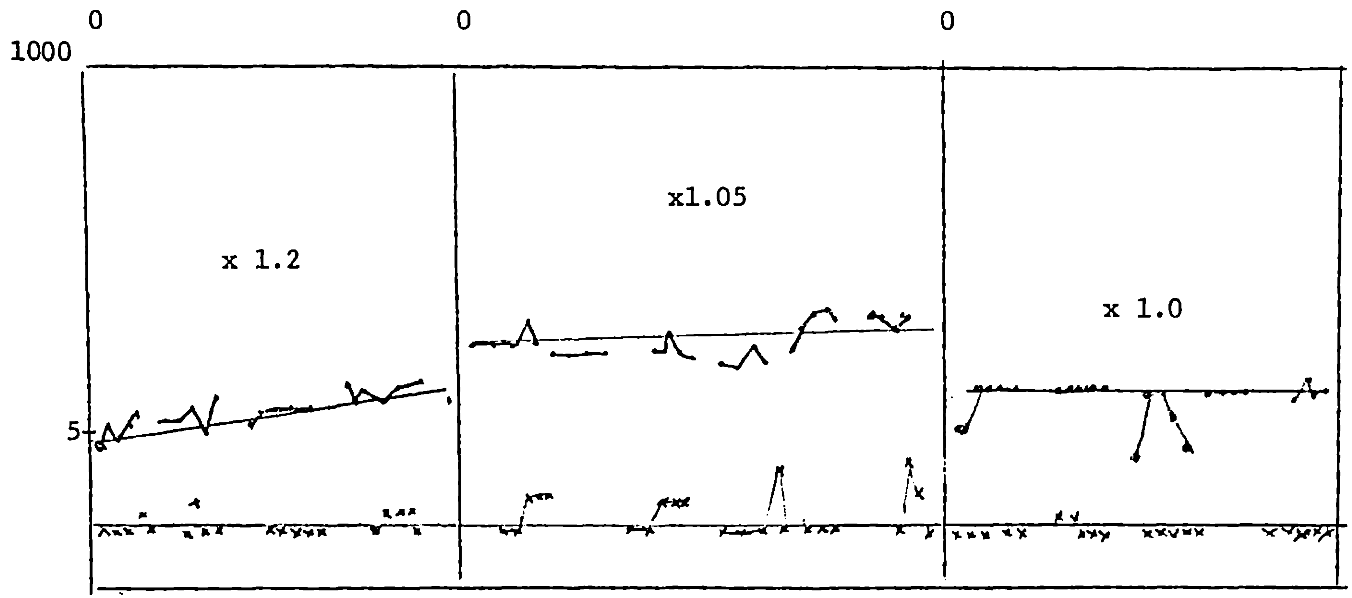


—— errors encouraged

—— median acceleration x 1.3

Figure 9. Sample of learning pictures for step-up (Phase II) (8 weeks)

April 14 - May 16, 1980



—— errors discouraged

—— median acceleration x 1.1

Figure 10. Sample learning pictures in leap-up (Phase III (5 weeks)

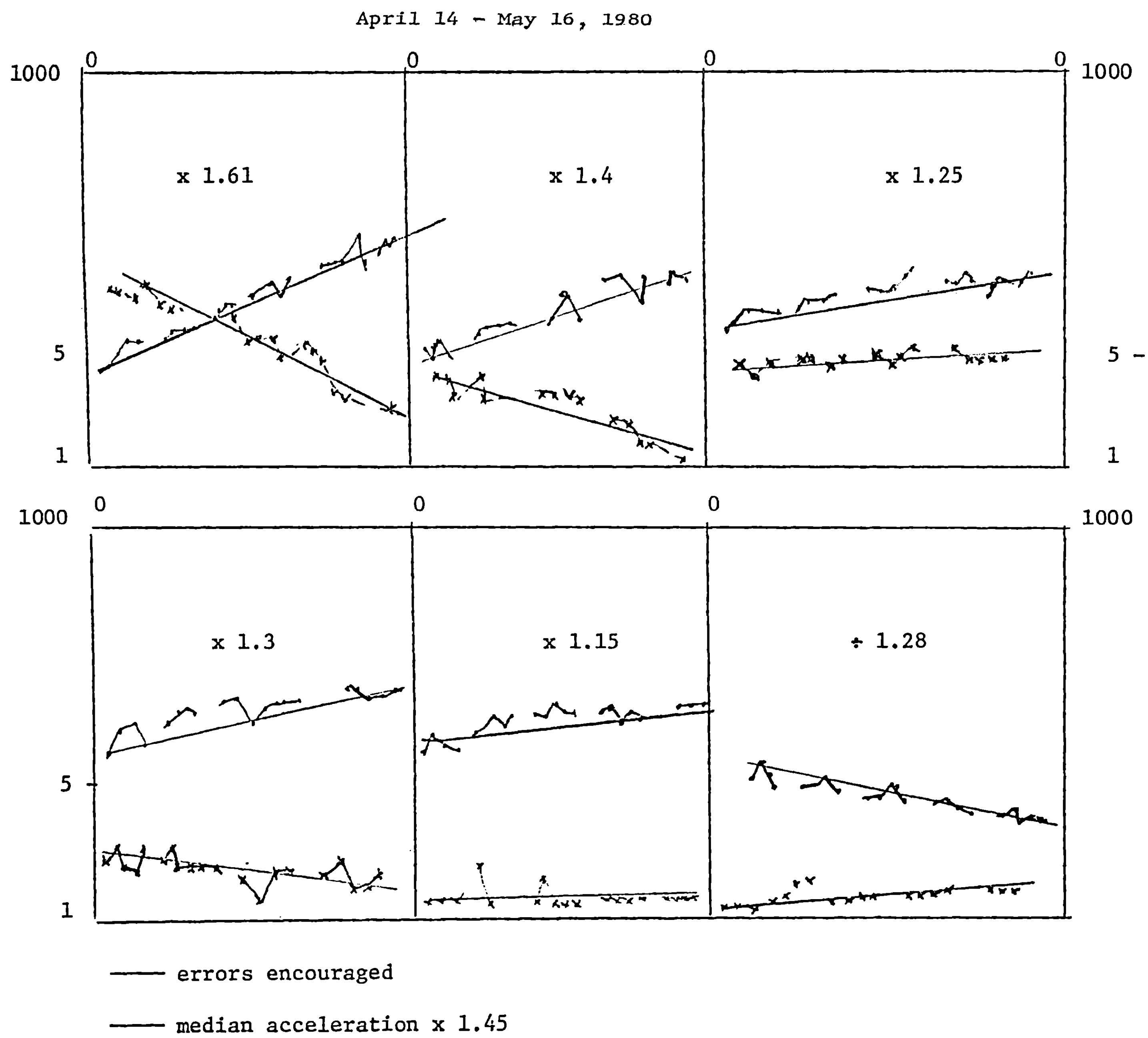
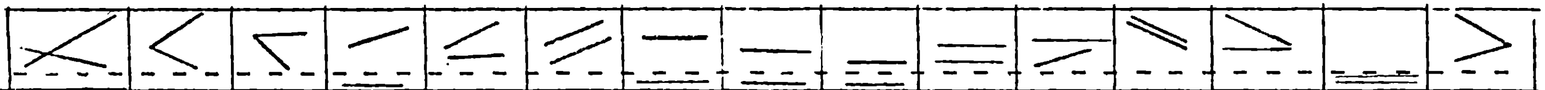


Figure 11. Sample learning pictures for leap-up (Phase III)



Phase I Reg. Math															
Errors encouraged			12	10	5	3	6		4	5					
Errors discouraged				15	8	3	7	3	9						
Phase II Step-up															
Errors encouraged				3	16	3	6	17							
Errors discouraged			5	9	12		10	7	2						
Phase III Leap-up															
Errors encouraged	12	8	4		4	8		3	2	1	1	1			1
Errors discouraged			4						30	8	1		2		
	Improving pictures						Maintaining				Worsening				

Figure 12. Learning Picture Counts

Conclusions

This research clearly demonstrates that in order to get maximum learning to occur, you must do two things together:

1. Leap-up the curriculum at least two grade levels so that it is challenging to the students, and

2. Reward students for trying by giving credit for close answers.

Implications

It is apparent that we teachers are going to have to take a closer look at what we are teaching, why we are teaching it, and our teaching methods.

Discipline seems to be the number one concern in our schools today. So many educators, administrators leading the pack, believe that if the students are quiet and in their seats they are learning. So often this is not the case. I am not suggesting a "free for all," but I do know that you would never have a winning football team if the players were talked to for 80% of the practice time and allowed to scrimmage the rest. Nevertheless, students are mostly talked to in most classrooms.

Teachers that allow students to explore, and discover, are usually highly criticized and in some instances stand in jeopardy of losing their jobs. This and similar research is necessary in that it shows teachers, parents, and administrators the details of how the greatest amount of learning takes place.

BIBLIOGRAPHY

All, P. From get truckin' to Jaws, students improve their learning pictures. Unpublished Master's Thesis, University of Kansas, 1977.

Alper, T., Nowlin, L., The Rated Assessment of Academic Skills. Academic Therapy. 1973-74, vol. 9, pp. 151-164.

Ayllon, T., & Haughton, E. Control of the behavior of schizophrenics by food in Human Learning, Arthur W. Staats, (Ed.), Holt, Rinehart and Winston, Inc., New York, 1964, pp. 458-471.

Bailey, R., Summarizing Special Education Classroom Instruction. Unpublished Master's Thesis, University of Kansas, 1979.

Bates, S., and Bates, D.F. ".... and a child shall lead them": Stephanie's chart story. Teaching Exceptional Children, 1971, 3, 111-113.

Berry, G.A., Prather, D.C., Effect of verbalization on trial-and-error and prompted learning of Perceptual Skill. Journal of Educational Psychology, 1973,8,481-482.

Caldwell, T.E., Can pupil performance rates tell us when a student teacher is ready for her own class? Unpublished Doctoral Dissertation, Kansas University, 1967.

Clark, C., The relationship between child, curriculum area, and the degree of detail in error making and error learning, unpublished Master's thesis, University of Kansas, 1979.

Duncan, A.D., and Lindsley, O.R. Precision teaching in perspective: An interview. Teaching Exceptional Children, 1971, 3, 114-119.

Edinger, D.L. A free operant analysis of programmed instruction performance with reading disabled children. Unpublished Doctoral Dissertation, University of Florida, 1969.

Freschi, D.F. "Where we are. Where we are going. How we're getting there." Teaching Exceptional Children, 6, (1974): 89-97.

Galloway C., and Galloway, K.D. Parent classes in perspective: An interview. Teaching Exceptional Children, 1971, 3, 120-128.

Gattegno, C. What We Owe Children, New York: Outerbridge and Dienstfrey, 1970.

Getto, Paul. "High School Freshmen Improve Their Reading and Survival Skills by Charting Daily Frequencies." Unpublished Master's Thesis, Kansas University, 1978.

Gollin, E.S., and Savoy, P. Fading procedures and conditional discrimination in children. Journal of the Experimental Analysis of Behavior, 1968, 11, 443-451.

Haughton, E.C. Great gains from small starts. Teaching Exceptional Children, 1971, 3, 141-146.

Hilgard, E.R., & Bower, G.H. Hull's Systematic Learning Theory in Theories of Learning, Appleton Century Crofts, New York, 1966, 171-173

Holvoet, J. Some general observations about errorless training and some examples of errorless programs used with SMH individuals. Unpublished manuscript University of Kansas, Department of Special Education, 1978.

Johnson, E.C. "Precision Teaching Helps Children Learn." Teaching Exceptional Children 3 (1971): 106-110

Johnson, N., Acceleration by a student teacher of both the planned and performed rates of primary learning-disabled pupils. Unpublished Masters Thesis, Kansas University, 1967.

Johnson, N., Acceleration of inner-city elementary school pupils' reading performance. Unpublished doctoral dissertation, University of Kansas, 1971.

Johnson, J., Chart-based supervision of academic skills for developmentally disabled adults. Unpublished Master's Thesis, University of Kansas, 1979.

Koenig, C.H., Precision teaching with emotionally disturbed pupils. Unpublished Master's Thesis, Kansas University, 1967.

Koorland, M.A., & Martin, M.D. Elementary Principles and Procedures of the Standard Behavior Chart. Third Edition, Gainesville, Fla.: Learning Environments, Inc. 1975.

Lembo, J.M., The Psychology of Effective Classroom Instruction. Columbus, Ohio: Merrill, 1969.

Lindsley, O.R. Experimental analysis of cooperation and competition. In T. Verhave (Ed.) The Experimental Analysis of Behavior, New York: Appleton-Century-Crofts, 1966, 470-501.

Lindsley, O.R., Children are not retarded. In G.A. Fargo, C. Behrns, & P. Nolen (Eds.) Behavior Modification in the Classroom. Belmont, Calif.: Wadsworth Publishing Co., Inc., 1970.

Lindsley, O.R., From Skinner to precision teaching: The child knows best. In J.B. Jordan & L.S. Robbins (Eds.) Let's Try Doing Something Else Kind of Thing. Arlington, Va.: Council on Exceptional Children, 1972, pp. 1-11.

Lovitt, T.C. & Curtiss, K.A. Effects of manipulating an antecedent event on mathematics response rate. Journal of Applied Behavior Analysis, 1968, 1, 329-333.

Lovitt, T.C., & Custiss, K.A., Academic response rate as a function of teacher and self imposed contingencies. Journal of Applied Behavior Analysis, 1969, 2, 49-53.

McGreevy, P. District-wide learning screening compared with average learning and learning picture produces of resource teachers. Unpublished Doctoral Dissertation, University of Kansas, 1978.

Neeley, M.D. Six years of supervising a special education program by learning products. Unpublished Master's Thesis, University of Kansas, 1978.

Nelson, A., A review of errorless stimulus control procedures. Unpublished manuscript. University of Kansas Department of Human Development, 1977.

Neufield, K. What charted learning tells supervisors about reading performance levels. Unpublished Doctoral Dissertation, University of Kansas, 1978.

O'Leary, K.D., Becker, W.C., A token reinforcement program in a public school: A replication and systematic analysis. Journal of Applied Behavior Analysis, 1969, 2, 3-13.

Pennypacker, H.S., Koenig, C.H., and Lindsley, O.R. Handbook of the Standard Behavior Chart. Kansas City, Kansas: Precision Media, 1972.

Phillips, D. "We have a successful tool now--Let's use it!" In J.B. Jordan and L.S. Robbins (Eds), Let's try doing something else kind of thing, Behavior Principles and the Exceptional Child. Arlington, Va: The Council for Exceptional Children, 1972. (ERIC Document Reproduction Service No. ED060581).

Prather, D.C., Trial-and-error versus errorless learning: Training, transfer, and stress. American Journal of Psychology, 1971, Vol. 84, 377-386.

Sokolove, Henri. "Blueprint for Productive Classrooms." Title IV-C ESEA, Shawnee Mission, Kansas School District, 1978.

Starlin, C.M. Peers and precision. Teaching Exceptional Children, 1971, 3, 129-132; 137-140.

Stein, Edwin. Fundamentals of Mathematics, Allyn & Bacon, Inc., Boston, 1972.

Terrace, H.S. Errorless transfer of a discrimination across two continua. Journal of the Experimental Analysis of Behavior, 1968, 11, 39-48.

Touchette, P.E. Transfer of stimulus control: Measuring the amount of transfer. Journal of the Experimental Analysis of Behavior, 1971, 15, 347-354.

White, J.F. Average learnings compared with learning picture distributions for easy and difficult eighth grade mathematics practice. Unpublished Master's Thesis, University of Kansas, 1977.