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Using a Constant Tie Delay to Teach Measurement to Middle School Students with Learning Disabilities

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Using a Constant Time Delay Procedure to Teach Measurement to Middle School Students with Learning Disabilities

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Running head: CONSTANT TIME DELAY
ABSTRACT

The purpose of this study was to teach the parts of an inch in sixteenths, using a constant time delay procedure. Constant time delay is a virtually effortless, or near errorless, instructional process involving the simultaneous delivery of a target stimulus and a controlling prompt for a limited number of trials, followed by trials where the target stimulus is presented, but the controlling prompt is delayed for a constant time period. The study was conducted with 6 sixth-grade students in a self-contained math class for students with learning disabilities. The subject group contained 5 males and 1 female. Each of the 6 sessions began with a group choral response to the stimuli with a zero-second delay. Next, three trials, with individual subject responses, were conducted with a three-second time delay.
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Children with learning disabilities form a heterogeneous group that exhibits a wide variety of difficulties (Cawley, 1984a). These children recall less information, use less semantic processing, and appear to have less insight into the working of their own memories than their non-learning-disabled peers. They also fail to utilize organizational strategies and do not utilize their limited attention capacity efficiently (Ceci, 1984).

Houck, Todd, Barnes, and Englehard (1980) stated that memory may be the most pervasive deficit across the academic skill areas. Torgesen and Kail (1980) suggested that memory problems may be an important correlate of academic difficulties. Memory skills are of paramount importance in the growth of general intellectual competence and are essential in the performance of complex academic skills, such as reading, writing, spelling, and arithmetic (Torgesen & Kail, 1980; Rosner, 1993). To be successful, a student’s capacity for internal manipulation of information must be paired with an efficient memory system (Houch et al. 1980).

Memory and Learning Disabilities

Memory is the ability to store information that can be retrieved at a later time and correlated to new information (Sharma, 1985). Memory involves elaboration, encoding, retention and retrieval, search, chunking, and rehearsal processes (Torgesen & Kail, 1980). Emphasis on memorization does not necessarily refer to "rote" memory but rather seeks "to clarify how children’s cognitive activities may enhance or interfere with their retention of learning experiences in school" (Torgesen & Kail, 1980, p. 56). Proficient memorizers, when presented with new
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data/information, immediately organize a study plan, are conscious of the goal,
know how to evaluate whether the goal is reached, and continually monitor the
effectiveness of each part of the study process (Gelzheiser, Solar, Shepherd, &
Wozniak, 1983). In order for a concept to be remembered, it must relate to prior
knowledge. Connecting the new with the old sets a strong context for retention
(Sharma, 1985). In addition to teaching concepts, rules and relationships should
also be taught. Understanding of these rules and relationships should precede
memorizing facts (Miller, Strawer, & Mercer, 1996).

Memory can be divided into structural (i.e., that which is not subject to
conscious control and not modifiable through short-term training) and control
memory (i.e., that which is subject to conscious control and can be trained)
(Torgesen & Kail, 1980; Torgesen & Houck, 1980). Research by Torgesen and
Kail (1980) suggested that structural limitations, as opposed to a control processing
problem, may account for poor performance on some memory tasks for some
students with learning disabilities. Therefore, the use and effectiveness of memory
strategies should be demonstrated for exceptional children, since they will frequently
not figure the strategies out on their own (Reetz, 1987). Areas of the brain that are
cited as the possible neurological location for memory performance deficits are the
parietal, adjacent occipital, temporal, and frontal regions (Houck et al. 1980).

Scruggs and Mastropieri (1990) cited memory deficits, especially with respect
to recall of semantically based information, as a central characteristic of learning
disabilities. Their research indicated that interventions that impact directly on
purposive semantic encoding and retrieval processes (i.e., teaching the students
intentional strategies or processes that will facilitate the student's ability to encode
and retrieve information) may have a positive effect on academic achievement. Memory deficits are frequently attributed to inadequate production of effective learning strategies. Simply, these students fail to remember important information (Scruggs & Mastropieri, 1990; Rosner, 1993; Torgesen & Houck, 1980; Bauer, 1979).

Children with learning disabilities may have difficulties with the transfer of information from short-term memory to long-term memory (Sharma, 1985). Short-term memory deficits may result from a lack of ability or inclination to use efficient task strategies on some memory tasks. Poor readers do not spontaneously use verbal rehearsal to the same extent that normal readers do. Students with learning disabilities may not be aware of rehearsal as a consciously applied mnemonic strategy (Torgesen & Goldman, 1977). Children with learning disabilities may have difficulty developing efficient and easily accessible memory codes (Torgesen & Houck, 1980).

Bauer's study (1979) indicated that rehearsal or other types of elaborate encoding are deficient in children with learning disabilities. The study further suggested that students are, in fact, attending during the first stage of memory processing for words. Children with learning disabilities do not fail to use elaborative encoding strategies, but use them less effectively. This may be the cause of the demonstrated short-term memory deficits of some students with learning disabilities and may account for the slow rate of acquisition of information (Bauer, 1979). That information processing difficulties hinder memory may result from the failure of the student to apply consciously organized mnemonic strategies, as appropriate, and may involve language-based problems in rapid and accurate
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encoding that are less susceptible to conscious control (Torgesen & Kail, 1980).

Leon and Pepe (1983), in a study of self-instructional training, noted that the
memory deficit of a student with learning disabilities was not a problem with
memory and attention, but rather a case of not knowing how to go about a task that
requires attention and memory. Their research further suggested that, given an
adult-generated strategy, a student with learning disabilities can perform at a level
comparable to normal peers.

In a review of strategy instruction, Goldman (1989) concluded that effective
strategy instruction in math for students with learning disabilities must focus on all
four phases of problem solving: strategies for arriving at adequate representations of
problems; for planning solutions; for carrying out the computational work; and for
evaluating the success of each of the foregoing. Students need to be instructed in
both what to do and how to do it. Strategy instruction must include task-specific
and general aspects. Specific strategy instruction to improve transfer and
generalization is necessary. Once effective strategies are taught, they must be
internalized (Goldman, 1989).

Students with learning disabilities may have difficulty reaching automaticity.
When the requisite level of automaticity has not been reached, the student is
required to utilize more central processing to think about each skill individually on a
conscious level. This effort keeps the student from reaching higher order skills and
being able to plan effectively. (Gelzheiser et al. 1983; Hasselbring, Goin, &
Bransford, 1988). In different studies, Garnett and Fleischner (1983) and
Hasselbring et al. (1988) stated that automaticity was a prerequisite in reading,
writing, and math, and Woodward (1991) named it as a primary instructional goal.
Being unable to recall facts from memory will result in the student's falling farther and farther behind.

Areas of difficulty

Students with learning disabilities have difficulty with basic academic subjects of reading, writing, spelling, and arithmetic (Rosner, 1993; Cawley, 1984b) including academic vocabulary and content (Scruggs & Mastropieri, 1990). Students with reading disabilities do poorly on memory tasks because they fail to adopt an active, well planned, and organized approach to the task. Many of these students may experience problems on tasks that require the rapid manipulation of verbal materials because they encode, and possibly access, these materials more slowly than students without disabilities. A reason that students with reading disabilities search memory more slowly than peers may be the manner in which information is encoded originally in working memory. They may be less likely to use various syntactic and semantic cues to aid in encoding (Torgesen & Kail, 1980).

Math deficits account for a substantial amount of learning disabilities referrals (McIntyre, Test, Cooke, & Beattie, 1991). McLeod and Armstrong (1982), in a study of junior high, middle-grade, and high school teachers of students with learning disabilities, found that teachers reported that the most common math deficit areas included upper level skills in the division of whole numbers, basic operations with fractions, decimals, percents, fraction terminology, and multiplication of whole numbers. Deficits in the areas of place value, measurement skills, and the language of math were attributed to a conceptual skill deficit preventing mastery. Memorization difficulties may be evident in a student's inability to retain a series of digits, a series of steps, or a multiplication table. Students may continue to
experience difficulties in the visual memory of the sequencing of numbers and symbols even after the acquisition of reading skills (Tomey, 1986). Deficits may be found in the areas of automaticity, metacognitive strategies, memory, attention, generalization, pro-active learning, and motivation (Mercer, Jordan, & Miller, 1994). In addition, Cawley (1984b) noted that deficits may occur in visual and auditory discrimination, visual and auditory association, spatial awareness and orientation, verbal expression, closure and generalization, and attending.

Houck et al. (1980) suggested that, depending on the possible site of neurological dysfunction, a student may demonstrate inefficiencies in internal data manipulation capability (e.g., performing mental computation and converting different units of measure); memory (e.g., making viable estimations of weight, space, time, performance of constructional tasks where the model must be revisualized/retrieved from memory, and attaching meaning to graphic symbols and numerical concepts); spatial, figural, and/or temporal differentiation (e.g., accurately observing spatial and temporal relationships and performance of a constructional task to duplicate a presented model); quantitative reasoning and concept formation (e.g., understanding the stability of quantity, and sifting out relevant from irrelevant data for problem solution). The initial capacity for internal data manipulation is a requisite for development of later efficiency. The system breakdown may center in memory storage deficits where previous experiences are not stored or are stored improperly; experiential synthesization deficits where commonalities of repeated exposures are not extracted and collapsed for more efficient retrieval; and retrieval deficits, where stored information remains totally or partially inaccessible for encoding purposes (Houck et al. 1980). For a student to be successful, the capacity
for internal manipulation of information must be paired with an efficient memory system (Houck et al. 1980; Sharma, 1985).

Greenstein and Strain (1977), using the KeyMath, determined that math skills for students with learning disabilities peak at about grade four. They hypothesized that math, after grade four, becomes increasingly more abstract and symbolic. Mercer et al. (1994) suggested the student’s ability to compute basic number facts reaches a plateau after grade seven. Arithmetic problems, concrete by nature, pose less problem for students with learning disabilities than does mathematics. Arithmetic problems encountered by children with learning disabilities are generally rooted in one or more of the following concepts: difficulty in understanding and mastering symbol-object relationships; reversibility of functions; sequencing and memory problems that can appear to be arithmetic problems; perceptual deficits; difficulty remembering which side to be on; difficulty with horizontal problem presentation; confusion with place value; difficulty determining what process to choose to solve a problem; an inability to memorize multiplication facts; difficulty counting money, making change and adding purchases; or confusion in setting up division problems (Cardoni, 1987).

Mastery of basic math facts is considered to be essential to acquiring more advanced mathematical skills. Students must reach a level of automaticity, especially with regard to math facts. The presence of information gaps may prevent further progress in math skills (Cooper, 1994; Koscinski & Gast, 1993b; Garnett & Fleischner, 1983; Koscinski & Hoy, 1993). Student performance must go beyond the accuracy (i.e., quality) of an acquired skill to encompass sufficient speed (i.e., quantity) of performance. This sort of proficiency with basic facts, rather than
accuracy per se, is notably lacking in the computation performance of many children with learning disabilities. Students may encounter particular difficulty shifting from the acquisition stage (i.e., strategies that require much focal attention) to proficiency stage (i.e., strategies that largely free attentional resources) (Garnett & Fleischner, 1983). Greater proficiency in math facts may enhance the solving of word problems by lessening the cognitive load, allowing the student to focus on the semantic properties (Woodward, 1991; Hasselbring et al. 1988).

Cooper (1994) proposed a hierarchy of skills for the recall of number facts based on the methods students use to remember basic number facts for addition, subtraction, multiplication, and division. The steps of the hierarchy, from top to bottom, were: automatic recall, delay in automatic recall, number relationships, number tricks, number fact guesses with occasional errors, counting or sequencing, and counting or sequencing with errors. A student with automatic recall is able to give number facts without hesitation. Delay in automatic recall means that the student must take a moment to think about some of the facts. Students who combine numbers, or use patterns, to determine number facts have reached the number relationships level of the hierarchy. The next level is the use of number tricks or mnemonic techniques like using music, rhymes, visualizations, and language clues. Some students try to remember by guessing. The result of guessing is frequent errors with the student usually unaware that the guesses are incorrect. Counting or sequencing is used when students who do not know the number facts count to calculate them. The students may use their fingers, count silently, or make marks. The lowest level in the hierarchy is counting or sequencing with errors. This may result as the student skips numbers when counting or if the student has a right/left
Cooper (1994) noted that there is a natural progression from the bottom to the top of this hierarchy.

Remediation

In attempting remediation of memory deficits, teachers should choose the least restrictive, least intrusive, most parsimonious, most effective, and most efficient strategy. The effectiveness of any strategy is determined by whether or not the student learns, and efficiency relates to the relative speed of learning. The teacher must also determine whether to use group or individual instruction (Wolery, Cybriwsky, Gast, & Boyle-Gast, 1991). To be effective, instruction must incorporate principles of learning and behavior (Kinney, Stevens, & Schuster, 1988). Remediation should assist in the acquisition of basic skills that provide the basis for future growth and enhance self-image and self-respect (Milman, 1979). Woodward (1991) stated that previously learned concepts should be mixed in with new concepts. The effects of memory deficits may be minimized by reducing the amount of material the student is expected to remember, using frequent repetition, and developing the student's experiences with the concepts and content of the information so as to extend its meaningfulness (Cawley, 1984b).

Tomey (1986) stated that once a student has reached middle school without requisite math skills, teachers can avoid student frustration if the repetition of previously implemented, but unproductive, approaches is avoided. He suggested that the use of a reference chart for unlearned facts might prove helpful, as well as the actual manipulation of tiles for the student to grasp various concepts. McLeod and Armstrong (1982) contended that at some point the teacher must make the curricular decision to abandon basic-skill instruction and begin life-skill
mathematics. Hasselbring et al. (1988) cited research indicating that counting strategies and calculators may interfere with the learning of higher level mathematics skills.

Houck et al. (1980) stated that two important factors contribute to mathematical learning disabilities: problems the learner brings to the math task, and the complexities of math terminology. Teachers must focus on how the mathematical problem is approached, not just whether the correct answer is obtained (Houck et al. 1980). Because students with learning disabilities often have visual and auditory perception deficits, information needs to be presented in a variety of ways (Lombardo & Drabman, 1985; Thornton & Toohey, 1985). Lombardo and Drabman (1985) stated that the Write-Say method of teaching facts is better than just writing alone because it allows continuous monitoring of the task behavior. This method is also enjoyable for the students. Fulk and Stormont-Spurgin (1995) presented fourteen teacher-directed and student study techniques for optimizing spelling instruction for students with learning disabilities. The strategies were divided into teacher-directed techniques (e.g., test-teach-test sequence; reduced word list; reinforcement; imitation plus modeling; analogy strategy; constant time delay; and student study techniques (e.g., relevance and transfer; error correction; systematic study procedures; self-monitoring; peer tutoring; variety in practice format; goal setting and graphing; computer practice).

Peer tutoring has been utilized to teach generalized reading of cooking product labels through the use of key words to adolescents with moderate retardation (Collins, Branson, & Hall, 1995). Koury and Browder (1986) trained intermediate students with moderate mental retardation to be peer tutors for primary moderately
retarded students. Miller, Barbetta, Duevno, Martz, and Heron (1996) used peer tutoring to improve the basic skill performance in math in a general education classroom setting. This study also noted that a well-designed peer tutoring program will provide directed repetition, regular review, and functional practice to enable students to overlearn skills, operations, and concepts. Additionally, small group peer tutoring can be used as an intervention to provide additional skills practice. Beirne-Smith (1991) concurred and added that the tutors must be trained and monitored, and the program must incorporate principles of effective instruction.

A variety of mnemonic strategies that will aid memory have been developed. These strategies include the use of pictorial mnemonics (e.g., loci method, pegwords, and keywords), rote memorization, chaining, clustering, and first letter mnemonics (Reetz, 1987; Scruggs & Mastropieri, 1990). Scruggs and Mastropieri (1990) also included "Yodai" (i.e., a Japanese mnemonic for learning mathematics procedure), reconstructive elaborations, phonics and spelling mnemonics, and number-sound mnemonics. Scruggs and Mastropieri (1993) and Mastropieri, Scruggs, and Levin (1983) found that the use of mnemonics with students with learning disabilities could be effective in memory for content, reading comprehension, listening comprehension, note taking, essay writing, and effective test taking. Brigham (1993) used mnemonic keywords to help students with learning disabilities remember locations and events on maps.

Intervention strategies that target memory deficits could be expected to benefit students with learning disabilities. Mnemonic instruction, as an intervention strategy, has been implemented with students with learning disabilities with positive results (Scruggs & Mastropieri, 1990; Scruggs & Mastropieri, 1993). The use and
effectiveness of memory strategies, which some students appear to figure out on their own, should be demonstrated explicitly for students with special needs (Reetz, 1987).

Brigham (1993) used a mnemonic strategy to teach social studies content with the use of maps. Evers and Bursick (1995) presented mnemonic strategies that may be useful to students with learning disabilities in technical classes. The CAN-DO mnemonic is a strategy for learning content information. The strategies CLUE and FUR, from the Reading Visual Aids Strategy, can be used to increase reading comprehension. Students may develop their own acrostics to assist in memorizing machine parts, the steps to complete a task, or shop procedures. Teaching students time management procedures and self-monitoring techniques may also help students be successful in technical classes.

Gelzheiser et al. (1983) reported that if the goal of mnemonic training is generalized improvement in the ability to memorize, simply teaching a fixed mnemonic will not be adequate. Children with learning disabilities have difficulty with the higher order components of memory and may be unable to attend to the goal of the task because the student must attend to the mnemonic. The mnemonic must be embedded in a more complete and complex study plan that will also involve monitoring and evaluation of progress to the goal.

McDonnell (1987) used least prompts with students with severe handicaps in the acquisition of purchasing skills. The least prompts procedure is designed to provide the student with the opportunity to perform the target response on each trial without teacher prompts. If an incorrect response is given, the teacher provides increasing levels of assistance until the step is performed accurately. This hierarchy
of prompts increases the amount of assistance, as needed (Gast, Ault, Wolery, Doyle, & Berlanger, 1988; Ault, Wolery, Gast, Doyle, & Eizenstat, 1988; Wolery, Ault, Doyle, & Griffen, 1990; McDonnell, 1987). Token reinforcements have been used to improve word recognition and math ability with students with severe learning disabilities (Pavchinski, Evans, & Bostow, 1989).

Time Delay

Time delay is a virtually errorless or near errorless instructional procedure (Schuster, Gast, Wolery, & Guiltinan, 1988; McDonnell, 1987; Koscinski & Hoy, 1993). Doyle, Winterling, Gast, and Wolery (1990) defined constant time delay as a response prompting strategy involving the simultaneous delivery of a target stimulus and a controlling prompt for a limited number of trials, followed by trials where the target stimulus is presented, but the controlling prompt is delayed for a constant time period. Touchette (1971) was the first to introduce the use of a time delay strategy in teaching a form discrimination task to three students with severe retardation. In a time delay procedure, the type and amount of teacher assistance remains constant during training. Use of the time delay leads to correct responding immediately after the presentation of an actual task stimulus. Appendix H contains a flow chart representation of the constant time delay procedure. Time delay is an effective and efficient instructional tool. It requires a minimal amount of teacher preparation, results in a high percent of correct responses, and is simple to implement (Cybriwsky & Schuster, 1990; Ault, Gast, Wolery, & Doyle, 1992; McDonnell, 1987; Mattingly & Bott, 1990; Schuster & Griffen, 1990). In addition, constant time delay is adaptable to a variety of instructional tasks and does not
require expensive instructional materials or equipment (Koscinski & Hoy, 1993; Mattingly & Bott, 1990).

A time delay procedure can be constant or progressive. Constant time delay (CTD) has a fixed number of seconds between the target stimulus and the prompt, while progressive time delay increases the interval gradually over trials and sessions (Schuster, Gast, et al. 1988). McDonnell (1987) found constant time delay easier to implement than progressive time delay due to the consistent interval of time. Wolery, Holcombe, Cybriwsky, Doyle, Schuster, Ault, and Gast (1992) reported that constant time delay is as efficient as progressive time delay, more efficient than a system of least prompts and a stimulus fading procedure, but less efficient than a simultaneous prompting procedure. Numerous professionals provided procedural methodology for the implementation of a constant time delay procedure, including methods of data collection (Ault, Gast, Wolery, & Doyle, 1992; Winterling, Gast, Doyle, & Wolery, 1990; Doyle, Winterling, et al. 1990; Doyle, Wolery, Ault, & Gast, 1986).

Studies comparing a constant time delay procedure and the system of least prompts found that both strategies produced criterion level performance, but that constant time delay was more efficient in terms of number of sessions required, the percent of errors, and the amount of instructional time to criterion. Wolery, Ault, Gast, Doyle, and Griffen's (1990) comparative study was conducted to teach chained life skills to children with moderate mental retardation. The two procedures were used to teach sight words to developmentally delayed preschoolers by Doyle, Wolery, Gast, Ault, and Wiley (1990) and to moderately retarded elementary students by Gast, Ault, et al. (1988). Ault, Wolery, Gast, et al. (1988) taught
numeral identification to autistic students. Miller and Test (1989) compared constant
time delay and most-to-least prompting to teach the operation of a washer and dryer
to students with moderate retardation enrolled in a community-based training class.

Ault, Gast, and Wolery (1988) utilized progressive and constant time delay in
teaching community-sign word reading to students with moderate mental retardation.
Though both were effective, the constant time delay was more efficient in terms of
the amount of instructional time required and the number of sessions to criterion
(Ault, Gast, & Wolery, 1988; Ault, Wolery, Doyle, & Gast, 1989). Ault, Wolery,
Doyle, et al. (1989) suggested that providing prompts prior to student responses may
decrease the probability of errors and increase the probability of error-free learning.

In reviewing the use of a constant time delay procedure with task analysis,
Schuster and Griffen (1990) stated that CTD was effective in teaching numerous
chained tasks to a variety of special education students. Schuster, Gast, et al.
(1988) used a constant time delay procedure to teach chained food preparation
behaviors (i.e., sandwich making) to adolescents with trainable mental retardation.
Schuster and Griffen (1991) taught drink preparation to intermediate-aged
elementary students with moderate mental retardation. Constant time delay was
used by Zhang, Gast, Hovat, and Dattilo (1995) to teach lifetime sport skills (i.e.,
one step bowling, overhand throwing, and short distance putting) to adolescents with
severe to profound retardation and by Chandler, Schuster, and Stevens (1993) to
teach adolescents with mild and moderate disabilities to fill a soda machine, use a
duplicating machine, and use a photocopier.

The constant time delay procedure was used by Gast, Collins, Wolery, and
Jones (1993) to teach developmentally delayed preschoolers appropriate responses to
the lures of strangers. The correct responses were quickly learned but not generalized until instruction was conducted \textit{in vivo}. Collins, Schuster, and Nelson (1992) used constant time delay to teach generalized responses to the lures of strangers to adults with severe handicaps. In this study, the responses were acquired but generalization was inconsistent and mixed.

Most of the studies reviewed were conducted with students with some level of mental retardation. A few published studies were found to date that used constant time delay to teach students with learning disabilities. Stevens and Schuster (1987) used a constant time delay procedure to teach written spelling to a student with learning disabilities who had severe spelling deficits. The student correctly learned and generalized the use of 14 out of 15 target words. The results of their study indicated that time delay was a viable alternative for students with learning disabilities who had not benefited from traditional instructional procedures. Schuster, Stevens and Doak (1990) taught word definitions to elementary students with learning and behavior disorders using CTD. The procedure was effective in teaching the three students to state the definitions of targeted vocabulary words. Accuracy was maintained up to 14 weeks after training ended. Pre-post generalization test scores indicated that two of the three improved on word reading and all improved on stating the word after hearing its definition.

Most of the studies reviewed provided one-to-one instruction using the constant time delay procedure. Several researchers noted that factors favoring group instruction are the demands on teacher time; opportunity for appropriate peer interaction; increasing the efficiency of instruction; the opportunity for observational learning; and generalization of skills to less restrictive setting (Wolery, Ault, Gast,
Constant Time Delay

Doyle, & Mills, 1990; Wolery, Ault, Gast Doyle, & Griffen, 1990; Collins, Gast, Ault, & Wolery, 1991). A potential problem with group instruction is maintaining attention. Constant time delay was used with small group instruction to teach sight word reading to five primary-aged students with moderate delays by Gast, Wolery, Morris, Doyle, and Meyer (1990). The results indicated that the CTD procedure was effective in teaching sight words to four students. Alig-Cybriwsky, Wolery, and Gast (1990) studied the effectiveness of the CTD procedure in teaching sight word reading to a group of four preschool children with handicaps (i.e., developmental delay, speech and gross motor deficit, hearing loss and speech delays, and motor planning difficulties). Wolery, Cybriwsky, et al. (1991) taught adolescents with learning or behavior disorders social studies and health facts using CTD. The results indicated that the procedure was reliable and effective.

Constant time delay has been effectively utilized with computer-assisted instruction (CAI). Kinney, Stevens, and Schuster (1988) taught the spelling of 15 state names to a 6th-grade student with spelling disabilities using these two procedures. After establishing the program, a minimal amount of teacher time was required. The student received immediate feedback, with sound effects when correct and corrective information when the answer was incorrect. The subject reported that he enjoyed the program and asked that all of his words be added to the program. In addition, the subject became familiar with the computer and its keyboard. Edwards, Blackhurst, and Koorland (1995) used CTD and CAI to teach abbreviation spelling to four adolescents. Three were identified as having learning disabilities and one was identified as educable mentally handicapped. The learners rapidly acquired the target skill and were able to maintain and generalize across
time, persons, and place. The study supported the feasibility and usefulness of constant time delay with computer assisted instruction.

Remediation in Mathematics

Constant time delay has been documented to provide remediation for a variety of instructional settings. It is equally effective in remediation of mathematics deficits. Milman (1979) documented the use of a metronome to teach the days of the week, months, songs, poems, and multiplication facts. The steady beat, plus the visual attraction of the moving arm, may foster relaxation and more effectively activate rote memory as a means of learning. Koscinski and Gast (1993b) noted the use of flash card and multiplication charts, number lines, Cuisenaire rods, and finger math in teaching facts. Project AutoMath is a program of drill and practice for students with mild disabilities designed to aid the student in developing rapid responses to basic math fact problems (U. S. Department of Education, 1990).

Thornton and Toohey (1985) provided a case study, incorporating visual, auditory, kinesthetic, and tactile (VAKT) approaches to modify instruction in teaching basic subtraction facts. Learning strategies are presented through areas of strength. Rivera and Smith (1988) implemented a demonstration strategy to teach students with learning disabilities how to compute long division. The instructional intervention, which included demonstration, imitation, and key guide words, was found to be effective with the eight students involved in the study. Lombardo and Drabman (1985) suggested a "Write-Say" approach to remediate difficulty in simple multiplication with students with learning disabilities. The students produced visual, auditory, and kinesthetic forms of information by vocalizing multiplication problems.
while they wrote them. The "Write-Say" method allowed for continuous monitoring of on-task behavior.

Greene (1992) found the use of manipulatives and logically ordering multiplication facts by difficulty level to assist children with learning disabilities. The author presented finger multiplication, the use of visual mnemonic flashcards, and putting the multiplication tables to music as methods to assist students with learning disabilities to learn multiplication facts. Ross and Kurtz (1993) presented a strategy for making manipulatives work in teaching math skills. The teacher used colorful manipulatives to teach counting, classifying, patterning, constructing, and exploring by playing various games. Lock (1996) noted that the use of games for continued practice and sequencing basic fact memorization will make the task of math fact acquisition easier. Campbell (1989) suggested that card games could be utilized to assist with basic facts. The series of arithmetic card games, using playing cards, was used for practice and reinforcement for the basic facts of addition, subtraction, multiplication, division, and various combinations of these operations.

Kurland (1990) utilized a number line to take addition and subtraction out of the realm of memorizing seemingly separate and unrelated facts and presented the procedures as an interrelated series of patterns. The number line and the use of an interval card allowed the students to observe, at a glance, several concepts pertaining to addition and subtraction, thus facilitating a mental picture of the concepts, their interrelatedness, and their transferability. Bullard and McGee (1983) conducted a study in which a resource teacher trained peer tutors to use strategies such as praise, correction, and charting of daily progress data to teach mastery of math facts. The results indicated that, as a group, the students mastered an average
of 9.1 sets of facts. Both students and tutors reported satisfaction with the program. In addition, inappropriate behavior in the tutors decreased, and tutors became more involved in school. Beirne-Smith (1991) explored the effects of peer tutoring on the acquisition of single-digit addition facts with primary-aged children with learning disabilities and their cross-age tutors. The tutors utilized a counting-on approach and a rote-memorization approach. Results of the study indicated that peer tutoring for students with learning disabilities is an effective instructional alternative for the acquisition of basic computational skills, particularly when the tutoring program incorporated the principles of effective instruction. No significant differences were noted between the two tutoring procedures. Miller, Barbetta, et al. (1996) provided a format of general training procedures for the use of peer tutors for students with learning disabilities. They noted that the utilization of peer tutoring was an instructional methodology that was consistent with most teacher goals. For students with learning disabilities, peer tutoring provided an opportunity to become active learners and offered a functional way for students to learn mathematics skills. The program can be managed in the same way as other small-group activities.

Pavchinski, et al. (1989) used a system of token reinforcers to improve math and reading skills with a fourth-grade student diagnosed with severe learning disabilities. The student was also diagnosed as emotionally disturbed and was in residential treatment in a family-style group home. The results of the study indicated that the student successfully learned the reading and math components. The items learned appeared to have generalized in that they became integrated with the student's academic performance in school.
Studies have shown that time delay is effective and efficient in teaching math facts to students with learning disabilities. Koscinski and Hoy (1993) described how to use a CTD procedure to teach multiplication facts to students with disabilities. The adaptability of the procedure with individual and small group instruction was noted. The methodology and materials were explained. The authors stated that the real promise of CTD was in the adaptability of the technique to other instruction tasks. Holcombe-Ligon, Wolery, Werts, and Hrenkevick (1992) taught dyads of preschool students with developmental delays to name the numerical value of sets of geometric figures, the corresponding numeral, the corresponding number word, and the corresponding Roman numeral through the use of instructive feedback and constant time delay. Three of the four students learned to name the numerical value of sets of geometric figures, the corresponding numeral, and the corresponding number word. The fourth student had to be removed from the study due to his behavior.

Sandknop, Schuster, Wolery, and Cross (1992) conducted a study using an adaptive number line with a constant time delay procedure to teach adolescents with moderate mental retardation to select lower-priced grocery items. The data indicated that the use of the number line with CTD was effective in teaching students to select lower-priced groceries. The results also indicated that the target skill taught was only one of a broader range of shopping behaviors that needed to be acquired if persons were to be independent shoppers.

Hasselbring et al. (1988) reviewed the efficiency of computerized drill-and-practice in teaching addition facts to automatization. The authors noted that the use of controlled response time forced students to abandon the use of counting strategies...
and to retrieve answers rapidly from their existing knowledge of basic problems and their answers. This research resulted in an experimental math program called Fast Facts that successfully developed the recall of basic math facts.

Koscinski and Gast (1993a) utilized computer-assisted instruction with constant time delay to teach multiplication facts to elementary students with learning disabilities. The study's results indicated that the constant time delay incorporated into the software program was an effective method of teaching multiplication facts. The results supported the effectiveness of the CTD instructional method in teaching multiplication facts to students with learning disabilities or mild intellectual handicaps. Generalization of the information had varying degrees of success for the four students. The study also supported the position that software design may be the determining factor in using CAI to improve academic skills with students with learning disabilities.

McIntyre et al. (1991) utilized the count-by technique with a constant time delay procedure to teach multiplication facts to a fourth-grade student with learning disabilities. The count-by strategy presented multiplication as repeated addition by teaching students rote counting sequences. Accuracy was achieved by teaching facts in ways that illustrated basic math principles. Williams and Collins (1994) evaluated the effectiveness of constant time delay while comparing the use of teacher-selected and student-selected material prompts. This investigation demonstrated that CTD, used with material prompts, was effective in teaching math facts. The students, diagnosed with learning disabilities, performed better when they selected the prompts. The authors noted that allowing students to select prompts may be more efficient, less intrusive, and simpler to implement, but the teacher may need to limit
choices and evaluate each student's ability to make a choice. Cybriwsky and Schuster (1990) successfully utilized a constant time delay procedure to teach multiplication facts to elementary-age students with mild learning handicaps and behavioral disorders. Using a four-second constant time delay, the students learned 15 facts with approximately one hour of instruction.

Mattingly and Bott (1990) investigated the effectiveness of a constant time delay procedure in teaching multiplication facts to fifth- and sixth-grade students with learning disabilities. The one hundred multiplication facts were written on 3 x 5-inch cards. Each subject was screened using the cards to determine the unknown facts. These facts were taught in groups of 30 using a five-second constant time delay. The results indicated that CTD was effective in teaching multiplication facts to the targeted students. Koscinski and Gast (1993b) utilized a CTD procedure teaching multiplication facts to five elementary school students with learning disabilities. This study used a four-second time delay. The results indicated that CTD was both efficient and effective in teaching multiplication facts to the students with learning disabilities. The group of students were heterogeneous, with varying strengths and weaknesses. Some students were able to verbalize responses within the time limit, while others were able to write the responses. All students were able to learn the targeted multiplication facts.

Purpose

The purpose of the present study was to investigate the effectiveness and efficiency of a constant time delay procedure in the teaching of the gradations of an inch in sixteenths to middle school students in a self-contained mathematics class for students with learning disabilities. The acquisition of this skill would assist students
with measurements in math and vocational classes, particularly Industrial Arts classes. Being able to recite and write the parts of an inch accurately in sixteenths was a requirement of the Industrial Arts class at the students' school. Students unable to fulfill this requirement did not successfully complete the course of study for the class. Acquisition of this skill would also be a life skill for some, if not all, students.

Some students with learning disabilities, especially those in self-contained math classes, have demonstrated significant difficulty with this task. The intent of this study was to teach, through the use of a constant time delay procedure, one measurement skill required for successful completion of the Industrial Arts classes.
METHODOLOGY

Subjects

The students who participated in this study were selected from a sixth-grade self-contained math class for students with learning disabilities. The school was located in a rapidly growing county that bordered a large metropolitan area. The school contained a large minority and a large at-risk population. Five males and one female, with ages ranging from twelve years two months to thirteen years seven months as of March 1997, were involved in this study. Permission was obtained for a seventh student, but he was absent for the pre-instruction and the pre-test and was eliminated from the study. All subjects were found eligible to receive services in the program for children with learning disabilities, based on eligibility requirements at the time of his/her eligibility. Services within the learning disabilities program ranged from 45% to 75% of the school day, as documented by the students' Individualized Educational Plan (IEP). All subjects were enrolled in self-contained math and language arts classes. Five subjects were in collaboratively taught science classes. All subjects were mainstreamed for an elective and health/physical education. Vision and hearing screenings indicated that both were within normal limits for all subjects.

To ensure confidentiality of the information specifically regarding each subject, the names, as used in the documentation, were changed. No mention was made of the school, county, or state involved in the study. Participation in the study was voluntary and could be refused without penalty. Permission was obtained from the county administration and from the principal of the school (See Appendix A).
Permission was also obtained from each parent or guardian prior to initiation of the study (See Appendix B).

The students were observed prior to the initiation of the study to determine each student's ability to demonstrate the following prerequisite skills: (a) attend for a period of ten minutes; (b) wait for the prompt; (c) respond to the prompt within the time limit; (d) make eye contact.

The students were observed attending for a ten-minute period in a class setting. During the pre-instruction session, the subjects were able, after some practice, to wait for a prompt, respond within the time limit, and make eye contact.

The target task of the study was to teach the subjects to recite the parts of an inch in sixteenths.

Setting

All sessions were conducted in a regular education sized classroom. There were eleven desks, two half tables that form an octagon with chairs, and two teacher desks with a table extension in the room. The two half tables were arranged in a V-shape. The students sat around the outside with the teacher sitting in front of the students at a small table desk. All stimulus cards and corresponding responses were visible and audible to all group members.

Materials and Task

A total of sixteen gradations of measurement of an inch were presented to all subjects. Black vinyl one-inch letters were used to form each measurement fraction on the front of large cards (5 x 8 inches). The one-inch card, with the symbol for an inch ("), was in red. On the back of each card the measurement was printed in light purple in the upper right hand corner along with a prompt to indicate the
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required attentional response. The cards were laminated. See Appendix C for a facsimile of the measurement card. Subjects were assigned seats at the table through the use of a place card bearing the students’ names (See Appendix D).

Procedures

Pre-training and instruction was conducted prior to Session One. The purpose of the study was explained to the subjects and their cooperation elicited. The subjects were instructed to attend when the prompt was given, respond when cued, and not to interrupt the response of others. The subjects, individually and as a group, responded orally to the presentation of the measurement cards.

An individual pre-test probe (See Appendix F) was administered to each subject following pre-instruction. Each subject was asked, individually, to recite the parts of the inch in sixteenths. Prompts were given to each student as needed. Incorrect responses were not corrected.

The instructional sessions were conducted on six consecutive school days. Each session began with a group choral response to the measurement cards, using a zero-second time delay. The subjects were cued ("Look"), the examiner read the measurement, and the subjects repeated the measurement. The group was given verbal praise (e.g., "Good job") after completing each choral response set.

Instructions for the individual response trials were explained to the subjects prior to initiation of each group of three trials. After the first session, different subjects were asked to explain the instructions, with reinforcement provided by the examiner. Each session trial started with a different subject, progressing in the order of seating around the table. The examiner held up a card and said "Look." After each subject was noted to be attending to the card, the examiner asked one student to read the
card ("Mary, what measurement?"); a three-second time delay was allowed for a response. If a prompt was given, the subject was given a three-second time delay for a response. If an error occurred, the examiner responded "No" and repeated the measurement for the subject to repeat within the three-second time delay. When interference (e.g., a subject answered out of turn) occurred, the examiner repeated the cue asking for a response from the indicated student. When a subject appeared not to be attending, the examiner waited until attention was noted before proceeding. Subjects received verbal praise after correctly saying the measurement.

A post-test (See Appendix F) was administered the day after Session Six was completed. Each student was individually asked to recite the parts of an inch. Subjects were given a three-second time delay for a response. If no response or an incorrect response was made, the subject was prompted and given a three-second time delay in which to respond.

A probe (See Appendix F) was conducted individually after pre-instruction was completed. The initial probe served as the pre-test. After the sixth session a post-test probe was administered to the subjects individually.

Response Definition and Data Collection

Data were collected continuously during all probes and individual trials (See Appendix G). During the pre-test/post-test probes, three student responses were scored: correct, incorrect, or no response/prompt. These responses were defined as:

1. Correct—correctly stating the answer within the three-second response interval.
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2. Incorrect--incorrectly stating the answer within the three-second response interval. The correct response prompt was given on the post-test so that the subject could continue with the probe.

3. No response/prompt--saying nothing within the 3-second interval. The subject was prompted with the measurement during the post-test.

Six possible student responses were available to be recorded during individual instruction trials. These responses were defined as:

1. Unprompted correct--correctly stating the answer within the three-second response interval.

2. Prompted correct--correctly repeating the answer within three-seconds after the examiner’s model.

3. Nonwait error--incorrectly stating the answer before the delivery of the examiner’s prompt.

4. Wait error--incorrectly repeating the answer within three-seconds after the prompt delivery.

5. No response--saying nothing within three-seconds of the prompt delivery.

6. Interference--another student gave the correct or incorrect answer before the target student answered. When this occurred, the interfering subject was told "No" and the prompt given again to the subject.

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After the choral responses at zero-second delay trial, the examiner waited for three seconds between the presentation of the stimulus and the controlling prompt.

After calling the student’s name, the teacher counted one thousand one, one
thousand two, one thousand three, then provided the prompt. This delay was maintained for all remaining trials. Verbal praise was given after the choral set was completed. During the remaining sets, each correct response resulted in a general praise statement. Negative feedback resulted when an incorrect response was given. The examiner said "No" before repeating the correct measurement and the subject repeated the measurement.

Generalization

Generalization was measured by use of pencil and paper two days after the post-test was administered. The students were given a sheet of paper with an enlarged scale drawing of the inch (See Appendix E) and asked to label the inch by sixteenths.

Measuring Performance

Data were collected on a continuous basis using the six types of student responses for the instructional sessions, and the three types of responses for the pre-test/post-test probes. Efficiency was measured through the data by a comparison of the correct responses from the pre-test to the post-test, the total number and percentage of errors/interference, and the length of instructional time.
RESULTS

Subjects

David, age twelve years two months, was initially identified as developmentally delayed during the first grade year. A subsequent evaluation during second grade found him eligible for learning disabilities services. He was also diagnosed with Attention Deficit Hyperactivity Disorder (ADHD). His doctor prescribed Dexedrine, which David continues to take. David’s performance on the WISC-III indicated an estimate of low average general intellectual ability, with uniform development noted between verbal and perceptual reasoning skills. A personal strength in the verbal realm of practical reasoning was noted. David’s performance in the areas of comprehension and expression of language, verbal and nonverbal concept formation, mental computation, auditory and visual memory, and nonverbal processing speed fell within the low average to average range. A significant strength for David, within the area of information processing, was fluid reasoning in a visual format. Significant weaknesses were noted in short-term auditory and long-term visual/auditory retention. Moderate deficits in visual-motor integration were also noted. David’s IEP indicated that he received learning disabilities services for 75% of the school day and that he responded to one-to-one attention and required repetition and practice in order to retain information. David presented himself, on a self-report inventory of self-concept, in an extremely positive light. David’s teacher ratings indicated that he continued to appear mildly inattentive and quite restless. Results of the Woodcock-Werder-McGrew Mini-Battery of Achievement indicated that David’s performance was average in writing and mathematics, with low average performance in reading. In factual knowledge,
David's performance was average. During the study, David was found to be interested and able to stay on task. Following Session 2, he asked if he could have a copy of the generalization tool, so that he could study on his own. The examiner responded that a copy would be provided at the conclusion of the study, if he still needed it. David was present for the duration of the study.

Matthew, age twelve years two months, transferred into the school before Christmas of the current school year. Only part of a recent psychological evaluation was sent with a copy of an active IEP. Matthew's overall cognitive ability on the Stanford-Binet Intelligence Scale—fourth edition (SB-IV) was within the low average range. He was functioning in the slow learner range on verbal comprehension, but within the average range in nonverbal problem solving. Matthew's current IEP indicated that he was achieving below average in vocabulary, spelling, and word usage. Weaknesses were also noted in punctuation, capitalization, and use of age-appropriate words. Matthew's overall math skills were weak, as indicated by the KeyMath. He displayed no specific strengths, but weaknesses were noted in numeration, rational numbers, geometry, subtraction, multiplication, division, mental computation, time, and money. Learning disabilities services were provided for Matthew for 45% of the school day. Matthew was absent during Session 3 in order to have his tonsils removed. He returned on Monday for Session 4 and was cooperative in his responses, although he had to whisper. He missed the group choral set for Session 5 because he had to go to the clinic to take his medication. During the sessions, Matthew would frequently look before the examiner had noted his attention, then pretend he was not looking. The examiner waited until he was
seen to be attending before proceeding. The examiner explained to him, as necessary, that the examiner needed to see that he was attending.

Mary, age twelve years three months, was found eligible to receive learning disabilities services at the end of her first-grade year. Prior to this identification, Mary had received remedial services through junior kindergarten, Chapter One, summer school, and the Early Intervention/Reading Recovery program. Her current level of performance, as documented by her IEP, indicated deficits in mental computation, visual perception, visual-motor integration, and auditory memory. The Weschler Intelligence Test for Children III (WISC-III) indicated a verbal IQ of 76; a performance IQ of 65; and a full scale IQ of 69. The Mini-Battery indicated that Mary was performing about two and a half years below her peers in mathematics. In reading and writing, her performance was approximately three to three and a half years below her peers. In factual knowledge, she was functioning approximately one and one half years below her age peers. Mary’s IEP indicated that she received learning disabilities services for 75% of her school day. The records also indicated that despite her academic challenges, Mary maintained a positive, fairly well-integrated self-concept. Mary was attentive during the sessions and responded as cued. Mary had no absences during the study.

Paul, age twelve years seven months, moved into the school district in September of the current school year. Records that accompanied Paul were sketchy at best. He was found eligible to receive learning disabilities and speech/language services prior to this year and he had had a least one triennial. The WISC-III indicated that Paul was currently functioning in the borderline range of intelligence. A significant difference between verbal and non-verbal skills with a verbal IQ of 74,
a performance IQ of 89, and a full scale IQ of 79 was reported. Overall weaknesses were noted in verbal concept formation and in interpreting and sequencing. Paul exhibited strengths in perceptual matching and perceptual/spatial organization. He exhibited significant weaknesses in verbal comprehension and in freedom from distractibility. Visual-motor integration skills were noted to be severely delayed. Weaknesses were manifested in poor written and oral language skills. Paul exhibited deficits in expressive and receptive language. His IEP indicated that learning disabilities services are provided for 45% of the school day, and speech services for 3% of the school day. Paul presented himself to the examiner as a child in need of attention. He played with the name cards and otherwise distracted himself frequently. Directions had to be explained to him, in addition to the explanation to the group. Paul liked to answer before the cue during the first choral set, but did stop after the instructions were explained again. He was often the recipient of hostility from other group members when his inattention caused delays. His need for attention led the examiner to provide time after the daily sessions were completed for Paul to ask questions or just speak with the examiner. Paul was present for the duration of the study.

Mark, age twelve years nine months, was found eligible to receive services in 1995 under Section 504 of the Rehabilitation Act of 1973 following a diagnosis of ADHD. He was also found eligible for speech/language services. The following year he was found eligible to receive learning disabilities services, with speech services continuing. Mark takes Ritalin twice daily. Records indicated a positive family history of learning disabilities and other neurological disorders. Mark displayed significant delays in both verbal and non-verbal intelligence and was noted
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to function within the borderline range of intellectual ability. His receptive and expressive language skills were notably delayed. He exhibited moderate weakness in visual-motor integration and speed of mental processing. Cognitively, Mark’s overall ability, as measured by the Woodcock-Johnson Cognitive Battery, was estimated to fall in the low average range. Areas of relative strength were in long-term retrieval, visual processing, and processing speed, all falling within the average range. Weaknesses were indicated in auditory processing and comprehension-knowledge. Visual-motor integration skills were within the average range when compared to age peers. Mark’s reading skills fell in the low to low average range, while scores for math and general knowledge were assessed as low average. Written language scores were low. In speech, improvement was noted in verbally communicating with others. Despite an apparently adequate prescription of Ritalin, records indicated that Mark continued to display significant behavioral difficulties within the classroom, particularly in terms of impulse control, attention span, and activity level. However, his self-report indicated adequate emotional adjustment. Mark’s IEP indicated that he received learning disabilities services for 45% of each day and speech for 3%. Mark appeared to enjoy participating in the study. He liked to look before the examiner saw him, then pretend he was not attending. The examiner used the same process with Mark that was used with Matthew. Mark missed the last three sessions due to a suspension from school and was absent for the generalization procedure.

Luke, age thirteen years and seven months, was found eligible for learning disabilities services while he repeated the first grade. Deficits were exhibited in long-term memory, processing speed, and oral language skills. Auditory and visual
processing were strengths, with relative strengths in short-term memory and comprehension/knowledge. Prior to the identification for learning disabilities services, Luke attended junior kindergarten, received Chapter One services, and attended summer school. In 1995, Luke was found eligible for speech and language services. Records indicated that Luke currently functioned below age and grade expectancy in all areas of reading, writing, and spelling. Math scores fell near grade level, but below age expectancy. Luke exhibited strength in the area of short-term memory, while a significant deficit in auditory processing adversely affected his academics. The WISC-III indicated functioning in the low average range of intelligence (verbal IQ--81; performance IQ--84; full scale IQ--81) with strengths in auditory memory and visual-motor integration. He demonstrated weakness in receptive vocabulary skills, expressive semantic functioning, and some areas of auditory processing. His overall expressive language appeared to be at risk. Luke's IEP indicated that he received speech/language services for 3% of the day and learning disabilities services for 60%. Luke was cooperative during the study. He was attentive, but like Matthew and Mark, liked to pretend he was not attending. He was present for all portions of the study.

Data Information

During the Pre-training and instruction session, the subjects copied the measurements from the model on the overhead projector onto an enlarged model of the inch (See Appendix E). An error in copying was made by Mark (copying 5/16 instead of 3/16) and by Mary (copying 3/8 instead of 3/15). Subjects were allowed to move closer to the overhead to facilitate copying.
The Pre-test data (See Figure 2) indicted that no subject was able to name correctly all of the measurements prior to the initiation of the study. Two subjects, David and Luke, were able to name correctly eight measurements. Three subjects, Mary, Paul, and Mark, were able to name seven correctly. Matthew correctly named only one. Mary, Paul, Mark, and Luke named the measurements in order without the correct reductions (e.g., 1/16, 2/16, 3/16, 4/16 ...).

In compiling the data for Figure 1, prompted correct responses were combined with unprompted error responses to provide a total of prompted correct responses. Both of these categories resulted in a prompted correct response from the subject since a prompt and a correct response followed each unprompted error. The subjects were successful utilizing the constant time delay procedure. Their unprompted responses to the cue "What measurement?" were Mary 100%, Luke 98%, David and Mark 96%, Tim 94%, and Paul 91%. The graph in Figure 1 visually demonstrated the success that the subjects achieved with CTD.

The results of the six sessions (see Figure 3) indicated that David made 52 unprompted correct responses, with only 2 prompted correct responses. Matthew responses resulted in only 2 of 45 responses that were prompted correct. Mary's fifty-four responses were unprompted correct. Paul made fifty-one unprompted correct responses. He made one unprompted error. During the first session Paul had one "no response." During the course of the sessions, Paul interfered with the responses of others three times.

The post-test results (See Figure 4) indicated that no subject was able to name correctly the parts of the inch in sixteenths after completion of the six instructional sessions. David correctly named nine; Matthew, three; Mary, zero; Paul, six;
Mark, zero; and Luke, one. Mark’s results may have been affected by his absence from three sessions.

A comparison of correct and incorrect responses on the pre-test and post-test results (See Figure 5) indicated that only David and Matthew increased the number of correct responses. The results achieved by Mary, Paul, Mark, and Luke indicated a decrease in the number of correct responses. No subject correctly named all of the same measurements on the pre-test and post-test. The measurements incorrectly named, prompted, or omitted, on both the pre-test and post-test, were: 1/4, 3/8, 5/8, and 3/4. The following subjects correctly named some measurements on both evaluations: David (i.e., 3/16, 7/16, 9/16, 11/16, 13/16, 1); Matthew (i.e., 1″); Paul (i.e., 5/16, 9/16, 11/16, 13/16, 15/16); Luke (i.e., 1/16, 15/16). Naming a measurement correctly on the pre-test, but naming it incorrectly on the post-test, were: David (i.e., 5/16, 15/16); Mary (i.e., 3/16, 5/16, 7/16, 9/16, 11/16, 13/16, 15/16); Paul (i.e., 3/16, 7/16); Mark (i.e., 3/16, 5/16, 7/16, 9/16); Luke (i.e., 3/16, 5/16, 7/16, 9/16, 11/16, 13/16). The following subjects named the measurement incorrectly on the pre-test, then named it correctly on the post-test: David (i.e., 1/16, 1/8, 7/8); Matthew (i.e., 1/16, 1/2, 15/16); Paul (i.e., 1″); Luke (i.e., 1/8).

The generalization task (See Figure 6) demonstrated the success the subjects experienced writing the parts of the inch. David was able to write eleven measurements correctly. Paul wrote ten measurements correctly. Luke and Matthew were able to write three, while Mary wrote one measurement correctly. Mark was absent when the generalization procedure was completed.
The length of each instructional session was approximately ten to nineteen minutes, with an average length of fifteen minutes.
DISCUSSION

Limitations of Study

The constant time delay procedure provided a method of instruction with a low margin of error. The ability of the subjects to identify correctly the given measurement did not, however, assist the subjects in reaching 100% mastery in saying the parts of the inch.

Intervening factors impacted the results of the study. Of the possible factors, gender did not appear to affect the performance of the subjects. Absences were a factor for Mark, who missed three of the six sessions. The subjects' performance on the post-test appeared to result from some confusion about the parts of the inch that were reduced (e.g., 1/8, 1/4, 3/8, 1/2, 5/8, 3/4, 7/8). The problem did not arise on the pre-test since the subjects were allowed to name the parts without correction. They were prompted only if no response was given. In addition, for the purposes of this study, the procedure was taught in isolation. The math class to which the students were assigned was being instructed in a geometry unit. The study’s success might have been enhanced if the procedure had been utilized within a unit on measurement. It is reasonable to assume that the subjects’ retention would have improved with the addition of multi-sensory tasks involving measurement. The length of each session (one choral and three trials) appeared to be sufficient, although the number of sessions to attain mastery should be increased. The subjects were able to complete the three trials and generally maintain attention. The examiner was not the regular teacher in this self-contained math class. The regular teacher was not in the room during the study because she was with the examiner’s eighth-grade class. The differences in the sixth- and eighth-grade schedules in the
school required some shifting of personnel in order to be able to accommodate the study.

The severity of the learning disabilities of the subjects may have affected the results. Two of the subjects (Mary and Mark) had been diagnosed with auditory processing and short-term memory deficits. David exhibited a severe deficit in short-term auditory and long-term visual/auditory retention. Luke had deficits in long-term memory and processing speed. Paul's need for attention and his off-task behavior may have been a factor due to the interruptions in the flow of the sessions. Even though the examiner tried to ignore his antics, the other subjects were not able to do so. Intellectual functioning levels of the subjects was another mitigating factor. David, Matthew, and Luke were functioning in the low average range of intelligence, while Mary, Paul, and Mark were functioning in the borderline range. The cognitive level of the students appeared to have had an impact on the results. The concept may have been too abstract for sixth-grade students to master.

A pre- and post-test that more accurately reflect the material being presented to the subjects should be developed in order to provide a reliable measure of what the subjects learned.

**Future Research**

Further study should investigate the use of the constant time delay in teaching measurements within the context of a unit on measurement. Working with a smaller, more homogeneous group of subjects for more sessions should also be investigated. Determining the age at which subjects would be most likely to experience success with measurements should be ascertained prior to the initiation of additional research. The constant time delay procedure should be expanded to
additional academic and vocational areas for children with special education. Few studies indicated its effectiveness with subjects in general education classes. Procedures that have been successful with special education students have also proved to be applicable to the general population.
References


Brigham, F. J. (1993, April). *Places, spaces and memory traces: showing students with learning disabilities ways to remember locations and events on maps.*


Strategies: A Literature Review (Grant No. G008530197). Lexington: University of Kentucky, Department of Special Education. (ERIC Document Reproduction Service No. 345 418)


Constant Time Delay


Sharma, M. C. (1985). Memorizing is not a dirty word: what should a mathematics teacher know to use it effectively in teaching and learning mathematics?


package for facilitating mildly handicapped pupil's acquisition of basic math skills


review of effectiveness and demographic, procedural, methodological parameters.

Research in Developmental Disabilities. 13, 239-266.


APPENDIX A

Permission Letter to the School System
Dear:

I am requesting permission to conduct a study as part of the requirements for completing a Master’s degree at Longwood College. The purpose of the study is to investigate the effectiveness and efficiency of a constant time delay procedure in teaching the gradations of an inch (in sixteenths) to sixth-grade students with learning disabilities in a self-contained math class.

Children with learning disabilities frequently have memory deficits that make it difficult to memorize content information. Acquisition of this skill will assist students with measurement in math and vocational classes. Students who fail to acquire this knowledge do not meet the requirements for successful completion of a vocational class. It can also be a life skill for most, if not all, students. It is hoped that by intentionally presenting this information the students will acquire the skill. If the use of the constant time delay procedure is successful in teaching the skill, its use could be expanded teaching content in the classroom.

The students will be selected from a sixth-grade self-contained learning disabilities math class. Approval will be solicited from the classroom teacher since the study will be conducted during math class.

Sixth-graders have not taken Industrial Arts and so have not been required to have the skill that will be taught in this study. The data collected will be based on the number of sessions required to criterion, number of trials, total number of errors, and minutes of instructional time. The study will consist of a pre-instructional session to determine that the students are able to read and write the measurement fractions, a pre-test, instructional sessions that will include an additional probe, a post-test, and a generalization activity to see if the acquired knowledge can be transferred to paper. Six instructional sessions (one per day) will be scheduled with days for the probes and pre-instruction. The study will take approximately 10 days. It is estimated that each session will take 15-20 minutes. An oral follow-up will be conducted one week after the conclusion of the instruction and an additional written generalization at two weeks. The study will be conducted as soon as the necessary permissions have been obtained.

To ensure the confidentiality of the information regarding each subject, the names will be changed. No mention will be made of the school, county, or state involved in the study. Written permission will be obtained from each parent or guardian prior to initiation of the study. The letter will also notify the parent or guardian that there is no penalty for declining to participate. The study will not detract from the educational program since measurement is a part of the math curriculum.
Copies of all instruments and forms to be used in this study have been included with this letter.

Sincerely,

Emily S. Lovell

Enclosures

CC: Principal
APPENDIX B

Parental Permission Letter
To the parent(s)/guardian of

I am a teacher of children with learning disabilities. I am writing a thesis to complete the requirements for a Master’s degree at Longwood College in Farmville, Virginia.

I am requesting your permission to use your child in a study that will teach the gradations of the inch by sixteenths. This is a skill that is difficult for many students and it is a requirement for Industrial Arts classes. This knowledge will also benefit your child in other vocational classes, such as home economics, and could be a useful life skill as your child prepares for a job after high school. The skill will be taught during math class. Your child will not be included in the study without your permission and permission from this county. Your child will not be penalized, in any way, should you decide not to participate.

All information will be used so that your child’s identity is kept confidential. The use of background information and the data collected will not contain either your child’s name or any reference to the school, county, or state.

Please check the appropriate line below, then sign and date on the indicated lines. A stamped self-addressed envelope has been enclosed for your convenience. If you have any questions about the study, please contact me at 743-3640. Thank you.

Sincerely,

Emily S. Lovell
LD teacher

____ I agree to allow my child to participate in the study described in this letter.

____ I do not agree to allow my child to participate in the study described in this letter.

parent/guardian signature __________________________ date __________________________
APPENDIX C

Facsimile of Fraction Measurement Card
APPENDIX D
Facsimile of Subject Name Card
PAUL
APPENDIX E

Generalization Instrument
Procedure ______________

Subject name ______________

Date _____________________
APPENDIX F

Pre-test/Post-test Probe
I. Ask subject to recite the parts of an inch by sixteenths.

II. For each correct response (+); incorrect response (-); no response/prompt (0).

1/16"  
1/8"  
3/16"  
1/4"  
5/16"  
3/8"  
7/16"  
1/2"  
9/16"  
5/8"  
11/16"  
3/4"  
13/16"  
7/8"  
15/16"  
1"  

PRE-TEST/POST-TEST PROBE  
SUBJECT NAME ____________________  
DATE ____________________
APPENDIX G

Data Forms
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<th>Stop time</th>
<th>Total time</th>
</tr>
</thead>
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<td></td>
</tr>
<tr>
<td>1/8</td>
<td>Matt</td>
<td></td>
</tr>
<tr>
<td>3/16</td>
<td>Mary</td>
<td></td>
</tr>
<tr>
<td>1/4</td>
<td>Paul</td>
<td></td>
</tr>
<tr>
<td>5/16</td>
<td>Mark</td>
<td></td>
</tr>
<tr>
<td>3/8</td>
<td>Luke</td>
<td></td>
</tr>
<tr>
<td>7/16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/16</td>
<td></td>
<td></td>
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<tr>
<td>5/8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/4</td>
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</tr>
<tr>
<td>13/16</td>
<td></td>
<td></td>
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<td>7/8</td>
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<td></td>
<td></td>
</tr>
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<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Unprompted correct
- Prompted correct
- Non-wait error
- Wait error
- No response
- Interference
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<th>prompt correct</th>
<th>unprompt correct</th>
<th>prompt correct</th>
<th>no respon</th>
<th>interf.</th>
</tr>
</thead>
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<td></td>
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<td>Mary</td>
<td>Total number of each response type</td>
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<tr>
<td></td>
<td>Percent of each response type</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Paul</td>
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<td></td>
<td></td>
<td></td>
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</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Mark</td>
<td>Total number of each response type</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent of each response type</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luke</td>
<td>Total number of each response type</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Percent of each response type</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Cumulative total of each type of response</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Percent of each type of response</td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX H

Flow Chart Depicting the Constant Time Delay Procedure
Assess Prerequisite Skills and Identify Reinforcers

Planning Decisions: Number of Trials at 0-Second Delay, Delay Interval, Criterion for Moving to Prompt Delay, and Consequence for Errors

For 0-Second Delay Trials: Secure Student's Attention, Present Task Direction, and Immediately Present Controlling Prompt

Is Student's Response Correct?

YES

Reinforce Student

NO

Implement Consequent Event for Errors

Are 0-Second Trials Completed?

YES

Present Next Trial

NO

For Delay Trials: Secure Student's Attention, Present Task Direction, and Present Prompt at Specified Delay Interval

Is Student's Response Correct?

YES

Did Correct Occur Before Prompt?

YES

Reinforce: Count Toward Criterion

NO

Teach Next Skill In Sequence

NO

Present Next Trial

Did Error Occur Before Prompt?

YES

Use Consequent Event for Non Wait Errors

NO

Reinforce: Do Not Count Toward Criterion

NO

Use Consequent Event for Wait Errors and No Responses

Figure 1

Unprompted Correct and Prompted Correct Responses

Constant Time Delay

Responses as Percent of Total

0 20 40 60 80 100

Paul  Mary  Mark  Luke  Matthew  David

STUDENT

Unprompted Correct

Prompted Correct
## Figure 2

**Pre-Test Results**

<table>
<thead>
<tr>
<th>student names</th>
<th>David</th>
<th>Matt</th>
<th>Mary</th>
<th>Paul</th>
<th>Mark</th>
<th>Luke</th>
</tr>
</thead>
<tbody>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>3/16</td>
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<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
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<td>-</td>
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<td>-</td>
</tr>
<tr>
<td>5/16</td>
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<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3/8</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7/16</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
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<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>9/16</td>
<td>+</td>
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<td>+</td>
<td>+</td>
</tr>
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<td>5/8</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>11/16</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>3/4</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
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<td>+</td>
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<td>-</td>
<td>+</td>
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<tr>
<td>7/8</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15/16</td>
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<td>+</td>
<td>+</td>
<td>-</td>
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<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
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**Key**

- + correct
- - incorrect
- 0 no response/prompt
### Figure 3
**Results of Instruction**

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<th>STUDENT</th>
<th>TYPE OF RESPONSE</th>
<th>unprompt correct</th>
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<th>unprompt error</th>
<th>prompt error</th>
<th>no respon</th>
<th>interf.</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>Percent of each response type</td>
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<td>4</td>
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<td></td>
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<tr>
<td>Matthew</td>
<td>Total number of each response type</td>
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<td>Percent of each response type</td>
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<td>4</td>
<td></td>
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<td>Mary</td>
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<td>Mark</td>
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<td>Percent of each response type</td>
<td>96</td>
<td>4</td>
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<tr>
<td>Luke</td>
<td>Total number of each response type</td>
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<td>Percent of each type of response</td>
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### Figure 4

**Post-Test Results**

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<th>Paul</th>
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<th>Luke</th>
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<tbody>
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**Key**
- + correct
- - incorrect
- 0 no response/prompt
Figure 5
Comparison of Pre-test/Post-test Results

<table>
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<th>Measurement</th>
<th>David</th>
<th>Matt</th>
<th>Mary</th>
<th>Paul</th>
<th>Mark</th>
<th>Luke</th>
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Key
+ correct   - incorrect  0 no response/prompt

Pre-test  Post-test
### Figure 6–
**Generalization Procedure Results**

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**Key**
- + correct
- - incorrect
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