A COMPARISON OF MATH ACHIEVEMENT BETWEEN MATHEMATICALLY-ABLE AND REGULAR MATH STUDENTS FOLLOWING SELF-INSTRUCTION TRAINING

By

JAMES ALAN CUNNINGHAM

Bachelor of Science
Oklahoma State University
Stillwater, Oklahoma
1969

Master of Education
Southwestern Oklahoma State University
Weatherford, Oklahoma
1977

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of the Oklahoma State University
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Thesis Approved:

S. D. Bell

Thesis Adviser

Paul G. Ward

Vernon Troxel

J. Barbara Wilkinson

Norman N. Durham

Dean of the Graduate College

1193229

PREFACE

This study is concerned with the application of self-instruction training theory to the classroom setting. The author wishes to provide additional information to those who are interested in the improvement of mathematics achievement through a cognitive behavior modification technique. It is felt that intervention strategies such as self-instruction training can be useful to classroom teachers. It is hoped that future research will develop studies which show with which groups of children this technique might be most beneficial.

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CHAPTER I

THE RESEARCH PROBLEM

Introduction

Teachers in the public schools have long recognized that improvement in achievement can be made by using a variety of instructional methods. Diagnostic-prescriptive teaching, programmed instruction, and computer-assisted instruction have been useful in improving achievement scores, but they have drawbacks such as the specialized training needed by the teacher and, in the case of computers, increased expense.

Meichenbaum (1974, 1977), and Meichenbaum and Turk (1972) have written about the usefulness of cognitive behavior training methods and, in particular, self instruction techniques. The cognitive-behavior training methods used to modify children's behavior are based on studies that show children tend to be impulsive or reflective in their thinking processes and behavior (Kagan, Rosman, Day, Albert, and Phillips, 1964).

Cognitive behavior can be classified as either impulsive or reflective. Some impulsive children, for example, tend to make errors in math calculation not because of not knowing the problem-solving methods, but because of the lack of impulse control. They often do not weigh the alternatives in their decision making. Impulsive children also appear to be satisfied with their initial choices. Reflectivity requires processes such as deciding upon alternatives and weighing the consequences of choices. Researchers (Kendall and Finch, 1978) have found that if children can be trained to become more reflective, their inappropriate school behavior, such as talking out of turn and getting out of chairs without permission, will decrease. Meichenbaum and Goodman (1969) found that cognitively impulsive children did not do as well as reflective children on verbal control tasks.

Peters and Davies (1981) found that mentally handicapped boys can be trained to become more reflective, causing less disruptive behavior, using a self-instruction technique. Although research concerning reflectivity/impulsivity in children with high cognitive abilities appears sparse, Alabasio and Hansen (1977) show that impulsivity occurs in children of all intellectual abilities. Messer (1976) implies that high achievers in school could be more reflective because their correct responses would require more evaluation of possible solutions. It has not, however, been shown that performance will increase if bright students become more reflective.

The self-instruction technique as proposed by Meichenbaum (1977) appears to be closely associated with the training needed by children who have difficulty with calculation in mathematics. Meichenbaum suggests that a child's inaccurate performance in solving a math problem, for example, may be characterized in several ways.

First, he or she may not understand the nature of the problem. He/she therefore cannot discover what mediators to use. Bem (1971) called this a comprehension deficiency. Second, a child may have the correct mediators but he/she may fail to appropriately produce them. Flavell, Beach, and Chinsky (1966) called this a production deficiency. The third problem might be that the mediators the child produces may not guide his/

her behavior concerning the solution of a math problem. Reese (1962) called this a mediational deficiency.

Math students often make mistakes in calculations because of what has become known as "carelessness." Actually, this carelessness is probably a result of faulty mediation, production, comprehension, or a combination of these. Meichenbaum (1977) discovered he could alter children's problem solving style. He did this with self-instruction training. Self-instruction training procedures as described by Meichenbaum follow the sequence below:

1. An adult model performs a task while talking to himself/herself aloud.

2. The child performs the same task under the direction of the model's instructions.

3. The child performs the task while instructing himself/herself aloud.

4. The child whispers the instructions to himself/herself as he/she goes through the task.

5. The child performs the task by talking himself/herself through the problem.

Although Meichenbaum's studies focused initially on hyperactive children, he has suggested that self instruction training has application to a wide range of problems caused by impulsive behavior.

Calculating correct solutions to math problems requires special cognitive skills, Ridge (1977) writes:

> The real key to creative ability in mathematics appears to be a sort of intuition which brings about solutions by placing all the pertinent ideas in the right order; the ability to see through a problem and experience a solution as a sudden illumination (pp. 16-17).

Aiken (1973) refers to this as a subconscious stage called incubation which is generally preceded by a period of preparation that includes deep involvement and concentration. This could be a mathematical form of task commitment. The "illumination" must be followed by a "verification." Verification is the refinement of a solution. Ridge (1977) points out that if students lack the special intuition needed for recalling an appropriate problem solving technique and if they do not have a good attention span, then the students will have difficulty solving complicated math problems.

The problem-solving process of Ridge (1977) and Aiken (1973) appears to follow generally the comprehension deficit explanation of Bem, the production deficit of Flavell, and the mediation deficit of Reese. Because solving mathematical problems requires the special requirements of searching and attentiveness, Meichenbaum's self-instruction training would appear an appropriate technique for creating conditions for which correct solutions to math problems would be facilitated. Meichenbaum's approach, in essence, attempts to make the student become reflective, thereby giving him a chance to search for correct procedures.

Statement of the Problem

Compared to such techniques as diagnostic-prescriptive teaching and computer assisted instruction, a self-instruction technique such as Meichenbaum has proposed would seem to be more widely available to teachers of mathematics than other more complicated strategies. If a teacher of mathematics chooses this technique to help students improve math achievement, would it be appropriate for children of differing intellectual abilities? Specifically, is a self-instruction training equally efficient for children with high math abilities and children with average abilities in the acquisition of mathematics problem-solving skills immediately after training or after a period of time has passed following training?

CHAPTER II

REVIEW OF RELATED LITERATURE

Cognitive Behavior Modification

Background

Although cognitive behavior modification appears not to have a true "founding father," it is based on the ideas of Pavlov, Skinner, and other behaviorists (Azrin, 1979). Behaviorists have always been interested in measurable change.

The beginnings of present-day cognitive learning approaches appear to be varied. Rotter (1954) and Kelly (1955) stressed the importance of conscious thought processes in mediating modification, and place a similar emphasis on cognitive mediational processes. Ellis (1962, 1971, 1974, 1977) has been one of the most influential writers in this area. The later writings of Lazarus (1971, 1974, 1977) have shown a cognitive emphasis in learning. The work of Beck (1963, 1976) and Meichenbaum (1969, 1974, 1977) appears to have made a major impact on practice as well as history. Meichenbaum's training will be reviewed in more depth later in this chapter.

Meichenbaum (1979) and Wilson (1978) have concluded that there is no commonly accepted definition of cognitive behavior modification. Mahoney and Arnkoff (1978) place coping-skills therapies, self-instructional training, and problem-solving skills development in the area of cognitive behavior modification. Each of these treatments would focus on different aspects of the student's cognitive process. These aspects could be problem-solving strategies, attributions, beliefs, or expectations. Rim and Masters (1979) point out that virtually every approach to cognitive learning training involves teaching students some manner of self-control.

Self-Instruction

Meichenbaum (1969) brought cognitive learning theory into practice. Meichenbaum trained hospitalized schizophrenics to emit "healthy talk" through operant conditioning, and the positive effects generalized to a follow-up interview. During the follow-up interview, the patients verbalized the experimental instructions (Meichenbaum, 1977). This led to Meichenbaum's interest in self-statements in the areas of skill-acquisition and problem-solving.

Meichenbaum's view of how individuals acquire control of their behavior reflects the theories of Russian researchers (Luria, 1969; Vygotsky, 1962). Luria provides a three-stage conceptualization of the acquisition of the control of voluntary behavior of children:

Stage 1: Control is exercised by the verbal behavior of others.

Stage 2: Overt speech on the part of the child exercises an important guiding function.

Stage 3: Much of the child's behavior comes under the control of self-speech.

Meichenbaum feels that self-speech exerts control over the individual's behavior in much the same way as speech coming from another person. A good deal of research by Meichenbaum and others has been with impulsive and aggressive children who usually engage in less self-regulatory speech than other less impulsive children (Meichenbaum and Goodman, 1969; Camp, 1977).

As pointed out in Chapter I, Meichenbaum's approach to treating impulsive children (defined by poor performance on a simple picture-matching task) is: (1) cognitive modeling, (2) overt, external guidance, (3) overt self-guidance, and (4) covert self-instruction (Meichenbaum, 1977).

Meichenbaum (1975) and Wozniak and Neuchterlein (1978) have shown that self-instruction procedures can be employed to enhance creative problem-solving and reading comprehension. The training sessions taught children how to use a cognitive skill effectively. Research (Higa, 1973; Robin, Armel, and O'Leary, 1975; Wein and Nelson, 1978) suggests that self-instruction training may prove most valuable for children who already have basic skills but tend to act impulsively. However, no evidence deals with making reflectives more effective through the use of this technique.

The Meichenbaum (1975) study described self-instruction training aimed at enhancing creativity in college students. The treatment was as follows: (1) having the subjects gain awareness of negative creativity inhibiting automatic thoughts, (2) the subjects then were trained to generate creativity-enhancing thoughts incompatible with negative thoughts, (3) the experimenter modeled self-statements refelcting several different theoretical conceptualizations of creativity, which the subjects then rehearsed. Relative to a placebo control and a nontreated control, the self-instruction treatment was associated with a significant increase in measures of originality, flexibility, and self-concept. Meichenbaum (1977) states that there is reason to believe that self-instruction training may be of value not only in controlling impulsive behaviors, but could help in solving problems related to academic skills.

In summary, it appears that research with impulsive children has shown that there may be a deficiency in children's ability to use their "self-speech" effectively in guiding their non-verbal behavior. It appears that self-instruction training holds some promise for improving behavior, academic skills, and creativity in impulsive children.

Giftedness and Mathematics

Giftedness

Throughout history people have been interested in persons who have displayed superior ability. As early as 2200 B.C., the Chinese had developed an elaborate system of competitive examinations to select persons for governmental positions (DuBois, 1970).

Within the field of education for the gifted, there has been more attention devoted to the topics of identification and characteristics than all other areas combined (Mirman, 1971). There is still a great deal of disagreement about the definition of gifted.

One way of analyzing definitions of giftedness is to view them along a continuum ranging from conservative to liberal according to the degree of restrictiveness that is used to determine who is eligible for special programs. At the conservative end of the continuum is Terman's (1925, p. 453) definition: "Giftedness is the top one-percent in general intellectual ability, as measured by the Stanford-Binet Intelligence Scale or a comparable instrument." At the other end of the continuum a more liberal definition is offered by Witty (1958):

> There are children whose outstanding potentialities in art, in writing, or in social leadership can be recognized largely by their performance. Hence, we have recommended that the definition of giftedness be expanded and that we consider any child gifted whose performance, in a potentially valuable line of human activity, is considered remarkable (p. 62).

In recent years the following definition set forth by the U.S. Office of Education (Marland, 1972) has grown in popularity, and many states and school districts throughout the nation have adopted it for their programs:

> Gifted and talented children are those who by virtue of outstanding abilities are capable of high performance. These children require differentiated educational programs and/or services beyond those normally provided by the regular school program in order to realize their potential contribution to self and society. Children capable of high performance include those who have demonstrated any of the following:
>
> 1. general intellectual ability
> 2. specific academic aptitude
> 3. creative or productive thinking
> 4. leadership ability
> 5. visual and performing arts
> 6. psychomotor ability (p. 10).

Guilford's (1956, 1959) structure of intellect has been especially effective in directing educators and psychologists away from dependence upon a single measure of giftedness. His theoretical model of the structure of intellect has three dimensions: operations, content, and products. Guilford's model gives a multi-faceted view of intelligence.

Torrance (1979) argues that creativity plays a major role in the definition of giftedness. He states that creativity involves openness to experience, adventuresomeness, and self-confidence. Torrance states also that creativeness requires necessary basic skills, motivation, and facilitating conditions.

Mathematical Giftedness

It is not intended that high math ability be necessarily equated with intellectual giftedness. It is felt that the mathematically-able could be included as possible members of the gifted as suggested by the broader definitions of Witty (1958) and Marland (1972).

Ashley (1973) has pointed out some of the characteristics of children having mathematical potential. The very young have an interest in numbers, clocks, and calendars. They love to measure anything. They exhibit exceptional mathematical reasoning, good memory, and persistence. From experience with a British program for mathematically gifted children from ages 4 to 16, Hayman, Dowker, Buxton, and Hayman (1976) note concentration spans of three to four hours or more when working with measurement of time and space.

Krutetskii (1969) identified outward signs of mathematical ability in children through experimentation with highly precocious children:

1. A clear interest in mathematics. The tendency to work with mathematics with pleasure and without compulsion.

2. Mastery of definite mathematical skills and habits at an early age.

3. Fast mastery of mathematics.

4. Attainment of a comparatively (by age) high level of mathematical development (p. 115).

According to Laycock and Watson (1971), mathematics consists of many interwoven threads. They state that the nature of mathematics lies in its patterns of relationships. They state further that calculation is an important skill in mathematical problem-solving, but not the only one required. One part of mathematics deals with numbers. A second part deals with counting. A third skill involves communication and ways or organizing thought. Other skills mentioned by Laycock and Watson are applying mathematics and geometry, which is the language of space, volume, and distance.

Renzulli (1977) states that research on creative-productive people has shown that no single criterion can be used to determine giftedness. He suggests that people who are gifted possess a relatively well-defined set of three interlocking clusters of traits. These traits consist of above average general abilities, task commitment, and facilitating conditions. According to Renzulli and Ridge (1981), mathematical giftedness is well accommodated by the three-ring conception of traits.

Fox (1976) states that although a high IQ does indicate a high learning potential, it provides little information about specific achievement, the relationship between verbal and quantitative skills, or a student's special interests. On the other hand, it appears mathematical talent does imply high general intelligence (Aiken, 1973; Moredock, 1966). In conclusion, it appears that above-average general ability is necessary but not sufficient for mathematical giftedness.

As discussed earlier, Ridge (1977) places a great deal of emphasis on creativity in solving mathematical problems. He describes this as a "special intuition." He states that this is the reason why some students who get high grades on the basis of computational skill become dismayed when they are no longer able to maintain their previous achievement in mathematics courses requiring higher level thinking.

Task commitment as a part of giftedness is noted by Collins (1969). He observed the tenacity of a group of gifted eight- and nine-year-olds in the Brentwood Experiment. The gifted children continued to try to solve very difficult problems, while less able children stopped working on the problems and seldom returned to them.

Instruction and the Gifted

As cited earlier, merely learning for "product" is not adequate; for that matter it must include "process learning" as one of its goals. Barbe and Frierson (1975) write:

> Traditionally, the teacher has been concerned with the product of learning rather than the process, the possession of knowledge rather than the projection of knowledge. Emphasis upon end-results fostered a teaching approach which called for the presentation of subject matter in a logical progression. Usually this meant simple to complex, concrete to abstract, cause to effect, singular to plural, and whenever possible, in chronological order.
>
> It is a credit to gifted students that they have been able to adjust themselves to this pattern of teaching. Underachievement might be only an indication of some gifted students' inability to fit themselves satisfactorily into this pattern of learning.
>
> The process-oriented teacher, as opposed to the product-oriented teacher, is concerned with how gifted students learn, rather than how the material is learned by most students. Emphasis upon the learning pattern of gifted students fosters a teaching approach which calls for the introduction of material at the exploratory level (p. 436).

The enrichment-triad model of Renzulli (1977) addresses the concerns of Barbe and Frierson. Renzulli's model of teaching to the gifted focuses on the teacher (1) identifying and structuring realistic solvable problems that are consistent with the student's interests, (2) acquiring the necessary methodological resources and investigative skills that are needed for solving these particular problems, and (3) finding appropriate outlets for student products.

The three types of enrichment in this model have been characterized by Renzulli (1977) as follows:

Type I: General exploratory activity to stimulate interest in specific subject areas.

Typical of this level would be interest centers in the classroom stocked with attention-getting stimuli.

Type II: Group training activities to develop processes related to the areas of interest developed through Type I experiences.

The content of these sessions is made up of (p. 25) ". . . processes or operations that enable the learner to deal more effectively with content." These thinking processes are critical thinking, problem-solving, reflective thinking, inquiry training, awareness development, and creative or productive thinking.

Type III: Individual and small-group investigations of real problems.

The main purpose of this approach is to help youngsters see the difference between structural exercises and real problems. The student becomes an actual investigator of a real problem.

According to Stanley (1979) the best use of a mathematics curriculum for mathematically-able students would be determined by the students' motivation to accelerate the pace. Stanley has several variations on the acceleration theme for mathematically-able students. Among the acceleration options suggested are: (1) fast-paced classes, (2) early part-time college study, (3) credit by examination, (4) early college admission, (5) college graduation in less than four years, and (6) bypassing the bachelor's degree. His ideas come from his work on a project for the Study of Mathematically Precocious Youth. This project began at Johns Hopkins University and has expanded to a nationwide network.

Summary

Studies using a cognitive-behavioral modification strategy with children have generally focused on the problem of impulse control (Bornstein and Quevillon, 1976; Camp, Bolom, Herbert, and Van Doornick, 1977; Douglas, Parry, Marton, and Garson, 1976; Meichenbaum and Goodman, 1971). These studies have indicated that self-control can be developed in children using a self-instructional training program. Self-instructional programs are usually composed of modeling, overt and covert rehearsals, prompts, and feedback. The cognitive strategies taught are (1) defining a problem and the various steps within it, (2) considering several possible solutions before acting on one, (3) checking the work and correcting any errors, (4) staying with the problem until everything possible has been tried to solve it correctly, and (5) reinforcing oneself for good works. Researchers such as Fox (1976) and Ridge (1977) have demonstrated that there is not necessarily a relationship between intelligence and mathematical talent. The teaching of mathematics is thought by Renzulli, Barbe, and Frierson to be at its best when "process" is emphasized rather than "product."

Meichenbaum's self-instruction training would appear to offer an intervention strategy that blends well with the advocates of "process" education related to mathematics instruction. Recent research by Genshaft (1982) has demonstrated that a self-instruction training program can provide gains in mathematics calculation.

As Meichenbaum (1977) has stated, a cognitive behavior modification strategy such as self-instruction training shows promise in the remediation of some academic skills. Self-instruction training, because of its "process" orientation, offers in the literature some evidence that it is well suited for mathematics instruction with average and mathematically gifted students.

Although the literature does offer some suggestions as to appropriate instructional guidelines for the gifted, it fails to show the appropriateness of using a specific training method, such as self-instruction training with the mathematically gifted students.

CHAPTER III

METHOD AND PROCEDURE

Introduction

The purpose of this study was to determine if a cognitive behavior modification treatment, specifically self-instruction, affects regular and mathematically-gifted students differently when their math achievement was compared. The study also sought to determine relationships between reflectivity and improvement in math achievement. The design chosen to measure changes in achievement and reflectivity took into account the nature of the subjects and how the subjects were grouped.

Instrumentation

Two instruments were used in this study: an achievement measure which tested high level mathematics knowledge and a measure of reflectivity, the Matching Familiar Figures Test (MFFT) (Kagan, Rosman, Day, Albert, and Phillips, 1964).

Many math achievement tests were examined. All of these were discarded because of problems with content, scope, or range of abilities tested. Of major concern was the possibility of a ceiling effect with the mathematically gifted group. Mathematically gifted students often answer most of the items on in-level standardized achievement tests and leave themselves little room for improvement on a posttest using the same or alternate forms of the same measure. A math achievement instrument was therefore constructed.

Based on the earlier work of Stanley (1979), sample items from the Scholastic Aptitude Test (SAT) (Carris and Crystal, 1982) were chosen to form the math instrument. A pool of 75 items was used in a pilot study of the newly constructed instrument. The 75-item instrument was given to three classes of high school (grades 10, 11, and 12) students. These classes were Algebra I, Geometry, and Algebra II. An item analysis was performed to reveal relatively easy and difficult items. Fifty items were chosen to be included in the instrument. The items were of sufficient difficulty (less than 0.60) to prevent a ceiling effect with the mathematically gifted group. The items consisted of computations and problem-analyses. The results from the administration of the pilot instrument revealed a mean score of 17.49 correct on the 50-item test. The split-half reliability was 0.81, the standard deviation was 6.27, and the standard error of measurement was 2.75. A copy of this instrument is found in Appendix A.

The MFFT was used to measure changes in reflectivity and impulsivity. The MFFT is a picture-matching test with which response time can be measured. In the test the student is shown a single picture of a familiar object and six or eight similar variations, only one of which is identical to the standard. The student is then asked to select one picture, from the six or eight, which is identical to the target stimulus. The variable scored is the student's response time, to the nearest half-second. The faster the student is in selecting the first response, the more impulsive he/she is assumed to be. Kendall and Finch

(1978) found the test-retest reliability for the MFFT to be 0.82 over a one-year test-retest. A copy of the MFFT is found in Appendix B.

Subjects

The subjects for this study were 9th and 10th grade students in algebra classes in a mid-high school. This school was located in a middle upper-class "bedroom" community outside a metropolitan area in the Southwest. Two groups of students were selected from intact classrooms as participants within the study. The intact classes consisted of two regular algebra classes and two "gifted" algebra classes. A student must have scored at least at the 95th percentile on the math calculation section of the California Achievement Test during the previous year's administration and he/she must have enrolled in the gifted algebra course. Students could choose not to participate in gifted math if they so desired. Regular students were composed of all those students who scored below the 95th percentile on the CAT math calculation section and those above the 95th percentile who did not choose to participate in the "gifted" algebra class. No other data were used to place or control for entry into the gifted group.

The four classes, two gifted and two regular, were randomly assigned (pairwise) to experimental and control conditions. Twenty subjects were randomly selected from each class to provide equal "N's" for the analysis described later in this chapter. No differentiations among subjects were made on the basis of pretest scores on the math achievement instrument and scores on the MFFT.

Treatment

This study utilized four groups of students who were enrolled in algebra classes. The four groups were from intact classes with 20 students participating in each of the four classes. The two treatment groups (one "regular" and one "gifted") received self-instruction training.

The self-instruction training emphasized math-related self-instruction techniques. The overall content covered: (1) problem definition, (2) problem approach, (3) focusing attention, (4) choosing an answer, and (5) a coping or self-reinforcing statement. Copies of the narratives used are included in Appendix C. The two treatment groups received a training session once a week for five weeks. The training sessions lasted from 10 to 15 minutes each. The two control groups (one "regular" and one "gifted") did not receive training. An example of an addition training session for the regular treatment group follows:

Given the problem $\begin{array}{r} 49 \\ \underline{+22} \end{array}$

Questions to Ask Myself	Action
1. What kind of problem is it?	Look for the sign (+).
2. What are the steps in an addition problem?	Add the number in the ones column and carry to the tens number.
3. Am I paying attention and doing it correctly?	I must make sure I don't go too fast.
4. How do I get the answer?	I must add the tens column.
5. Did I get the right answer?	I better check to make sure. If I am correct, good job; if I am wrong, I will correct it and won't make the same mistake again.

Each of the five weeks was devoted to the training in self-instruction with a different mathematical operation:

Week one - addition

Week two - subtraction

Week three - multiplication

Week four - division

Week five - a review of the self-instruction technique.

An example of an algebra training session for the mathematically gifted student treatment group was:

Given the problem: $a + b = c$, where $a = 5$, $c = 8$; find b.

Questions to Ask Myself	Action
1. What kind of a problem is it?	I look at the sign = and see that this is an algebraic equation.
2. What are the steps to follow in solving this equation?	First, I substitute 5 for a and 8 for c so that 5 + b = 8. I can then change the form of the equation without changing the solution. I'll try by subtracting 5 from each side so that I get 5 + b - 5 = 8 - 5.
3. I must pay attention so I don't make a mistake. Did I do the same to both sides of the equation?	I must subtract 5 from both sides of the equation.
4. What is the answer?	I get 3 as the answer.
5. Did I get the right answer?	I check my work to make sure, or, if I miss it I need to concentrate more go slower to make sure I don't make a mistake.

The five-week training sessions for the mathematically gifted students were as follows:

Week one - basic algebra--addition

Week two - basic algebra--subtraction

Week three - basic algebra--multiplication

Week four - basic algebra--division

Week five - a review of the self-instruction technique.

Research Hypotheses

This research study tested three hypotheses related to between-group differences in reflectivity scores for the pre- and posttests as measured by the MFFT. The study also tested two hypotheses related to within-group differences in math achievement scores for the pre- and post-delayed tests as measured by the math instrument.

Research Hypothesis 1: There was a difference between mathematically gifted treatment group and control group in math achievement from pre- to posttesting.

Research Hypothesis 2: There was a difference between regular treatment group and control group in math achievement from pre- to posttesting.

Research Hypothesis 3: There was a difference between mathematically gifted treatment and regular treatment groups in math achievement from pre- to posttesting.

Research Hypothesis 4: There was a difference within the mathematically gifted treatment group in math achievement from pre- to post-delayed testing.

Research Hypothesis 5: There was a difference within the regular treatment group in math achievement from pre- to post-delayed testing.

Research Hypothesis 6: There was a difference between mathematically gifted treatment and regular treatment groups in math achievement from pre- to post-delayed testing.

Research Hypothesis 7: There was a difference between the mathematically gifted treatment group and control group in reflectivity from pre- to posttesting.

Research Hypothesis 8: There was a difference between regular treatment and control groups in reflectivity from pre- to posttesting.

Research Hypothesis 9: There was a difference between mathematically gifted treatment and regular treatment groups in reflectivity from pre- to posttesting.

Research Hypothesis 10: There was a difference within the mathematically gifted treatment group in reflectivity from pre- to post-delayed testing.

Research Hypothesis 11: There was a difference within the regular treatment group in reflectivity from pre- to post-delayed testing.

Research Hypothesis 12: There was a difference between mathematically gifted treatment and regular treatment groups in reflectivity from pre- to post-delayed testing.

Pre-, Post-, and Delayed Posttesting

All the students, regular class (20 treatment and 20 control) and mathematically gifted (20 treatment and 20 control), were given the math achievement instrument prior to the beginning of the treatment. Each student was also administered the MFFT prior to treatment. Immediately following the self-instruction training of the treatment groups, all students were again administered the math achievement instrument and the

MFFT. Approximately one month later the students were again administered the math instrument and the MFFT as post-delayed testing.

Analysis of Data

There were two types of comparisons made with the data collected from the math instrument and the MFFT tests administered to the students. The first type of comparison was between the different groups (regular treatment and control, gifted treatment and control). The second type of comparison was of the repeated measure scores of the groups. Kirk (1968) recommends the procedure of a Split-Plot Factorial Analysis of Variance (SPF pr-q), since the procedure incorporates both the completely randomized (between group effects) and the randomized block (repeated measure effects) designs into one design.

The hypotheses were tested with score data which consisted of four levels of between-groups and three levels of within-group treatments. The four levels of between-groups were as follows: (1) regular treatment (self-instruction training), (2) regular control (no training), (3) mathematically gifted treatment, and (4) mathematically gifted control. The within group treatments were pre-, post, and post-delayed testing with the math achievement instrument and MFFT.

The computer package BMDP2V-Analysis of Variance and Covariances With Repeated Measures (University of California, Los Angeles, 1979) was used to analyze the data collected in this study.

Assumptions

The SPF pr•q requires four assumptions for analysis of variance. The variance of the populations must be equal, the numerator and the denominator of the F ratio must be independent, the observations must be drawn from normally distributed populations, and represent random samples from populations. Although analysis of variance is robust with regard to violations of assumptions, Kirk (1968) recommends a conservative F test when violations of variance are suspected. The variance of the mathematically gifted student population and the regular group appear to be unequal. The specially grouped gifted students were more homogeneous than the regular students. The gifted students formed a sample that was negatively skewed. The regular students were distributed more normally as far as abilities are concerned. Therefore, the assumption of normally distributed populations was violated. In such a case, Kirk has recommended a test such as the Geisser-Greenhouse Conservative F Test be applied. The Geisser-Greenhouse Conservative F Test was applied in this study.

CHAPTER IV

RESULTS

Introduction

This chapter presents the results of the analyses and compares the results to the hypotheses. This study sought to determine if a cognitive behavior modification treatment such as self-instruction training would cause regular and mathematically gifted students to become more reflective in their problem solving techniques. This study also sought to determine whether or not self-instruction training would cause a significant increase in math achievement. The dependent variables consisted of the number of correct answers on the math instrument and the number of seconds to the first response on the MFFT.

Meichenbaum and Goodman (1971) found that self-instruction training was effective in improving impulsive behavior in children. This study sought to determine if self-instruction training could be of value in improving academic performance. A split-plot factorial analysis of variance with four between groups (gifted-control, gifted-treatment, regular-control, and regular-treatment) and repeated measures (pretest, posttest, and delayed posttest) were conducted using each of the two dependent measures.

Tests of Hypotheses Related to Achievement

Hypotheses are discussed in terms of the statistical results of the data. Tables of means and standard deviations for each of the dependent variables for the four groups are also presented. The hypotheses related to achievement are hypotheses 1 through 6.

Table I reveals several differences related to math achievement. There is a significant Type of Class effect ($F_{1,76} = 339.17$, $p < .01$), a significant Type of Class by Treatment Groups effect ($F_{1,76} = 52.59$, $p < .05$), a significant Periods of Time effect ($F_{2,152} = 3.70$, $p < .01$).

The significant Type of Class effect is expected since the mathematically gifted group must have higher achievement levels than the regular group. As can be seen in Table II, the significant effects of Type of Class by Treatment group is caused by the higher achievement of the mathematically gifted students at both levels of the treatment groups when compared to the regular students (see Figure 1).

Of more important interest in this study are the changes in achievement that occur across time. Table I reveals that there is a significant effect caused by Periods of Time combined with Type of Class. Table III presents a simple effects breakdown of Type of Class by Assessment Period. There is a significant effect of Type of Class by all assessment periods (b_1, b_2, b_3). Further examination of Table III shows that the regular group has a significant effect across time where the mathematically gifted group does not.

Research Hypothesis 1 sought to find whether a difference will exist in treatment and control for mathematically gifted students over the assessment periods, specifically from pre- (b_1) to posttesting (b_2). Table IV shows the significance of Type of Treatment group (C) by mathematically gifted (a_2). This effect can be explained in that the mathematically gifted treatment group (c_1) had a lower level of achievement

TABLE I

ANALYSIS OF VARIANCE SUMMARY TABLE FOR MATH ACHIEVEMENT SCORES BY TYPE OF CLASS, TREATMENT GROUP AND PERIOD OF TIME

Sources	SS	df	MS	F
Between Subjects	148,454.00	79		
A (Type of Class)	17,836.50	1	17,836.50	339.17**
C (Type of treatment Group)	63.04	1	63.04	1.20
A x C	246.04	1	246.04	4.68*
Subjects Within Groups	3,996.68	76	52.59	
Within Subjects	6,480.68	160		
B (Periods of Time)	273.06	2	136.53	3.70*
A x B	392.11	2	196.05	5.31*
B x C	147.93	2	73.96	2.00
A x B x C	52.98	2	26.49	0.72
B x Subjects Within Groups	5,614.60	152	36.94	
Total	154,934.68	239		

*p < .05.

**p < .01.

TABLE II

MEANS AND STANDARD DEVIATIONS OF ACHIEVEMENT SCORES
AT THE ASSESSMENT LEVELS FOR THE FOUR GROUPS*

Treatment Groups	Assessment Periods 1		2		3	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Regular Treatment	13.25	3.91	18.05	12.57	18.95	6.47
Regular Control	12.95	3.47	19.20	3.90	15.10	7.97
Gifted Treatment	32.90	5.40	30.40	7.63	32.60	6.95
Gifted Control	34.40	4.68	35.50	5.52	35.15	3.41

*n = 20 for each group.

1 = pre; 2 = post; 3 = delayed post.

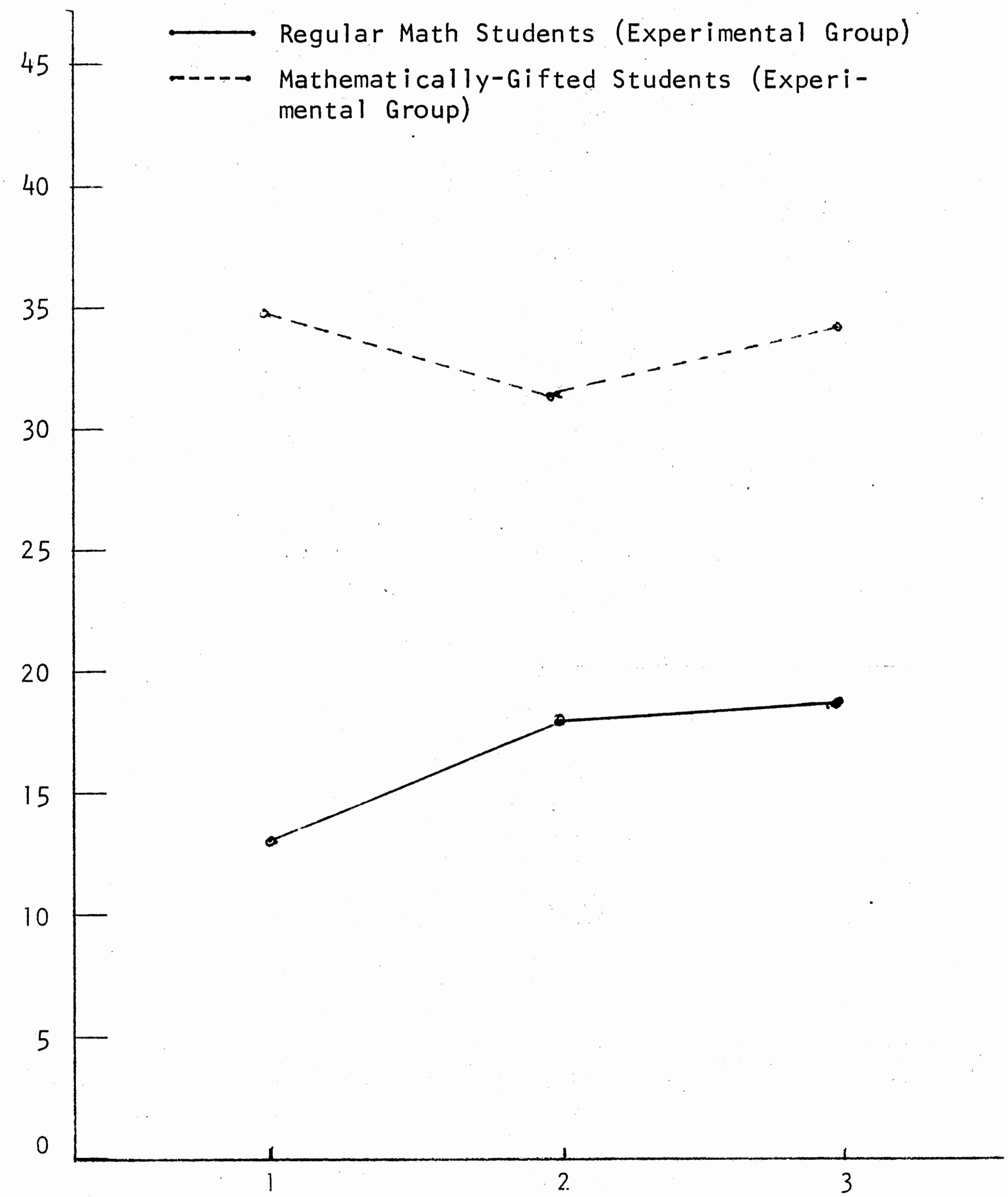

Figure 1. Groups by Assessment Period Interaction: Achievement Scores

TABLE III

SIMPLE EFFECTS BREAKDOWN OF TYPE OF CLASS
BY ASSESSMENT PERIOD INTERACTION
FOR MATH ACHIEVEMENT

Sources	SS	df	MS	F
A x B				
A at b_1	8,446.05	1	8,446.05	200.33**
A at b_2	4,104.15	1	4,104.15	97.35**
A at b_3	5,678.45	1	5,678.45	134.69**
Pooled Error	9,612.48	228	42.16	
B at a_1	646.56	2	323.28	8.75**
B at a_2	18.63	2	9.32	0.25
B x Subjects Within Groups	5,614.88	152	36.94	

**$p < .01$.

TABLE IV

SIMPLE EFFECTS BREAKDOWN OF TYPE OF CLASS BY TYPE OF TREATMENT INTERACTION FOR MATH ACHIEVEMENT

Sources	SS	df	MS	F
A x C				
A at c_1	6,946.42	1	6,946.42	132.08**
A at c_2	11,136.17	1	11,136.17	211.75**
C at a_1	30.00	1	30.00	0.57
C at a_2	279.10	1	279.10	5.31*
Pooled Error	3,996.84	76	52.59	

*$p < .05$.

**$p < .01$.

than the mathematically gifted control group (c_2) (refer to Table II) at all three assessment times. Table I shows that there are no effects caused by Type of Treatment group (C) over Assessment Period (B). Because there are no differences in Type of Treatment group over time, Research Hypothesis 1 must be rejected. Research Hypothesis 2 is concerned with Type of Treatment group differences with the regular. Research Hypothesis 2 must be rejected.

Research Hypothesis 3 is concerned with significant effects caused by Assessment Period and Type of Class. As Table I reveals, there is a significant effect of Type of Class (A) and Assessment Period (B). A simple effects breakdown in Table III shows that there was a significant effect in the regular group (A_1) by Assessment Period (B). Post hoc comparisons of the regular treatment group using Tukey's (HSD) ratio (Kirk, 1968) revealed the trend which is illustrated in Table II and graphed in Figure 1. There was a significant difference in achievement for the regular treatment group at the interval between pre- and posttesting (B_1-B_2).

Analysis of the data reveals differences between the regular treatment group and the mathematically gifted treatment group; therefore, Research Hypothesis 3 must be accepted.

Research Hypothesis 4 is concerned with differences within the mathematically gifted treatment group from pre- to delayed posttesting. Table I reveals differences caused by Type of Class (A) and Assessment Period (B). Table III, however, shows that there are no differences in the mathematically gifted group (a_2) by Assessment Period (B). Since there were no differences in the mathematically gifted treatment or control group over time, Research Hypothesis 4 must be rejected.

Research Hypothesis 5 concerns differences in the regular treatment group from pre- to delayed posttesting. As mentioned earlier, Table III reveals differences over time with the regular group. Post hoc comparisons of the regular treatment group using Tukey's (HSD) ratio revealed the trend which is illustrated in Table II and Figure 1. There was a significant difference in achievement for the regular treatment group at the interval between pre- and delayed posttesting (b_1-b_2). Because of these differences, Research Hypothesis 5 must be accepted.

Research Hypothesis 6 is concerned with differences between the regular treatment group and the mathematically gifted treatment group. Table I shows significance caused by Type of Class (a) and Assessment Period (B). A simple effects breakdown (Table III) reveals that significant changes occurred with the regular group but not with the mathematically gifted group. Post hoc comparisons of the regular treatment group reveal, as mentioned earlier, that there were significant changes from pre- to delayed posttesting. Because there were significant differences between the regular group and the mathematically gifted group from pre- to delayed posttesting, Research Hypothesis 6 must be accepted.

The F's for all significant differences were tested with conservative degrees of freedom to control for heterogeneity of variance in between and within error terms (Kirk, 1968). All significant probabilities as reported in Tables I, III, and IV remained significant after Giesser-Greenhouse corrective was applied.

Tests of Hypotheses Related to Reflectivity

Hypotheses are discussed in terms of the statistical results of the data. Tables of means and standard deviations for each of the dependent variables for the four groups are also presented. The hypotheses related to reflectivity are Hypotheses 7 through 12.

Table V reveals that there are no significant differences related to reflectivity. Table VI shows means and standard deviations for reflectivity. The data reveal that there were no changes in reflectivity across time and between groups and, therefore, Research Hypotheses 7 through 12 are rejected.

TABLE V

ANALYSIS OF VARIANCE SUMMARY TABLE FOR REFLECTIVITY BY TYPE OF CLASS, TREATMENT GROUP, AND PERIOD OF TIME

Sources	SS	df	MS	F
Between Subjects	327,325.36	79		
A (Type of Class)	89.18	1	89.18	0.21
C (Type of Treatment Group)	853.91	1	853.91	2.04
A x C	950.82	1	950.82	2.27
Subjects Within Groups	31,808.42	76	418.53	
Within Subjects	15,065.29	160		
B (Periods of Time)	187.22	2	93.61	0.98
A x B	71.35	2	35.68	0.37
B x C	17.94	2	8.97	0.09
A x B x C	290.75	2	145.37	1.52
B x Subjects Within Groups	14,498.03	152	95.38	
Total	342,390.65	239		

TABLE VI

MEANS AND STANDARD DEVIATIONS FOR REFLECTIVITY SCORES AT THE ASSESSMENT LEVELS FOR THE FOUR GROUPS*

Treatment Groups	Assessment Periods 1		2		3	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Regular Treatment	34.19	14.04	34.08	13.47	32.73	16.12
Regular Control	42.10	14.29	38.60	11.29	43.55	15.28
Gifted Treatment	35.08	15.51	34.75	15.46	39.45	14.29
Gifted Control	35.80	16.05	36.28	12.85	36.58	11.27

*n = 20 for each group.

1 = pre; 2 = post; 3 = delayed post.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary of the Investigation

This study examined the effects of a cognitive behavior modification strategy, specifically self-instruction training, on math achievement. The dependent variables were math achievement and latency to first response (reflectivity) from the MFFT. Four mid-high school algebra classes were chosen for this study. Two of the algebra classes were considered "regular" and they were labeled as either a control class or a treatment class. Two other classes contained students who had been placed in these classes because the school had determined that they were mathematically gifted. These two classes were also designated as either control or treatment. Twenty students in each of the four classes were randomly selected as participants.

Each of the four groups was administered an achievement test in mathematics. These four groups were given the achievement test before (pretest) and after (posttest) the self-instruction training for the treatment groups. All of the groups were also given an achievement test four weeks following the completion of the training with the two treatment groups. The delayed posttesting was done four weeks following the posttest. Students in each of the four groups were also administered the Matching Familiar Figures Test (MFFT). The MFFT was administered as a pre-, post-, and delayed posttest.

Each of the dependent variables was analyzed with a split-plot factorial ANOVA (Kirk, 1968) that consisted of two treatment groups and two control groups and three repeated measures.

Conclusions

Within the scope of this study, conclusions are suggested from the results of the analysis in Chapter IV:

Research Hypothesis 1: There were no significant differences between mathematically gifted treatment and control groups from pre- to posttesting with achievement.

Research Hypothesis 2: There were no significant differences between the regular control and treatment groups in achievement from pre- to posttesting. Both increased significantly.

Research Hypothesis 3: There was a significant effect in math achievement between the regular group and the mathematically gifted group. There was an increase in both the regular treatment and control groups.

Research Hypothesis 4: Self-instruction training did not cause a significant increase in math achievement from pre- to delayed posttesting with the mathematically gifted treatment group.

Research Hypothesis 5: There was a significant increase in math achievement from pre- to delayed posttesting with the regular treatment group. There was also a significant increase in the regular control group.

Research Hypothesis 6: Self-instruction training did not cause a significant increase in achievement with the regular treatment group nor with the mathematically gifted treatment group from pre- to delayed posttesting.

<u>Research Hypothesis 7</u>: The self-instruction training did not cause a significant difference in reflectivity between the mathematically gifted treatment and control groups from pre- to posttesting.

<u>Research Hypothesis 8</u>: The self-instruction training did not cause a significant difference between the regular treatment and control group in reflectivity from pre- to posttesting.

<u>Research Hypothesis 9</u>: The self-instruction training did not cause a significant difference between the mathematically gifted treatment and the regular treatment groups from pre- to posttesting.

<u>Research Hypothesis 10</u>: The self-instruction training did not cause a significant difference within the mathematically gifted treatment group in reflectivity from pre- to delayed posttesting.

<u>Research Hypothesis 11</u>: The self-instruction training did not cause a significant difference within the regular treatment group in reflectivity from pre- to delayed posttesting.

<u>Research Hypothesis 12</u>: The self-instruction training did not cause significant differences between the mathematically gifted treatment and regular treatment groups in reflectivity from pre- to delayed posttesting.

Discussion

The findings of this study indicate that a cognitive behavior modification treatment, specifically self-instruction training, did not significantly increase math achievement scores nor cause the treatment groups to become more reflective. Although the regular treatment groups improved significantly in achievement, the regular control group did also, indicating the cause of the improvement was not the treatment. Research hypotheses 3, 5, and 6 must be accepted as written; however, the implication that self-instruction training caused the differences cannot be substantiated because of the improvement of the regular control group. The average score of the regular treatment group on the pretest was 13.25 correct. The average score of the regular control group was 12.95. Following self-instruction training, the treatment group improved to an average score of 18.05 while the control group improved to an average score of 19.20.

Meichenbaum (1977) discovered he could alter children's problem-solving skills. His self-instructional techniques have been used with hyperactive children. He stated he could possibly use this technique with other children who had impulsive behaviors. It would appear the Meichenbaum technique would be beneficial to students who would need impulse control to solve math problems. This study found that with the students sampled, reflectivity was not altered significantly with regular or gifted math students using a self-instruction technique. It should be noted, however, that students in this study were not selected on the basis of impulsivity as were Meichenbaum's subjects.

Although the "process" method of teaching mathematics by Renzulli and Ridge (1981) showed hope in teaching mathematics to gifted students, the specific method of self-instruction training did not significantly alter mathematically-gifted students scores in achievement. The mathematically-gifted students in the study evidently possessed enough reflective control prior to the treatment to give them their high scores initially and no change with the treatment group could occur.

Both the regular treatment and regular control students improved in achievement significantly. With both the control and treatment groups improving significantly, the self-instruction training with the treatment group was apparently not the cause of this group's improvement in achievement. Improvement in math scores by the regular group, both treatment and control, was apparently caused by such factors as learning that may have taken place in the course of instruction or increased motivation on the posttest.

The failure of the gifted and regular groups to increase their scores apparently resulted from their possession of the cognitive strategy that was being taught. The treatment also failed to increase reflectivity with the treatment groups. Students not identified as impulsive apparently do not respond to this training technique.

It should be noted there are several possible reasons for the treatment groups' failure to increase their reflective thinking beyond the treatment. The students sampled appeared very concerned with whether they should take their time and get the correct answer the first time or answer quickly. Although the researcher gave no indication to the students as to the purpose of speed in answering, the students' teacher could have prompted the students by revealing the fact that speed of their first answer was important. If this occurred, the data collected would not be an accurate measurement of their true reflective behavior.

A negative test-retest reliability (-0.81) occurred between the pre- and post-achievement test. This indicates that there were many students who scored relatively high on the pretest who scored low on the posttest. Students scoring relatively low on the pretest scored high on the posttest. The students' motivation during the achievement testing must come into question. The students appeared not to be giving an honest effort during the test sessions. This raises a question of validity with the regular groups.

Several of the gifted students expressed boredom due to the "repetition in the self-instruction training," week after week. One of the gifted students made the remark, "We're not retarded!" This is an indication that the gifted students either learned the procedure the first week or they already possessed the cognitive skills prior to the initial treatment. The regular group did not appear to become bored with the treatment.

As mentioned earlier, there was some instability with regard to the math achievement test. The Pearson r correlations for the regular control students with the math achievement instrument were:

pre- to posttesting = 0.60

pre- to delayed posttesting = -0.85

post to delayed posttesting = 0.27.

The test-retest correlations for the gifted control students with the math achievement test were:

pre- to posttesting = 0.47

pre- to delayed posttesting = 0.33

post to delayed posttesting = 0.32.

Although the correlations for the gifted group are more stable, they still remained relatively low. This would seem to indicate there were some motivational problems with the gifted group, although not nearly as great as with the regular students. Another possibility, of course, is that the math instrument itself was not reliable with this group of 9th and 10th grade students. The pilot study had a reliability of 0.81 with 10th, 11th, and 12th grade students.

There were no significant changes in reflectivity with the gifted or the regular groups. There is less question of a reliable instrument with the MFFT than with the math instrument. As described earlier, a test-retest reliability after one year of 0.82 was found with the MFFT. The reliability using the Pearson r formula for the gifted and regular control groups was:

pre- to posttesting = 0.65

pre- to delayed posttesting = 0.93

post to delayed posttesting = 0.61.

These figures are substantially higher than the correlations for math achievement. The interest level in the MFFT remained higher or the MFFT was more reliable itself than the math instrument. The math instrument was administered to groups of 20 whereas the MFFT was administered individually. The administrator of an individual test has more control over the motivation of a student than a person who administers a group test.

There was a significant change with both the regular control and treatment groups. The improvement of the treatment group apparently was not caused by the treatment as the control group improved also. Students in both the regular control and treatment groups could have learned how to solve more types of algebra problems during their regular course of instruction. That the treatment did not increase the regular treatment group's score would account for thenearly same mean scores on the posttest. As mentioned earlier, because of reliability problems with the regular students, the scores may be less than expected with the treatment group because of motivational problems. It must be noted that the gifted students (treatment and control) failed to increase their math score significantly. This would lead one to believe that the gifted students already possessed the skill being taught or the gifted students did not learn anything from their teacher that related to the math instrument.

The regular control group dropped somewhat from a mean score of 19.20 to a mean score of 15.1 from posttesting to delayed posttesting. The regular treatment group remained about the same, going from a mean score of 18.05 to a mean score of 18.95. The regular treatment group may have been able to maintain their scores because of the exposure to the treatment. The treatment group's teacher may have had an effect in that she may have unintentionally been more sensitive to the treatment group than to the control group.

In reviewing the standard deviations for achievement there was one inconsistency found. For the regular treatment group the standard deviations were:

pre- = 3.91

post = 12.57

delayed posttesting = 6.47.

The scores on the pretest were much closer together than those on the posttest. The students probably were trying harder on the pretest than on the posttest or delayed posttest. Some students on the posttest may have lost interest and were not really trying to answer the problems. This fact coupled with the negative reliability on the posttest leads the researcher to believe that lack of motivation was the cause of the increase in the standard deviations.

Tables III and IV show the simple effects breakdown of Class by Assessment Period and Class by Type of Treatment. Table III reveals there is a significant effect of Type of Class by all levels of Assessment Period. The table also shows that the significance is with the regular group that improved significantly from pre- to posttesting and from pre- to delayed posttesting in math achievement. Table III shows that the gifted group did not improve significantly. Table IV shows that there was a significant difference in Type of Treatment (treatment or control). This can be explained in that the gifted classes (treatment and control) had significantly higher scores than either of the regular groups. This was expected since the gifted students had more knowledge of math than the regular group initially. There was no significant difference between the regular control and regular treatment groups. Table IV shows a significant difference between the gifted treatment and gifted control groups. Examination of Table III indicates that the gifted control group had higher mean scores for math achievement than the gifted treatment group. The scores remained higher through all assessment periods.

The standard deviations for reflectivity remained relatively consistent except for the gifted control group. Their standard deviations became smaller from pretest (16.05) to posttest (12.85) and to delayed posttesting (11.27). Although the variation of the scores became smaller, the mean scores of this group remained approximately the same. As time passed, there were fewer extreme high and low scores.

Reflectivity scores from the MFFT remained consistent throughout. There were no significant changes in reflectivity between the control or treatment groups, between regular or gifted, or within groups over time.

It appears as discussed earlier that reflectivity was not changed by the treatment. There was a drop in mean score of the regular control group from 42.10 seconds (pretest) to 38.6 seconds (posttest). This was not significant (see Table V).

In summary, it appears that the strategy of teaching self-instruction to math students did not have a significant effect on performance. There were several factors such as motivation, help from the teacher, and actual learning in the classroom that could have obscured the true effects of the treatment.

Implications for Practitioners

It was originally hoped that a self-instruction technique could be a useful tool to be used by classroom teachers or school psychologists to help students who were having difficulty with mathematics. There were indications in the literature that this technique could be beneficial to both regular and gifted math students. The findings of this study indicate, however, that self-instruction training is not appropriate for students who have not demonstrated a lack of impulse control. There are other possibilities using a cognitive behavior modification method and suggestions for further research.

Recommendations for Further Research

Although this study did not indicate that self-instruction training would be an appropriate intervention strategy for regular algebra or gifted algebra students, the following recommendations are made:

1. This study did not make hypotheses concerning error rates on the MFFT following the self-instruction training. The math achievement

test served this purpose. Future research might disclose any differences between regular algebra and gifted algebra students in error rate following a similar treatment. Fast-accurates, for example, might be compared to slow-accurates.

2. This study sampled only students placed in math classes without regard to their impulsiveness. Past studies, illustrated in Chapter II, have shown that students with demonstrated hyperactivity can be made to be more reflective using a cognitive behavior modification technique. Future studies should use self-instruction with identified gifted students who are impulsive.

3. This study examined only mid-high school students. Future studies should examine self-instruction training with elementary and high school students from both populations with varying levels of reflectivity. There is some indication that younger children are more impulsive than older children (Kendall and Finch, 1978).

4. Self-instruction intervention was the cognitive behavior modification therapy used in this study. Future research could use other cognitive strategies such as coping-skills therapy or problem-solving therapy. These strategies have shown promise in improving cognitive skills and have not been used with gifted students.

5. This study used five sessions with the treatment groups. Future studies should examine the effects of more than five treatment sessions.

6. In similar studies, more control over what information students receive about scoring should be maintained. This should increase the reliability of the instruments.

7. To prevent possible misinterpretation of the data, the paired

treatment and control groups should not be significantly different on the measure taken at pretesting.

8. It is recommended that the content of the subjects that the students are learning during their regular course of instruction be examined to determine the possible effects there may be in regard to the research.

9. Confidentiality as to the scoring criteria should be maintained by the classroom teacher. This would have a positive effect on the reliability of the test instruments.

10. The classroom teacher should emphasize the seriousness of the project and try to maintain attentiveness on the part of the participants.

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APPENDIX A

MATH ACHIEVEMENT INSTRUMENT

AND ANSWER KEY

1. The sum of -24 and -3 is

(a) 8 (b) -8 (c) -21 (d) 21 (e) -27

2. If a = 3 and b = 4, then $a^b + b^a =$

(a) 30 (b) 145 (c) 345 (d) 1,000 (e) 3,000

3. From a temperature of 15°, a drop of 21° would result in a temperature of

(a) -36° (b) -30° (c) -6° (d) 36° (e) 6°

4. If 3/4 of a class are absent and 2/3 of those present leave the room, what fraction of the original class remains in the room?

(a) 1/24 (b) 1/12 (c) 1/8 (d) 1/4 (e) 1/6

5. In a 45 minute gym class, 30 boys want to play basketball. Only 10 can play at once. If each player is to play the same length of time, how many minutes should each play?

(a) 8 (b) 12 (c) 15 (d) 20 (e) 25

6. $A^6 \times A^2 =$

(a) A^3 (b) A^4 (c) A^8 (d) A^{12} (e) $2A^{12}$

7. $\sqrt{960}$ is a number between

(a) 20 and 30
(b) 30 and 40
(c) 60 and 70
(d) 70 and 80
(e) 80 and 90

8. If $\begin{vmatrix} K & M \\ R & T \end{vmatrix}$ equals KT - MR, then $\begin{vmatrix} 5 & 6 \\ 3 & 4 \end{vmatrix} =$

(a) -5 (b) 0 (c) 2 (d) 5 (e) 18

9. The factors of $x^2 + 8x - 20$ are

(a) $(x - 8)(x - 20)$
(b) $(x - 10)(x - 2)$
(c) $(x + 8)(x + 2)$
(d) $(x + 10)(x + 2)$
(e) Not given above

10. The fraction $\frac{-3a^2}{-3a^2}$ equals

(a) 1 (b) 0 (c) a (d) a^2 (e) -3^2

11. $(2/3)^2 \cdot (1/2)^2 =$

(a) 1/9 (b) 49/36 (c) 4/6 (d) 3/5 (e) 9/25

12. If $m = 2n$, find $3/5\ m + 1/3\ n$ in terms of m

(a) 23/15 m (b) 23/15 n (c) 4/11 (d) 23/50 m (e) n/10

13. $4c - 3a + 6c + a =$

(a) 8ac
(b) $10c - 4a$
(c) $2c - 4a$
(d) $10c - 3a$
(e) None of the above

14. If $a = -2$, then $-3a =$

(a) -6 (b) -4 (c) 0 (d) 4 (e) 6

15. Which of the following are equations?

I. $x - 3 = 4$
II. $x^2 - 8 = 4$
III. $(x + 3)(x - 3)$

(a) Only I
(b) Only II
(c) I and II only
(d) Only III
(e) I, II, and III

16. If $x = y = -1$, then $(x + y)(x - y) =$

(a) -2 (b) -1 (c) 0 (d) 1 (e) 2

17. If $\frac{2\ xyz}{5\ ab} = \frac{2\ xytz}{c}$, then c =

(a) 5 abc (b) 5c (c) 5 abt (d) t (e) 5 ab

18. $x/y = m/t$, $y = 6$, $t = 8$ and $x/t = hm$; find the numerical value of h

(a) 10 2/3 (b) 3/32 (c) 1/5 (d) 3/5 (e) 4/5

19. For which, if any, of the following values of a and b will ab be negative?

(a) $a = -3$, $b = 4$
(b) $a = 3$, $b = 4$
(c) $a = -3$, $b = -4$
(d) $a = -3$, $b = 0$
(e) $a = 0$, $b = -4$

20. If 3/5 of a container is filled with water in 1 minute, how many minutes longer will it take to fill the container?

(a) 1/3 (b) 1/2 (c) 5/3 (d) 3/4 (e) 4/5

21. If x is an odd number, what is the 3rd consecutive odd number preceding x?

(a) $x + 4$
(b) $x + 3$
(c) $x - 3$
(d) $x - 4$
(e) None of the above

22. A boy has 5 pairs of slacks and 3 sport jackets. How many different combinations can he wear?

(a) 3 (b) 5 (c) 8 (d) 15 (e) 20

23. If $.04\ y = 1$, then $y =$

(a) .025 (b) .25 (c) 2.5 (d) 25 (e) 250

24. A rectangular field is 900 yds. by 240 yds. What is the largest number of rectangular lots 120 yds. by 60 yds. that it can be divided into?

(a) 20 (b) 30 (c) 40 (d) 50 (e) 60

25. The average of 3 fractions is 13/26. Two of them are 1/3 and 1/4. What is the other fraction?

(a) 11/12 (b) 1/2 (c) 2/3 (d) 3/4 (e) 4/5

26. If $x + x + x + 1 = x + x - 1$, then $x =$

(a) 3 (b) 2 (c) 1 (d) -1 (e) -2

27. A piece of rope m yards long has a piece t feet long cut off one end and a piece x inches long cut off the other. How many feet were left?

(a) $m/3 - t + 12x$
(b) $36m - 12t - x$
(c) $3m + (t + x/12)$
(d) $3m - (t + x/12)$
(e) $m/3 - (t + 12x)$

28. 1/3 is what percent of 2/3?

(a) 50 (b) 67 (c) 75 (d) 80 (e) 120

29. $8m \cdot 3t \cdot m =$

(a) $24 + m^2t$
(b) $8\ m^2 + 3t$
(c) $24\ mt$
(d) $24\ m^2t$
(e) None of the above

30. If it takes 30 minutes to type 6 pages, how many hours will it take to type 126 pages at the same rate?

(a) 6.3 (b) 10.5 (c) 15 (d) 25 (e) 630

31. Which variable is the largest if $a = 2b = c^2 = d^3 = e/2$?

(a) a (b) b (c) c (d) d (e) e

32. If $a/5 = -3$, then $2a =$

(a) -6 (b) 30 (c) -30 (d) -15 (e) 15

33. A large pie can be sliced 3 different ways:
i into 8ths
ii into 7ths
iii into 6ths

Which of the following yields the largest portion?

(a) 1/3 of iii
(b) 1/4 of ii
(c) 2/5 of i
(d) 1/2 of ii
(e) 3/8 of iii

34. B owes A 80¢; A owes B $1.00; B gives A $1.20. What is now needed to cancel the debt?

(a) B gives A $1.20
(b) B gives A 40¢
(c) A gives B $1.20
(d) A gives B $1.00
(e) A gives B $1.40

35. $3(x + y) - (3x - y) =$

(a) $-2y$
(b) $2y$
(c) $-4y$
(d) $4y$
(e) None of the above

36. $(4 + xy)(5 - xy) =$

(a) $20 - x^2y^2$
(b) $20 + x^2y^2$
(c) $20 + xy - x^2y^2$
(d) $20 - xy$
(e) 20

37. Which of the following fractions is closest to 1/3?

(a) 1/5 (b) 2/5 (c) 5/9 (d) 3/11 (e) 3/8

38. What fraction of 63 is 2/7 of 21?

(a) 1/42 (b) 2/21 (c) 1/3 (d) 6/7 (e) 7/5 .

39. Nickeline is an alloy in which the ratio of nickel to copper is 1:4. If 240 pounds of copper is available, how many pounds of nickeline can be made?

(a) 30 (b) 60 (c) 240 (d) 300 (e) 400

40. A car owner finds he needs 12 gallons of gas for each 120 miles he drives. If he has his carburetor adjusted, he will need only 80% as much gas. How many miles will 12 gallons of gas then last him?

(a) 90 (b) 96 (c) 140 (d) 150 (e) 160

41. The library charges 5¢ for the first day and 2¢ for each additional day that a book is overdue. If a borrower paid 65¢ in late charges, for how many days was the book overdue?

(a) 12 (b) 15 (c) 20 (d) 30 (e) 31

42. If 9 is 9% of x, then x =

(a) .01 (b) .09 (c) 20 (d) 9 (e) 100

43. If 5 pints of water are needed to water each square foot lawn, the minimum gallons of water needed for a lawn 8' by 12' is

(a) 5 (b) 20 (c) 40 (d) 60 (e) 240

44. If x = y, find the value of 8 + 5 (x - y).

(a) 8 + 5x - 5y
(b) 8 + 5xy
(c) 13x - 13y
(d) 8
(e) 0

45. If 4/t = 3, then ?/t = 1.

(a) 4 (b) 3 (c) 12 (d) 4/3 (e) 3/4

46. 22 ab + 12 = 28 ab. Find ab.

    (a) 2 (b) 1 (c) 0 (d) -1 (e) -2

47. What is the correct time if the hour hand is exactly 2/3 of the way between 5 and 6?

    (a) 5:25 (b) 5:30 (c) 5:35 (d) 5:40 (e) 5:45

48. What is the maximum number of books each 1/4 inches thick that can be placed standing on a shelf 4 feet long?

    (a) 16 (b) 20 (c) 48 (d) 96 (e) 192

49. Find the number of degrees in the angle between the hands of a clock at 5:15.

    (a) 50° (b) 60° (c) 65° (d) 67½° (e) 80°

50. A farmer has a total of 200 cows and chickens. There is a total of 448 legs. How many cows does the farmer have?

    (a) 24
    (b) 50
    (c) 100
    (d) 176
    (e) Impossible to determine

MATH ACHIEVEMENT INSTRUMENT SCORING KEY

1. E	21. E	41. E
2. B	22. D	42. E
3. C	23. D	43. D
4. B	24. B	44. D
5. C	25. A	45. E
6. C	26. E	46. A
7. B	27. D	47. D
8. C	28. A	48. E
9. E	29. D	49. D
10. A	30. B	50. A
11. A	31. E	
12. D	32. C	
13. E	33. D	
14. E	34. E	
15. C	35. D	
16. C	36. C	
17. C	37. D	
18. B	38. B	
19. A	39. D	
20. B	40. D	

APPENDIX B

MATCHING FAMILIAR FIGURES TEST

DIRECTIONS FOR MATCHING FAMILIAR FIGURES

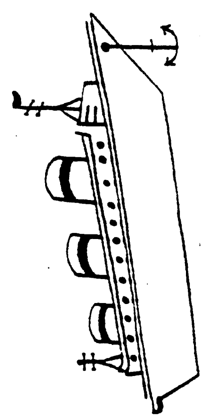
Adolescent/Adult Set

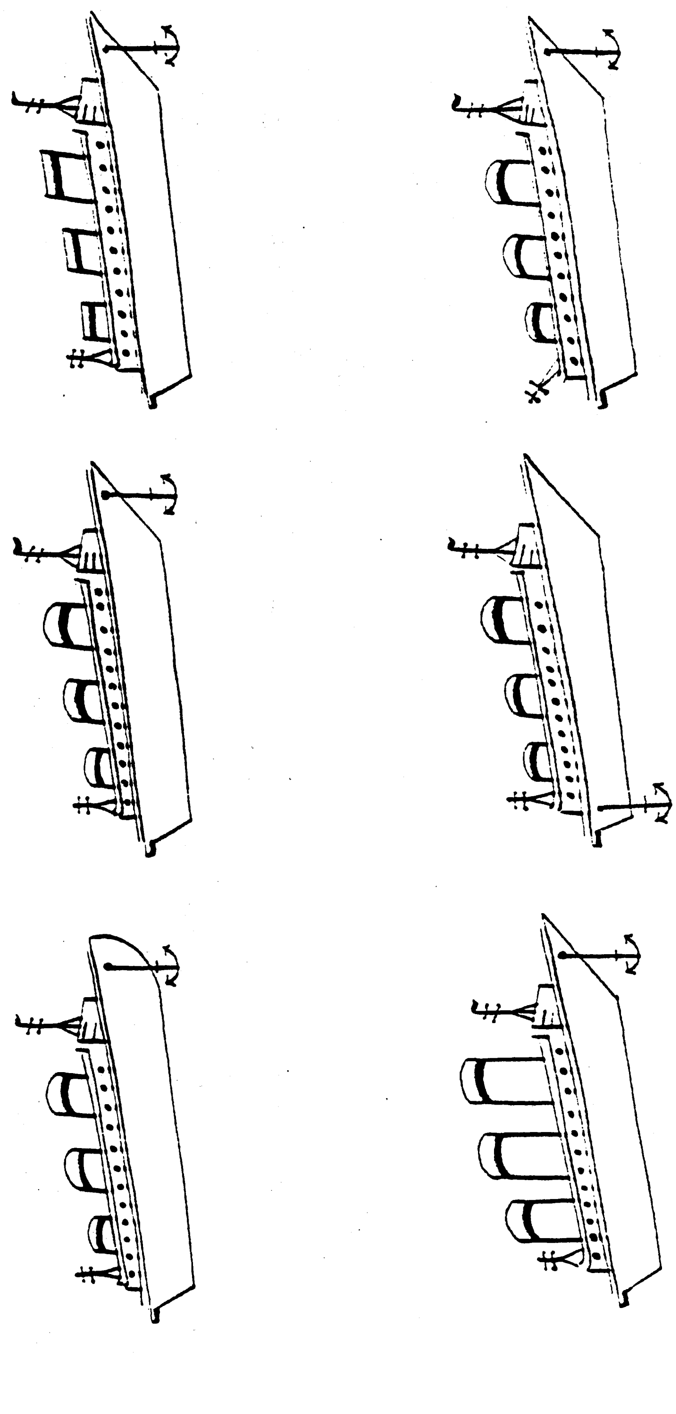
"I am going to show you a picture of a familiar item and then some pictures that look like it. You will have to point to the picture on this bottom page (point) that is just like the one on this top page (point). Let's do some for practice." E shows practice items and S selects the correct item. "Now we are going to do some that are a bit harder. You will see a picture on top and eight pictures on the bottom. Find the one that is just like the one on top and point to it."

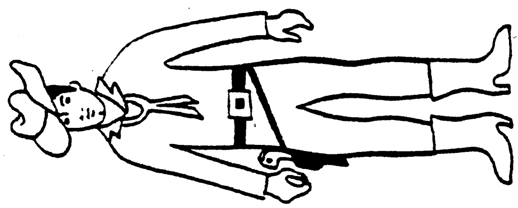
E will record latency to the first response to the half-second, total number of errors for each item and the order in which the errors are made. If S is correct, E will indicate this to him. If wrong, E will say, "No, that is not the right one. Find the one that is just like this one (point)." Continue to code responses (not times) until S makes a maximum of eight errors or gets the item correct. If incorrect, E will show the right answer.

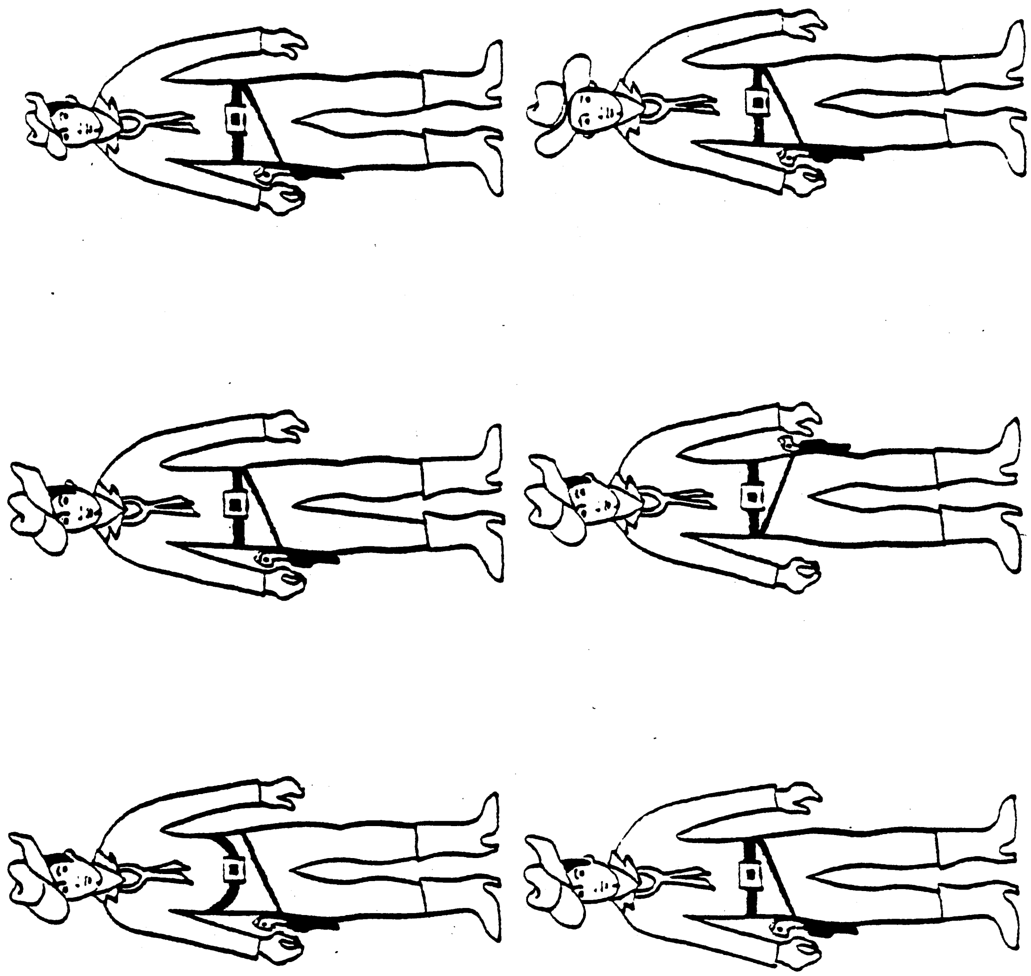
The test should be set up in a notebook. It is necessary to have a stand to place the book on so that both the stimulus and the alternatives are clearly visible to the S at the same time. The two pages should be practically at right angles to one another.

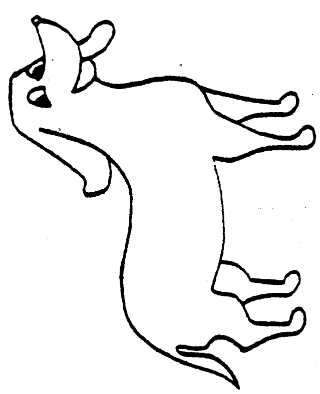
Note: It is desirable to insert the pages in clear plastic which helps to keep the pages clean.

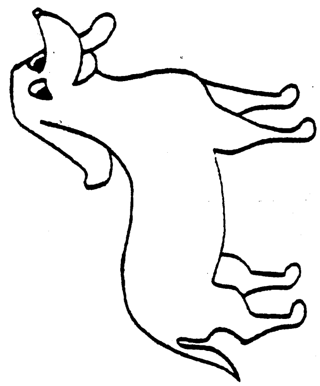
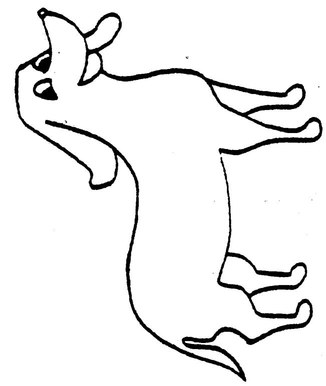
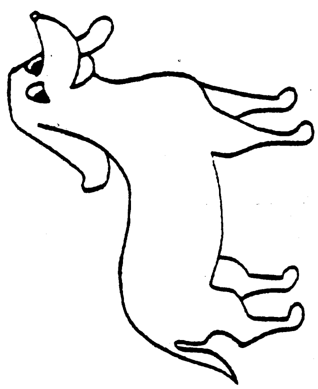
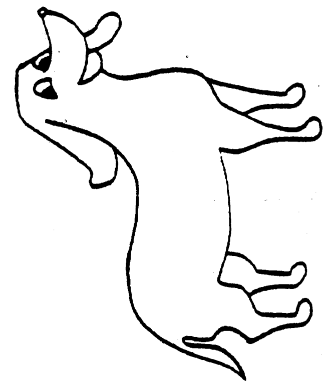
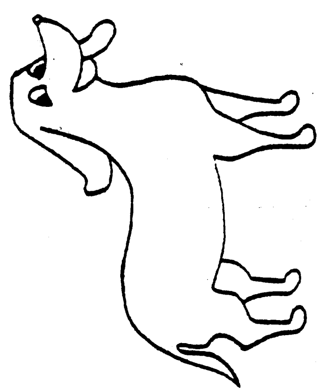
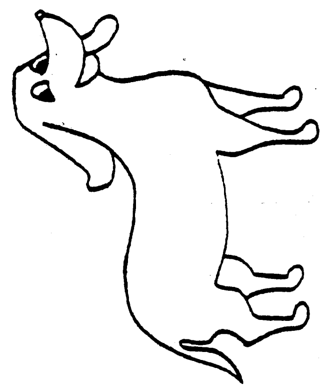
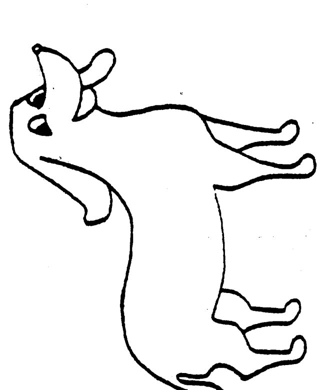
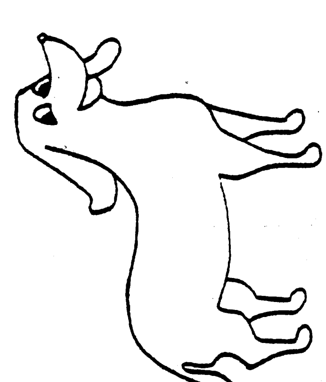


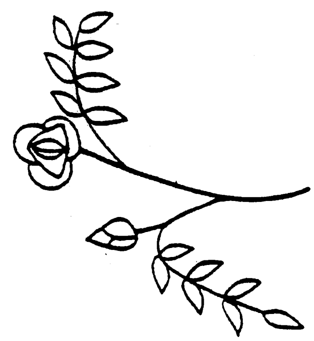


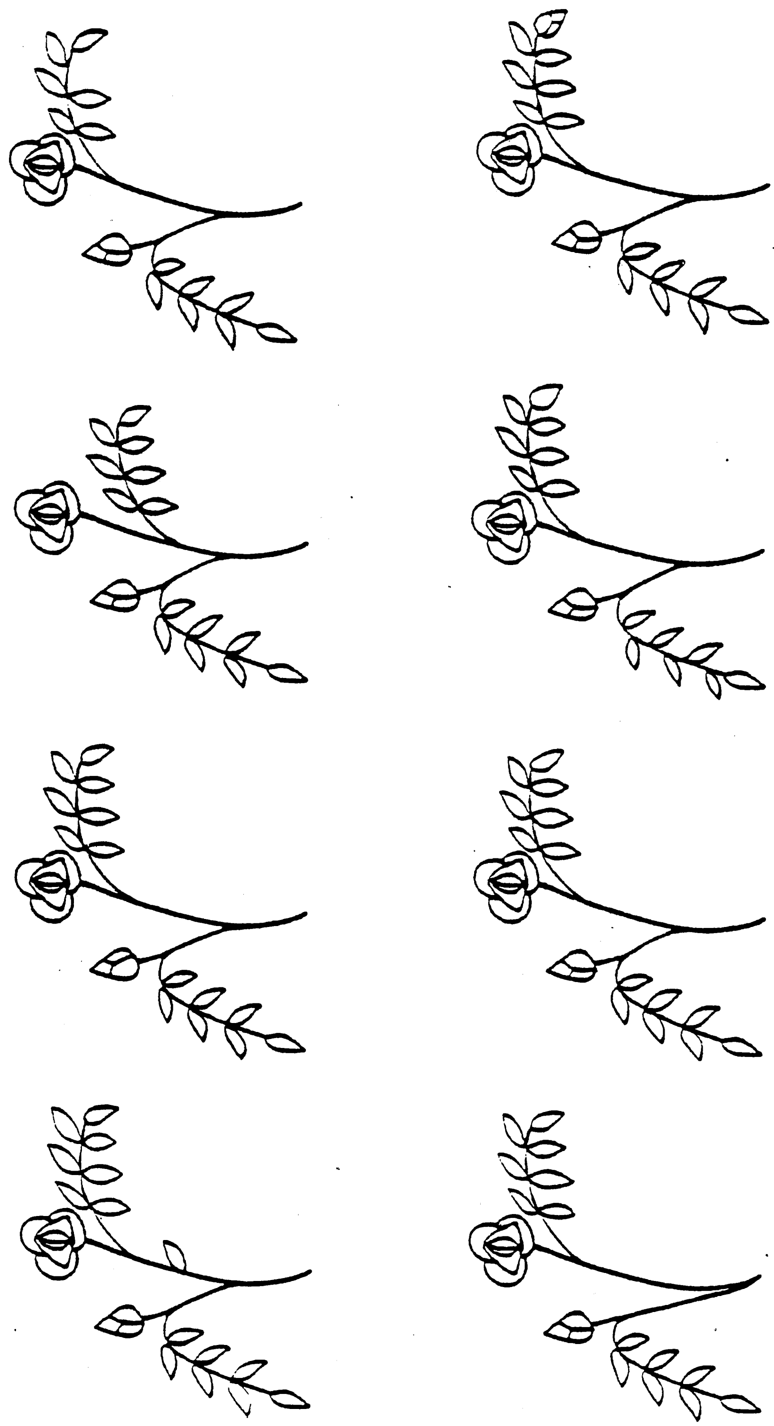


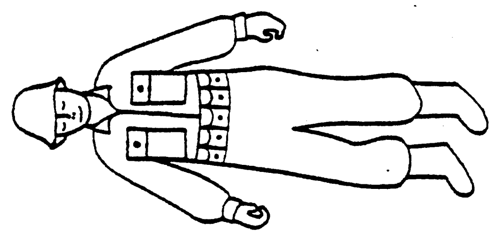


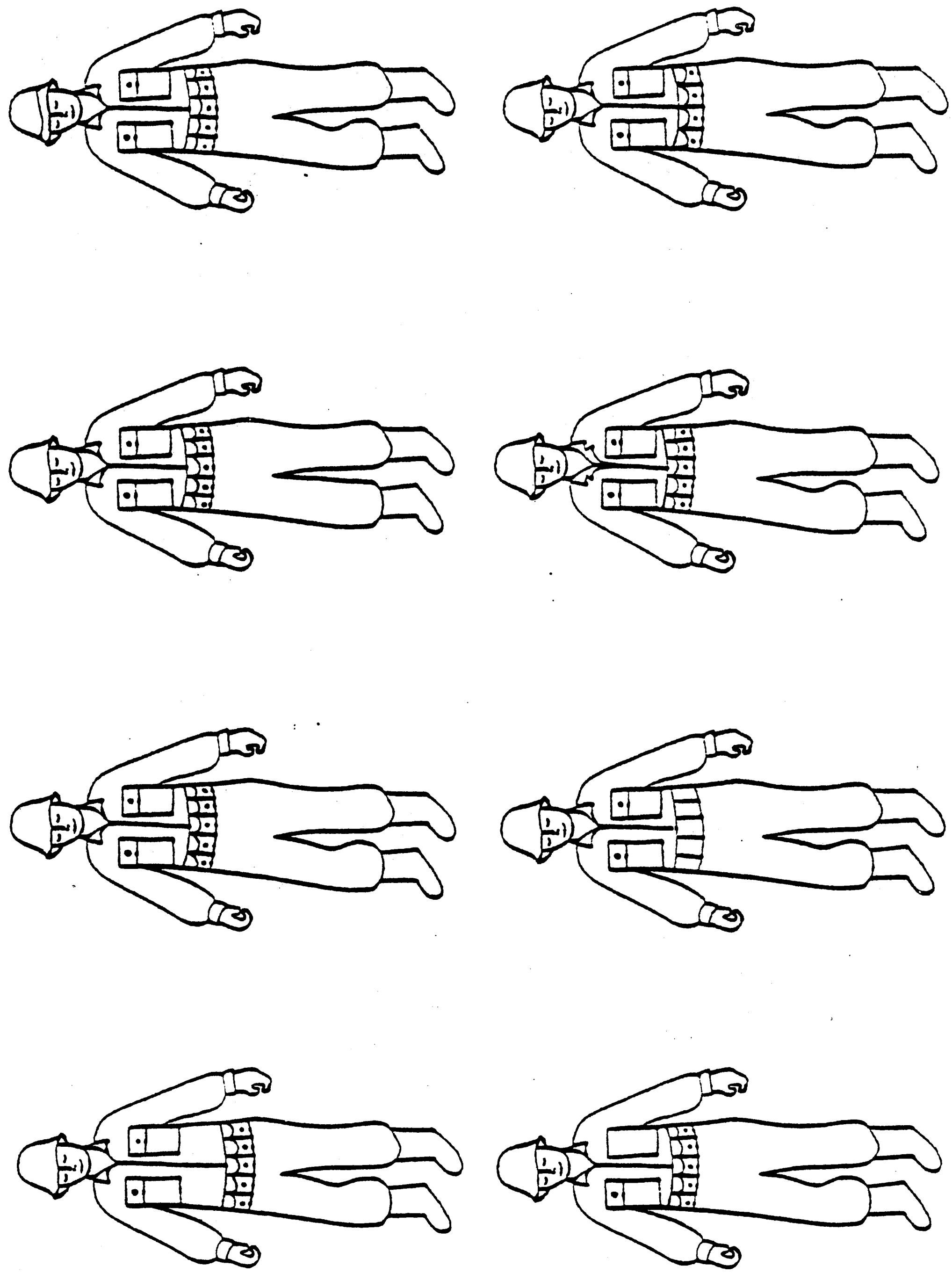


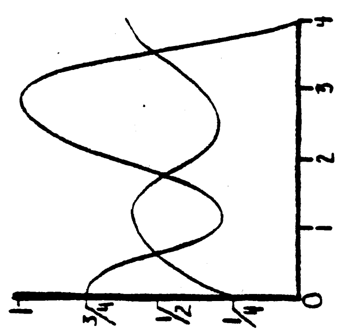















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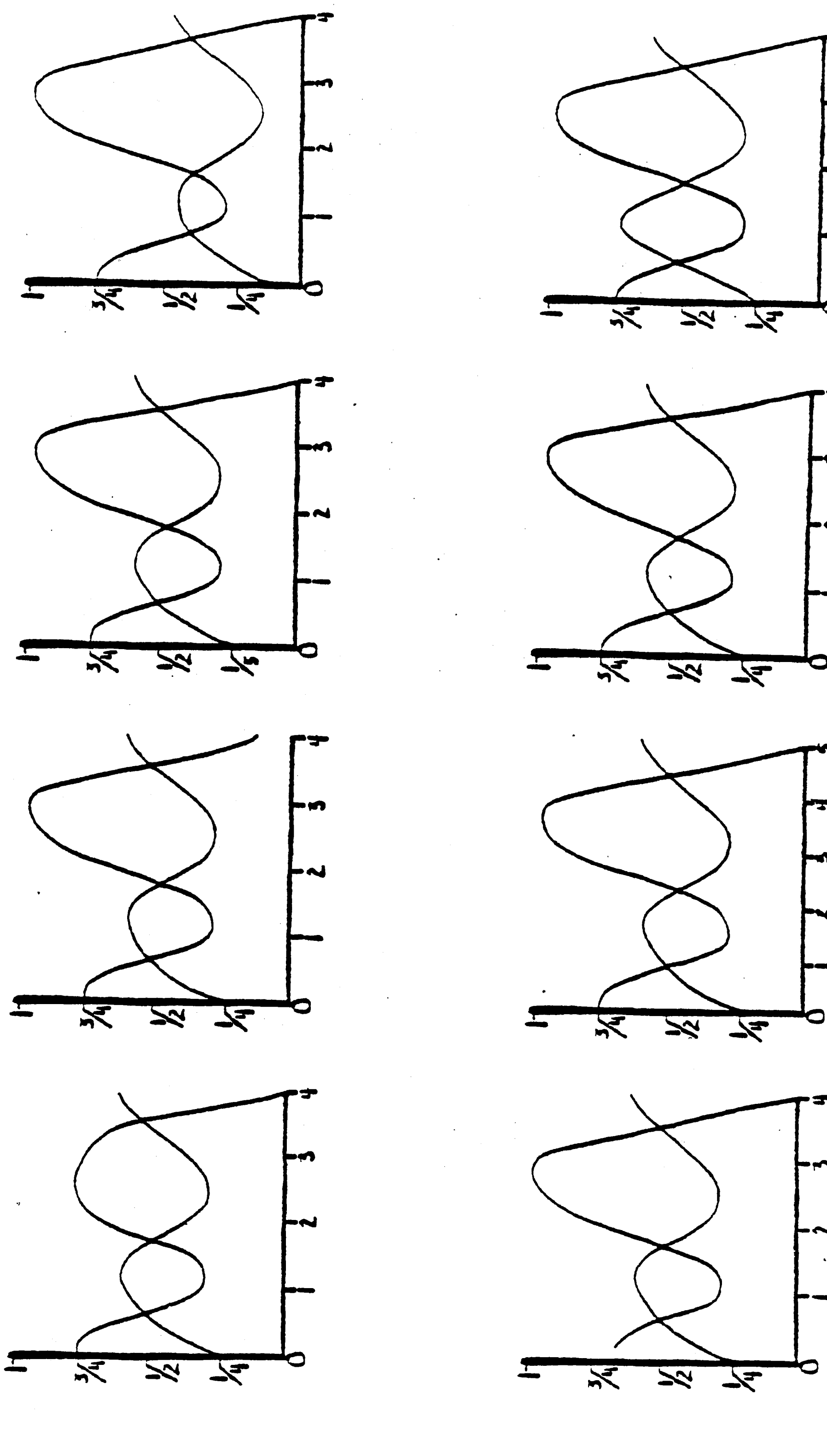

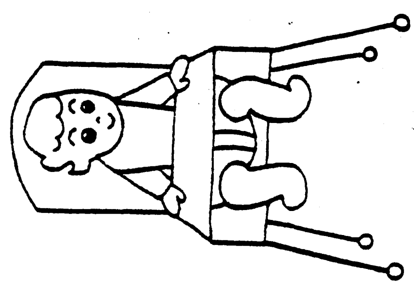

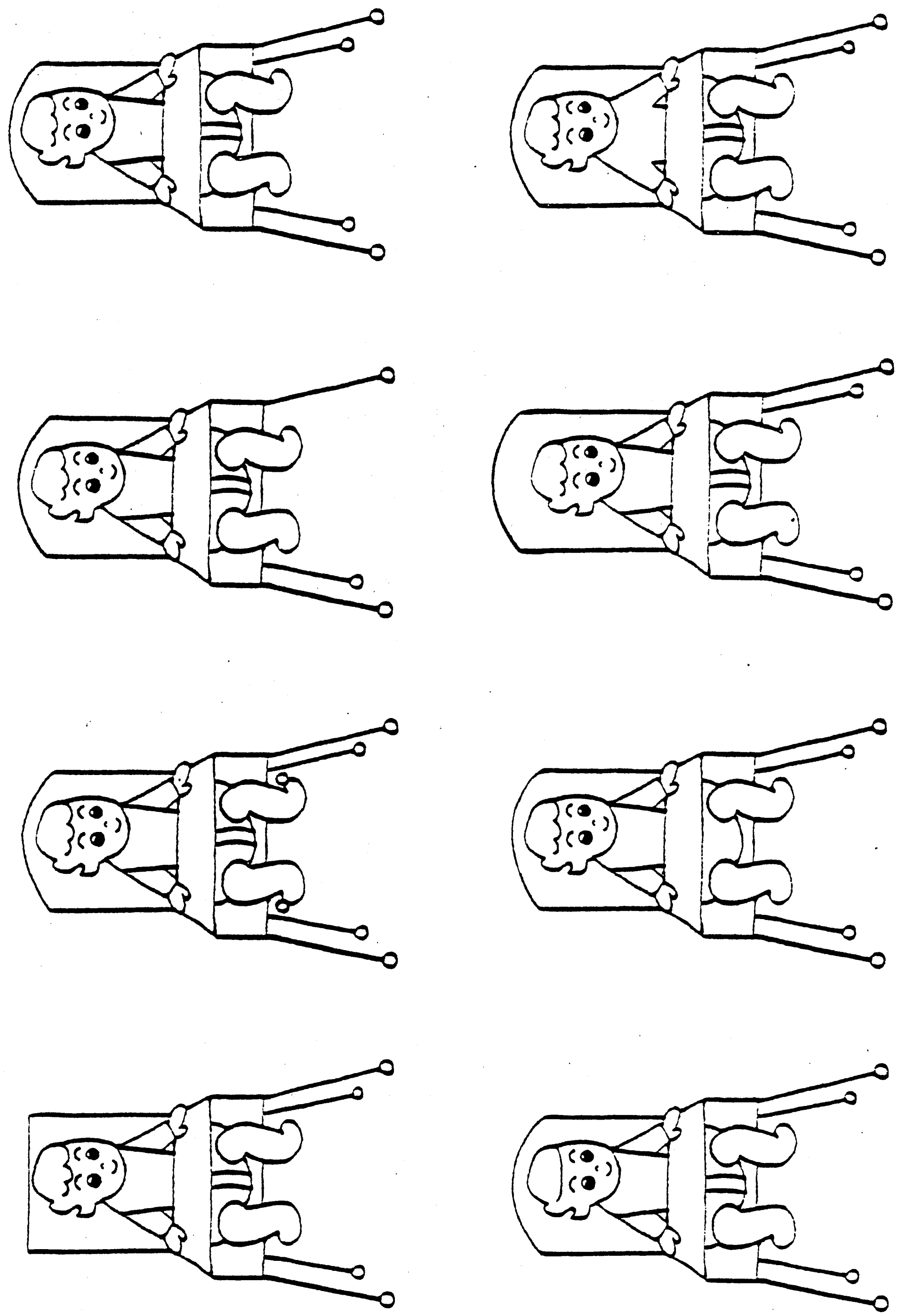

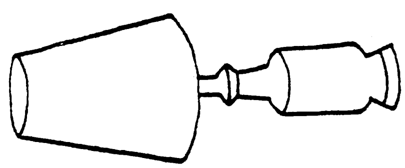

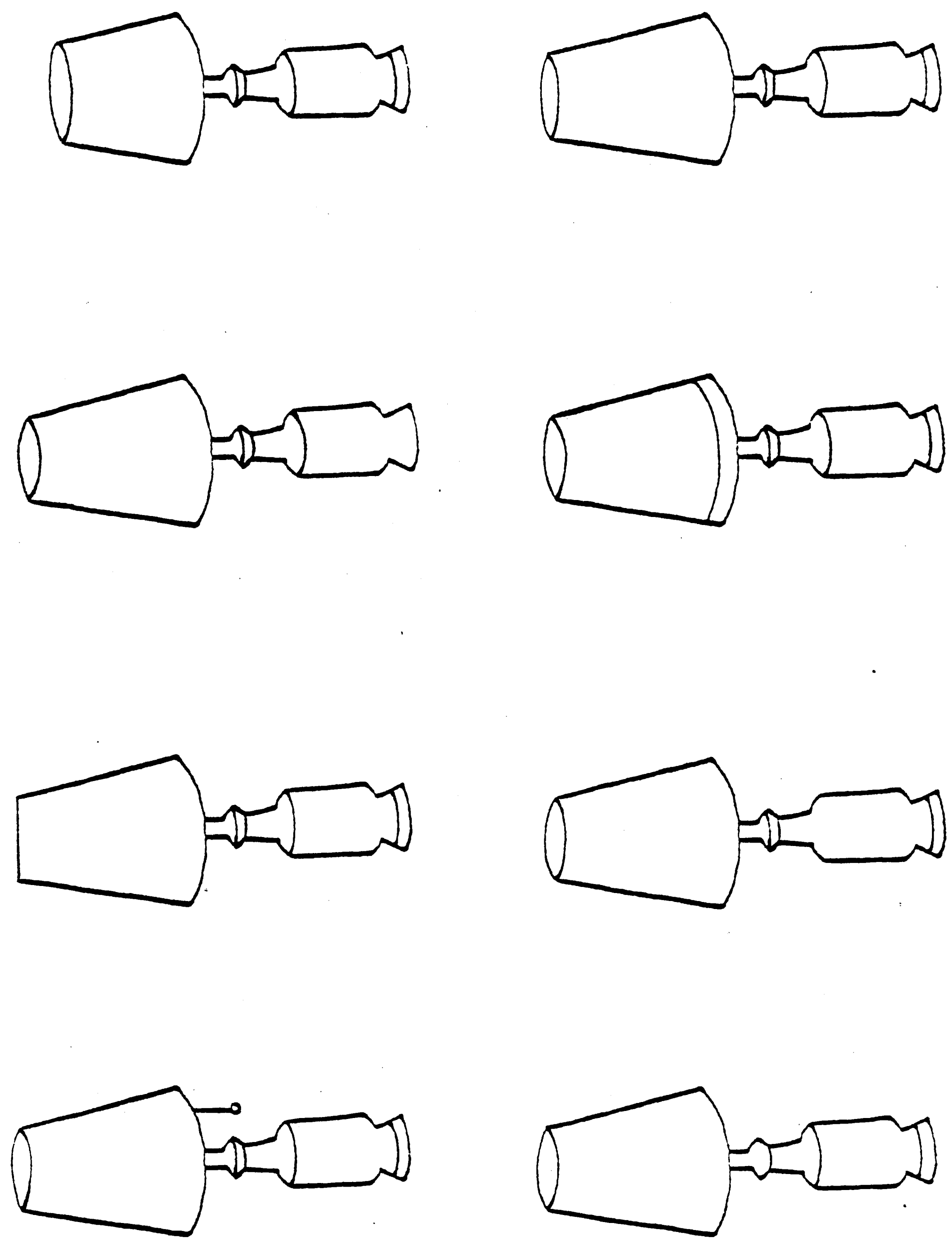

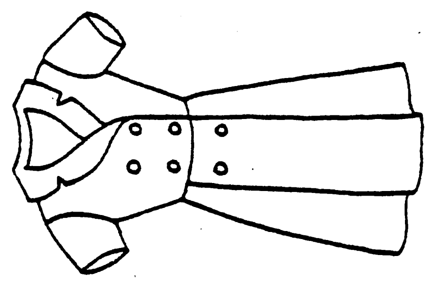

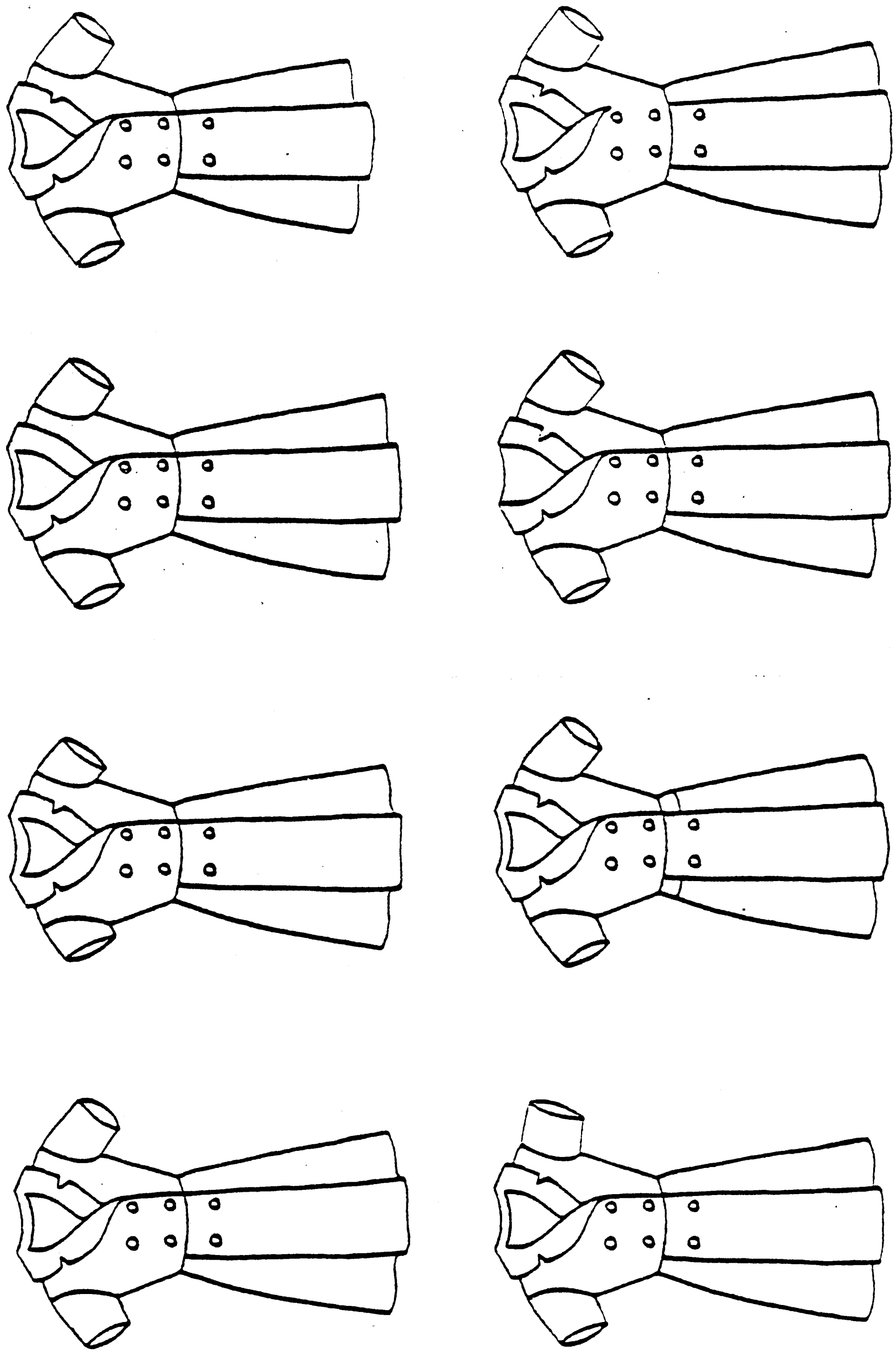

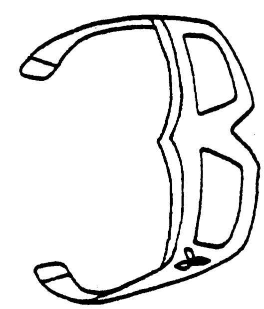

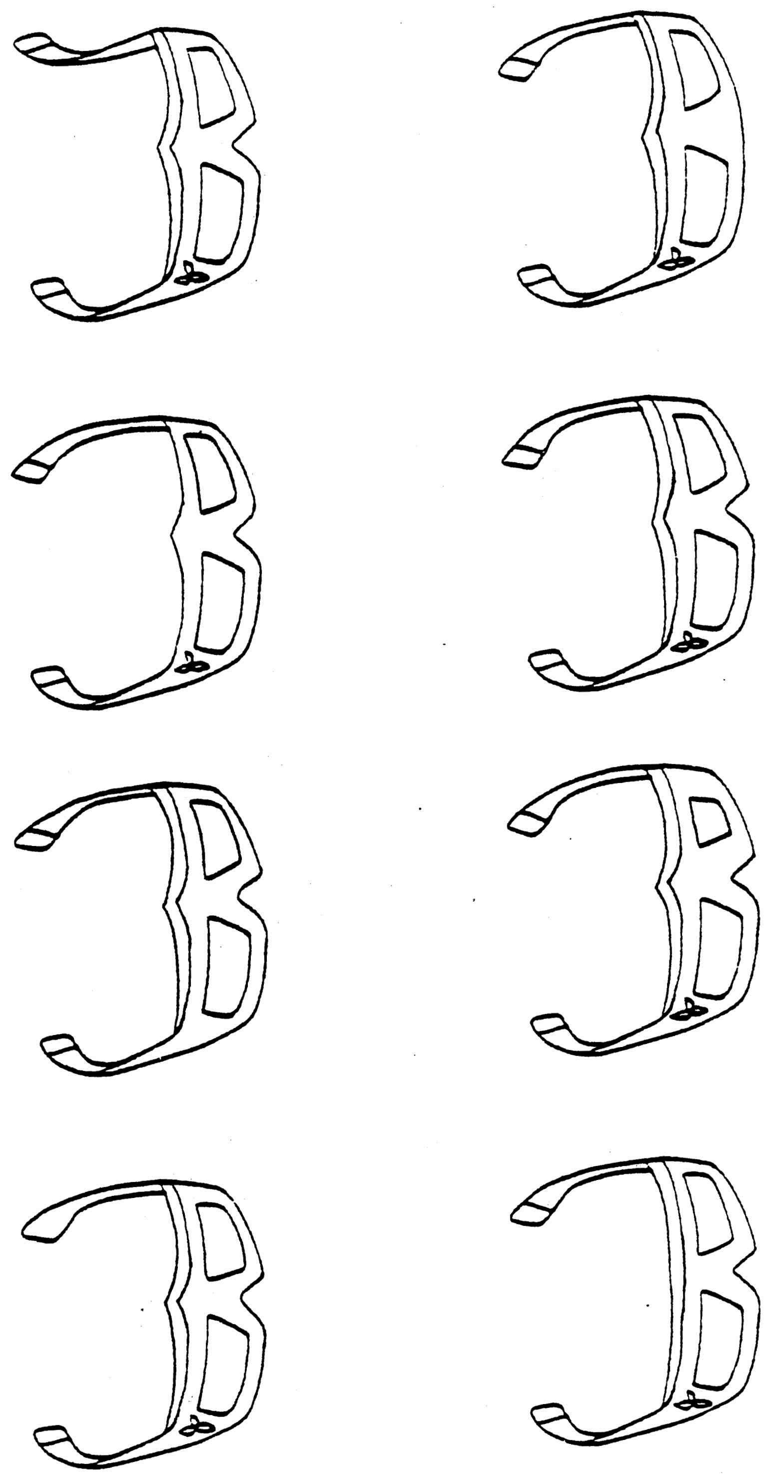

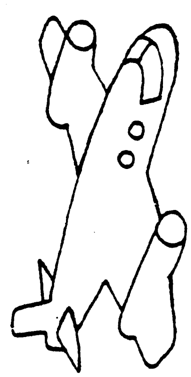

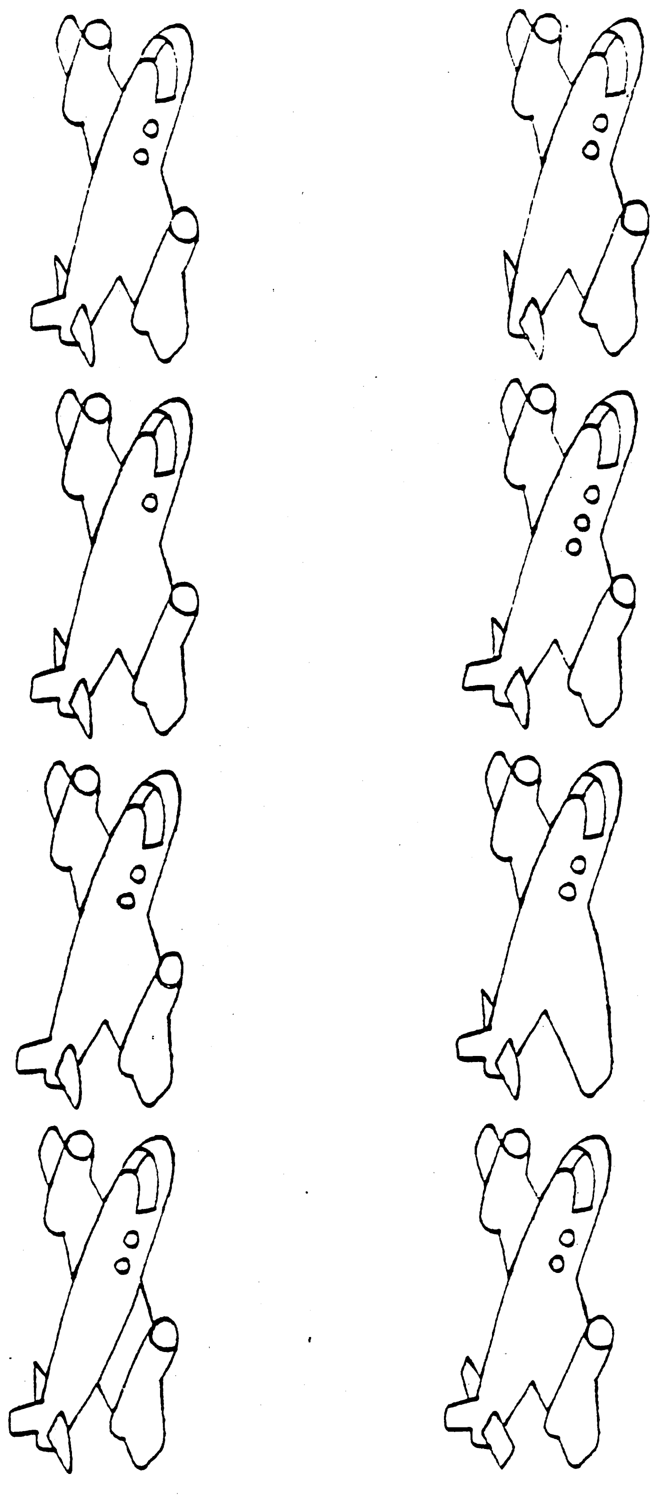

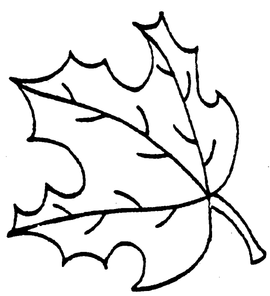

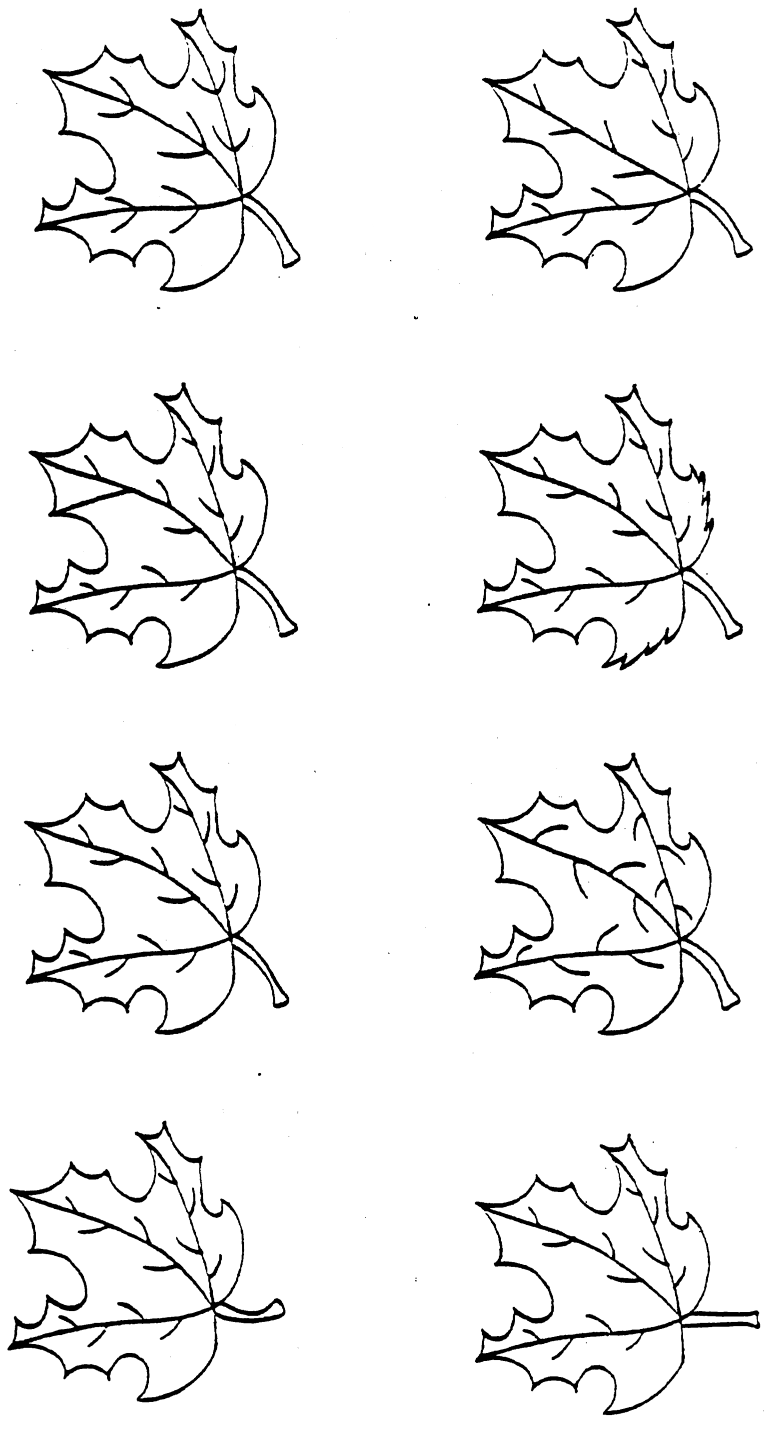

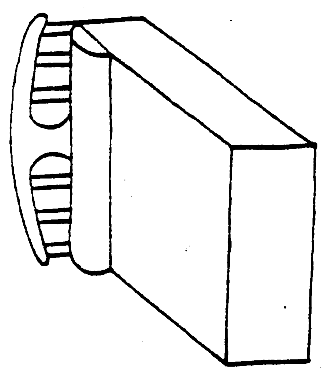

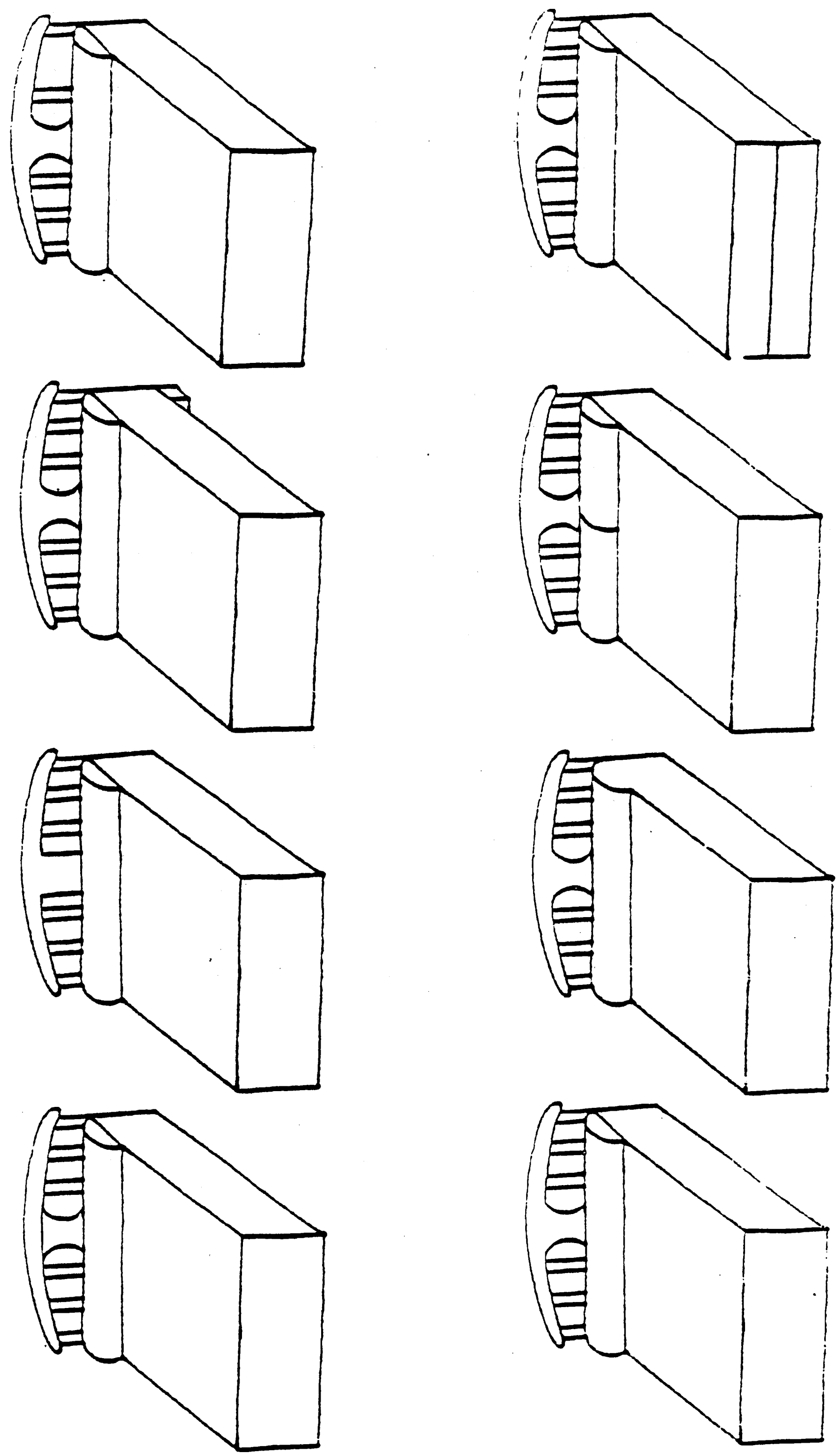

Adolescent/Adult Set

Scoring Sheet

Date ______________________ Examiner ______________________

Name ______________________ Time Started ______________________

Age ____ Birth Date ______________ Time Finished ______________________

Education ______________________ Place of Testing ______________________

Dominance Eye _______ Hand _______ Foot _______

			Latency of first response to ½ sec.	Answers in chronological order to correct response								Total no. of errors
				1	2	3	4	5	6	7	8	
Practice	1.	boat	___	___	* ___	___	___	___	___	___	___	___
	2.	cowboy	___	___	___	___	* ___	___	___	___	___	___
Item	1.	dog	___	___	___	___	* ___	___	___	___	___	___
	2.	rose	___	___	___	___	___	___	* ___	___	___	___
	3.	soldier	___	___	* ___	___	___	___	___	___	___	___
	4.	graph	___	___	___	___	___	___	___	* ___	___	___
	5.	baby	___	___	___	___	* ___	___	___	___	___	___
	6.	lamp	___	___	___	___	___	___	___	___	* ___	___
	7.	dress	___	* ___	___	___	___	___	___	___	___	___
	8.	lion	___	___	___	___	___	* ___	___	___	___	___
	9.	glasses	___	___	___	___	___	___	___	* ___	___	___
	10.	plane	___	___	___	___	* ___	___	___	___	___	___
	11.	leaf	___	___	* ___	___	___	___	___	___	___	___
	12.	bed	___	___	___	___	___	* ___	___	___	___	___

Examiner's Observations: ____

____

____

____

____

____

MATCHING FAMILIAR FIGURES

Answer Sheet

Adolescent/Adult Set

Practice	1.	boat	. . . 2
	2.	cowboy	. . . 4
Item	1.	dog	 4
	2.	rose	 6
	3.	soldier	. . . 2
	4.	graph	 7
	5.	baby	 4
	6.	lamp	 8
	7.	dress	 1
	8.	lion	 5
	9.	glasses	. . . 7
	10.	plane	 4
	11.	leaf	 2
	12.	bed	 5

APPENDIX C

TREATMENT NARRATIVE

General Treatment

The general treatment technique follows Meichenbaum's (1977) approach cited on page 8 of this study. The general self-instruction technique used in this study was:

1. Cognitive modeling: the students observe the trainer as he explains the problem-solving approach.

2. Overt external guidance: the students followed the directions of the trainer.

3. Overt self-guidance: the students think aloud how to solve the problems. They respond orally to the trainer.

4. Covert self-instruction: the students are trained to think about the steps involved in solving a problem and to "reward" themselves when they get the problems correct.

The specific training follows.

Treatment for Regular Algebra Group

Week One

The trainer enters the classroom of regular algebra students and says: "Good morning, we are going to practice using a method that will help you solve math problems better. I am going to write five steps on the board that should help you solve math problems without making so many mistakes."

The trainer writes the following on the board:

1. What kind of problem is it?
2. What are the steps in this type of problem?
3. Am I paying attention and doing it correctly?
4. How do I get the answer?
5. Did I get the right answer?

The trainer then says, "We are now going to solve a problem using the five steps I have written on the board." The trainer then says, "The problem we will work will probably seem easy but we are really interested in following the steps that I have on the board." The trainer then writes on the board:

$$\begin{array}{r} 49 \\ \underline{+22} \end{array}$$

The trainer asks someone in the class to respond to the first question and the trainer repeats the question. "What kind of a problem is it?" When someone correctly identifies the problem as addition, the trainer responds, "We now know that it is an addition problem; now what is the next step?" After a student has identified the second step, the trainer asks, "Now what are the steps in solving this problem?" The students should respond with the various steps needed to solve a two-digit addition problem. If the students do not respond with each appropriate step, the trainer should remind them that they must think about each step. The trainer would say, "First we must add the ones column and carry to the tens column."

When the steps have been identified, the trainer will say, "Look at step 3. Are you paying attention and making no mistakes? You should remember to concentrate on doing the problem correctly?"

The trainer says, "What is step 4?" The class will respond "How do I get the answer?" The trainer then says, "What must we do to get the answer? We should add the tens columns. After we have answered the problem, we should think about step 5. We should check our work to make sure it is correct. If it is not correct, we should begin with step 1 again and go through the steps again until you get an answer. In our problem the answer is 71. If we get it right, we should tell ourselves that we did a good job."

The trainer then asks if everyone understands the 5-step technique for solving problems. The trainer should answer questions related to the 5-step approach to solving problems.

The trainer tells the class that next week they will have a different kind of problem to solve using this new technique. In closing, the trainer says, "Try to remember the steps in solving a problem." The trainer thanks the class for their attention and leaves the classroom.

<u>Week Two</u>

The trainer enters the classroom of regular algebra students and says: "Good morning, we are going to practice some more using a method that will help you solve math problems. Let's review what we learned before."

The trainer says, "What are the five questions to ask yourself when solving a math problem that we learned before?" As the students respond the trainer writes the steps on the board:

1. What kind of problem is it?
2. What are the steps in this type of problem?
3. Am I paying attention and doing it correctly?
4. How do I get the answer?
5. Did I get the right answer?

The trainer then says, "We are now going to solve a problem using the five steps I have written on the board." The trainer then says, "The problem we will work will probably seem easy but we are really interested in following the steps that I have on the board." The trainer then writes on the board:

$$\begin{array}{r} 56 \\ \underline{-37} \end{array}$$

The trainer asks someone in the class to respond to the first question and the trainer repeats the question, "What kind of a problem is it?" When someone correctly identifies the problem as subtraction, the trainer responds, "We now know that it is a subtraction problem; what is the next step?" After a student has identified the second step, the trainer asks "Now what are the steps in solving this problem?" The students should respond with the various steps needed to solve a two-digit subtraction problem. If the students do not respond with each appropriate step, the trainer should remind them that they must think about each step. The trainer might have to say "First we must borrow from the tens column. We then subtract in the ones column."

When all the steps have been identified, the trainer will say "Look at step 3. Are you paying attention and making no mistakes? You should concentrate on doing the problem correctly."

The trainer says "What is step 4?" The class will respond "How do I get the answer?" The trainer then says "What must I do to get the answer? We should subtract in the tens column. After we have answered the problem we should think about step 5. We should check our work to make sure it is correct. If it is not correct, we should begin with step 1 again and go through the steps again until you get an answer. In our problem the answer is 19. If we get it right, we should tell ourselves that we did a good job."

The trainer then asks if everyone understands the 5-step technique for solving problems. The trainer should answer questions related to the 5-step approach to solving problems.

The trainer tells the class that next week they will have a different kind of problem to solve using this new technique. In closing, the trainer says "Try to remember the steps in solving a problem." The trainer thanks the class for their attention and leaves the classroom.

Week Three

The trainer enters the classroom of the regular algebra students and says, "Good morning, we are going to practice some more using a method that will help you solve math problems better."

The trainer says, "What are the five questions to ask yourself when solving a math problem that we learned before?" As the student respond the trainer writes the steps on the board:

1. What kind of a problem is it?
2. What are the steps in this type of problem?
3. Am I paying attention and doing it correctly?
4. How do I get the answer?
5. Did I get the right answer?

The trainer then says, "We are now going to solve a problem using the five steps I have written on the board." The trainer then says, "The problem we will work will probably seem easy but we are really interested in following the steps I have on the board." The trainer then writes on the board:

$$\begin{array}{r} 49 \\ \underline{\times 23} \end{array}$$

The trainer asks someone in the class to respond to the first question and the trainer repeats the question, "What kind of problem is it?"

When someone correctly identifies the problem as multiplication, the trainer responds, "We now know that it is a multiplication problem; what is the next step?' After a student has identified the second step, the trainer asks, "Now what are the steps in solving this problem?" The students should respond with the various steps needed to solve a two-digit mulitplication problem. If the students do not respond with each appropriate step, the trainer should remind them that they must think about each step. The trainer should say "First we must multiply the ones column and carry to the tens place and then multiply the tens place by the ones place and add what we carried."

When all the steps have been identified, the trainer will say, "Look at step 3. Are you paying attention and making no mistake? You should concentrate on doing the problem correctly."

The trainer says, "What is step 4?" The class will respond, "How do I get the answer?" The trainer then says, "What must I do to get the answer? We should add the numbers after we have multiplied. After we have answered the problem, we should think about step 5. We should check our work to make sure it is correct. If it is not correct, we should begin with step 1 again and go through the steps again until you get an answer. In our problem the answer is 1127. If we get it right, we should tell ourselves that we did a good job."

The trainer then asks if everyone understands the 5-step technique for solving problems. The trainer should answer questions related to the 5-step approach to solving problems.

The trainer tells the class that next week they will have a different kind of problem to solve using this new technique. In closing, the trainer says, "Try to remember the steps in solving a problem." The trainer thanks the class for their attention and leaves the classroom.

Week Four

The trainer enters the classroom of the regular algebra students and says, "Good morning, we are going to practice some more using a method that will help you solve math problem better."

The trainer says, "What are the five questions to ask yourself when solving a math problem that we have learned?" As the students respond, the trainer writes the steps on the board:

1. What kind of a problem is it?
2. What are the steps in this type of problem?
3. Am I paying attention and doing it correctly?
4. How do I get the answer?
5. Did I get the right answer?

The trainer then says, "We are now going to solve a problem using the five steps I have written on the board." The trainer then says, "The problem we work today will probably seem easy but we are really interested in following the steps I have on the board." The trainer writes on the board:

$$25\sqrt{475}$$

The trainer asks someone in the class to respond to the first question and the trainer repeats the question, "What kind of a problem is it?" When someone correctly identifies the problem as division, the trainer responds, "We now know that it is a division problem; what is the next step?" After the students have identified the second step, the trainer asks, "Now what are the steps in solving this problem?" The students should respond with the various steps needed to solve this division problem. If the students do not respond with each appropriate step, the trainer should remind them that they must think about each step. The trainer should say, "First we must divide 25 into 47 and place the answer above 47. Then we multiply 1 times 25 and place that answer below the 47.

When all of the steps have been identified, the trainer will say, "Look at step 3. Are you paying attention and making no mistake? You should concentrate on doing the problem correctly."

The trainer says, "What is step 4?" The class will respond, "How do I get the answer?" The trainer then says, "What must I do to get the answer? We must continue following the correct steps to solve this problem until we get our answer. After we have an answer, we should think about question 5. We should check our work to make sure it is correct. If it is not correct, we should begin with step 1 and go through the steps again until you get an answer. In our problem the answer is 19. If we get it right, we should tell ourselves we did a good job."

The trainer asks if everyone understands the 5-step technique for solving problems. The trainer should answer questions related to the 5-step approach to solving problems.

The trainer tells the class that next week they will review the 5-step approach to solving math problems. In closing, the trainer says, "Try to remember the steps in solving a problem." The trainer thanks the class for their attention and leaves the classroom.

Week Five

The trainer enters the classroom of the regular algebra students and says, "Good morning, we are going to review what we have learned about solving math problems." The trainer asks for volunteers to give the five questions that should be asked to oneself when solving a math problem. The trainer says, "Can someone tell me what questions you should ask yourself when solving a math problem?" As the students respond, the trainer writes the questions on the board:

1. What kind of a problem is it?
2. What are the steps in this type of problem?
3. Am I paying attention and doing it correctly?
4. How do I get the answer?
5. Did I get the right answer?

After all of the questions have been identified, the trainer says, "Remember when solving a math problem, you will probably get more problems correct if you ask yourself these questions while you are doing a problem. Also remember to tell yourself that you did a good job if you get the problem right. Thank you for your cooperation and I hope this will help you get more math problems right."

The trainer leaves the classroom and thanks the students' teacher for his/her cooperation.

Treatment for Gifted Algebra Group

Week One

The trainer enters the classroom of the gifted algebra students and says, "Good morning, we are going to practice using a method that will help you solve math problem better. I am going to write five steps on the board that should help you solve math problems without making so many mistakes."

The trainer writes the following on the board:

1. What kind of a problem is it?
2. What are the steps in this type of a problem?
3. Am I paying attention and doing it correctly?
4. How do I get the answer?
5. Did I get the right answer?

The trainer then says, "We are now going to solve a problem using the five steps I have written on the board." The trainer then says, "The problem we will work will probably seem easy, but we are really interested in following the steps that I have on the board." The trainer then writes on the board:

$$\begin{array}{rl} \text{if} & a + b = c \\ \text{and} & a = 5,\ c = 8 \\ \text{find} & b. \end{array}$$

The trainer asks someone in the class to respond to the first question, and the trainer repeats the question: "What kind of a problem is it." When someone correctly identifies the problem as an algebraic equation, the trainer responds, "Yes, it is an algebraic equation, but we must also look at the addition sign. Now what is the next step?" After a student has identified the second step, the trainer asks, "Now what are the steps in solving this problem?" The students should respond with the various steps needed to solve a simple algebraic equation with addition. If the students do not give the steps correctly, the trainer should remind them of the correct steps involved in solving this problem.

When the steps have been correctly identified, the trainer will say: "Look at step 3 on the board. Are you paying attention and making no mistakes? You should concentrate on doing the problem correctly."

The trainer says, "What is step 4?" The class will respond, "How do I get the answer?" The trainer then says, "What must we do to get the answer? We should make sure we complete the last step in solving this problem. After we have answered the problem we should think about step 5. We should check our work to make sure it is correct. If it is not correct, we should begin with step 1 again and go through the steps again until we get an answer. In our problem the answer is b = 3. If we get it right, we should tell ourselves that we did a good job."

The trainer then asks if everyone understands the 5-step technique for solving problems. The trainer should answer questions related to the 5-step approach to solving problems.

The trainer tells the class that next week they will have a different kind of problem to solve using this new technique. In closing, the trainer says, "Try to remember the steps in solving a problem." The trainer thanks the class for their attention and leaves the classroom.

Week Two

The trainer enters the classroom of the gifted algebra students and says, "Good morning, we are going to continue practicing using a method that will help you solve math problems. Let's review what we learned before."

The trainer says, "What are the five questions to ask yourself when solving a math problem?" As the students respond, the trainer writes the steps on the board:

1. What kind of a problem is it?
2. What are the steps in this type of problem?
3. Am I paying attention and doing it correctly?
4. How do I get the answer?
5. Did I get the right answer?

The trainer then says, "We are now going to solve a problem using the five steps I have written on the board." The trainer then says, "The problem we will work will probably seem easy but we are really interested in following the steps I have on the board." The trainer then writes on the board:

if $a - b = c$
and $a = 8$, $c = 5$
find b.

The trainer asks someone in the class to respond to the first question, and the trainer repeats the question, "What kind of a problem is it?" When someone correctly identifies the problem as an algegraic equation, the trainer responds, "Yes, it is an algebraic equation, but one must also look at the subtraction sign. Now what is the next step?" After a student has indicated the second step, the trainer asks, "Now what are the steps in solving this problem?" The students should respond with the various steps needed to solve a simple algebraic equation with subtraction. If the students do not give the steps correctly, the trainer should remind them of the correct steps involved in solving this problem.

When the steps have been correctly identified, the trainer will say, "Look at step 3 on the board. Are you paying attention and making no mistakes? You should concentrate on doing the problem correctly."

The trainer says, "What is step 4?" The class will respond, "How do I get the answer?" The trainer then says, "What must we do to get the answer? We should make sure we complete the last step in solving this problem. After we have answered the problem, we should think about step 5. We should check our work to make sure it is correct. If it is not correct, we should begin with step 1 again and go through the steps again until we get an answer. In our problem, the answer is $b = 3$. If we get it right, we should tell ourselves that we did a good job."

The trainer then asks if everyone understands the 5-step technique for solving problems. The trainer should answer questions related to the 5-step approach to solving problems.

The trainer tells the class that next week they will have a different kind of problem to solve using this new technique. In closing, the trainer says, "Try to remember the steps in solving a problem." The trainer thanks the class for their attention and leaves the classroom.

Week Three

The trainer enters the classroom of the gifted algebra students and says, "Good morning, we are going to continue practicing using a method that will help you solve math problems. Let's review what we learned before." The trainer says, "What are the five questions to ask yourself when solving a math problem?" As the students respond, the trainer writes the steps on the board:

1. What kind of a problem is it?
2. What are the steps in this type of problem?
3. Am I paying attention and doing it correctly?
4. How do I get the answer?
5. Did I get the right answer?

The trainer then says, "We are now going to solve a problem using the five steps I have written on the board." The trainer then says, "The problem we will work will probably seem easy, but we are really interested in following the steps I have written on the board." The trainer then writes on the board:

$$\begin{array}{rl} \text{if} & a \times b = c \\ \text{and} & a = 5,\ c = 40 \\ \text{find} & b. \end{array}$$

The trainer asks someone in the class to respond to the first question and the trainer repeats the question. "What kind of a problem is it?" When someone correctly identifies the problem as an algebraic equation, the trainer responds, "Yes, it is an algebraic equation, but we must also look at the multiplication sign. Now what is the next step?" After a student has identified the second step, the trainer asks, "Now what are the steps in solving this problem?" The students should respond with the various steps needed to solve a simple algebraic equation with multiplication. If the students do not give the steps correctly, the trainer should remind them of the steps involved in solving this problem.

When the steps have been correctly identified, the trainer will say: "Look at step 3 on the board. Are you paying attention and making no mistakes? You should concentrate on doing the problem correctly."

The trainer says, "What is step 4?" The class will respond, "How do I get the answer?" The trainer then says, "What must we do to get the answer? We should make sure we complete the last step in solving this problem. After we have answered the problem, we should think about step 5. We should check our work to make sure it is correct. If it is not correct, we should begin with step 1 again and go through the steps again until you get an answer. In our problem the answer is b = 8. If we get it right, we should tell ourselves that we did a good job."

The trainer then asks if everyone understands the 5-step technique for solving problems. The trainer should answer questions related to the 5-step approach to solving problems.

The trainer tells the class that next week they will have a different kind of problem to solve using this new technique. In closing, the trainer says "Try to remember the steps in solving a problem." The trainer thanks the class for their attention and leaves the classroom.

Week Four

The trainer enters the classroom of the gifted algebra students and says: "Good morning, we are going to continue practicing using a method that will help you solve math problems. Let's review what we learned before." The trainer says, "What are the five questions to ask yourself when solving a math problem?" As the students respond, the trainer writes the steps on the board:

1. What kind of a problem is it?
2. What are the steps in this type of problem?
3. Am I paying attention and doing it correctly?
4. How do I get the answer?
5. Did I get the right answer?

The trainer then says, "We are now going to solve a problem using the five steps I have written on the board." The trainer then says, "The problem we will work will probably seem easy, but we are really interested in following the steps I have on the board." The trainer then writes on the board:

$$\begin{aligned} \text{if} \quad & a \div b = c \\ \text{and} \quad & a = 8,\ c = 2 \\ \text{find} \quad & b. \end{aligned}$$

The trainer asks someone in the class to respond to the first question, and the trainer repeats the question, "What kind of a problem is it?" When someone correctly identifies the problem as an algebraic equation, the trainer responds, "Yes, it is an algebraic equation but we must also look at the division sign. Now what is the next step?" After a student has identified the second step, the trainer asks, "Now what are the steps in solving this problem?" The students should respond with the various steps needed to solve a simple algebraic equation with division. If the students do not give the steps correctly, the trainer should remind them of the steps involved in solving this problem.

When the steps have been correctly identified, the trainer will say, "Look at step 3 on the board. Are you paying attention and making no mistakes? You should concentrate on doing the problem correctly."

The trainer says, "What is step 4?" The class will respond "How do I get the answer?" The trainer then says, "What must we do to get the answer? We should make sure we complete the last step in solving this problem. After we have answered this problem, we should think about step 5. We should check our work to make sure it is correct. If it is not correct, we should begin with step 1 and go through the steps until we get an answer. In our problem the answer is 4. If we get it right, we should tell ourselves that we did a good job."

The trainer then asks uf everyone understands the 5-step technique for solving problems. The trainer should answer questions related to the 5-step approach to solving problems.

The trainer tells the students that next week they will review the 5-step approach to solving math problems. In closing, the trainer says, "Try to remember the steps in solving a problem." The trainer thanks the class for their attention and leaves the classroom.

Week Five

The trainer enters tbe classroom of the gifted algebra students and says, "Good morning, we are going to review what we have learned about solving math problems." The trainer asks for volunteers to give the five questions that should be asked to oneself when solving a math problem. The trainer says, "Can someone tell me what questions you should ask yourself when solving a math problem?" As the students respond, the trainer writes the questions on the board:

1. What kind of a problem is it?
2. What are the steps in this type of problem?
3. Am I paying attention and doing it correctly?
4. How do I get the answer?
5. Did I get the right answer?

After all the questions have been identified, the trainer says, "Remember when solving a math problem, you will probably get more problems correct if you ask yourself these questions while you are doing a problem. Also remember to tell yourself that you did a good job if you get the problem right. Thank you for your cooperation and I hope this will help you get more math problems right."

The trainer leaves the classroom and thanks the students' teacher for his/her cooperation.

VITA

James Alan Cunningham

Candidate for the Degree of

Doctor of Philosophy

Thesis: A COMPARISON OF MATH ACHIEVEMENT BETWEEN MATHEMATICALLY-ABLE AND REGULAR MATH STUDENTS FOLLOWING SELF-INSTRUCTION TRAINING

Major Field: Applied Behavioral Studies

Biographical:

Personal Data: Born in Memphis, Tennessee, December 3, 1946, the son of Donna Willingham and John Cunningham.

Education: Graduated from Lawton Senior High School, Lawton, Oklahoma, in May, 1965; received the Bachelor of Science degree in Social Studies Education from Oklahoma State University, Stillwater, Oklahoma, in 1969; received the Master of Education degree from Southwestern Oklahoma State University, Weatherford, Oklahoma, in Psychometry in 1977; completed requirements for the Doctor of Philosophy degree at Oklahoma State University in December, 1983.

Professional Experience: Public school teacher, 1969-70 and 1972-76 in Lawton, Oklahoma; U.S. Army, 1970-72; School Psychometrist, Wichita Mountains Regional Educational Service Center, Lawton, Oklahoma, 1978; School Psychologist Intern, Lawton, Oklahoma Public Schools, 1979-80; graduate teaching assistant, Oklahoma State University, 1980-81; instructor, Oklahoma State University, 1981-83;

Professional Associations: Member, National Association of School Psychologists, 1981-83; member, Oklahoma School Psychological Association, 1981-83.