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To the Graduate Council:

I am submitting herewith a dissertation written by Charleen Mitchell DeRidder entitled "A Study of Selected Factors to Identify Sixth Grade Students Gifted in Mathematics." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

Donald J. Dessart, Major Professor

We have read this dissertation and recommend its acceptance:

A. Paul Wishart, Arnold R. Davis, J.J. Bellon

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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and recommend its acceptance:

A Paul Wishart

Arnold R. Davis

Jerry J. Bellon

Accepted for the Council:

C W Minkel

Vice Provost
and Dean of The Graduate School

A STUDY OF SELECTED FACTORS TO IDENTIFY SIXTH GRADE STUDENTS GIFTED IN MATHEMATICS

A Dissertation

Presented for the

Doctor of Philosophy Degree

The University of Tennessee, Knoxville

Charleen Mitchell DeRidder

August 1986

Dedicated

to

Jason

ACKNOWLEDGMENTS

It is with very deep appreciation that I acknowledge Dr. Donald J. Dessart, my major advisor and mentor, for his guidance and counsel throughout the course of this study. I wish also to acknowledge the members of my Doctoral Committee, Drs. J. J. Bellon, A. R. Davis, the late W. C. Murphy, and A. P. Wishart for their sustaining support and encouragement.

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I would also like to acknowledge the support of my husband, Larry, and my son, Jason, who is the same age as the subjects of this study and who, because of restricted physical activity due to health reasons, has been a close companion to me during this work.

ABSTRACT

The identification of children who are gifted is common in schools of the United States. High I.Q. and achievement scores are traditionally used. This study explored the adequacy of these variables in mathematics education. Based on the Renzulli model for giftedness, the study assessed problem solving ability, creative mathematics ability, and task commitment. Only students identified as having above average general ability were selected as subjects. Eighty-seven sixth graders were selected from three Knox County, Tennessee, middle schools to form six groups. These groups were stratified as high (128 or above), mid upper (116-127), and average (95-115) I.Q. scores coupled with either a mathematics achievement score of at least the 96th percentile or one of the 50th through the 95th percentile. No subject was state certified gifted at the time of testing. Since I.Q. and achievement scores are used in Tennessee to certify gifted students, the study addressed the question of whether the performance of students in Group I (highest I.Q. and achievement range and eligible for gifted certification) was significantly different from that of other groups. No significant differences in student performance, $p < .05$, were found between Group I and other groups having high achievement scores (III and V) except for task commitment in Group V. These three groups represented an I.Q. range from average to the highest possible scores. Group I differed significantly

only from Group VI (average I.Q./average-mid upper achievement) in all measures. The conclusions of the study were:

1. A particular I.Q. range is inadequate as a criterion for identifying gifted students in mathematics.

2. A particular mathematics achievement range could serve as a factor in identification.

3. Students who are certified gifted by I.Q. and achievement scores in some other subject area are not necessarily gifted in mathematics.

4. Because some students who appear gifted in mathematics are being overlooked by traditional measures, tests similar to those of this study should be used in addition to other measures for the identification of students gifted in mathematics.

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CHAPTER I

INTRODUCTION

Stimulus for This Study

In light of the current public concern for the improvement of education of the young, as exhibited by the plethora of national reports of the 1980s in this country, educators are being called upon to reexamine and reevaluate their curricular programs and their effects on the students being served. Implicit in most reports and explicit in some is the expression of need that gifted and talented students receive more adequate attention for their educational needs. Goodlad (1984) cited the need to make "judicious provisions for individual differences." Boyer (1983) stated that "Gifted and talented students represent a unique challenge if they are to realize their potential." However, the accurate identification of students who are gifted appears to be more complex than one might expect. Also, if a student is considered "gifted" according to the widely used criteria of intelligence and achievement tests, does this imply giftedness in all subject areas? Then, too, is it possible that a student might be gifted in a particular subject, such as mathematics, yet not meet the requirements of the traditional criteria for giftedness?

In the process of reviewing studies about children who are considered gifted, creative, or insightful problem solvers in the subject of mathematics, there are two works that can be considered particularly

germane to this present investigation. Blaeuer in 1973 cited (1) Getzels and Jackson (1962), who stated that the relationship between creativity and intelligence is at best tenuous and (2) Torrance (1964), who stated that work with college subjects (as with lower age groups), has shown very low correlations between measures of creativity and intelligence or scholastic aptitude. In fact, Torrance (1962) is quoted as stating that 70% of the more creative students are overlooked because of the emphasis on I.Q. (intelligence quotient) as a basis for rewarding students in the schools. Dodson, however, in 1970 determined that the mathematics achievement variables were the strongest discriminators among ability groups and that the cognitive variables, such as I.Q., were second strongest in characterizing insightful problem solvers.

In view of a study of the literature concerning giftedness in mathematics, both creativity and problem solving ability appear to be integral characteristics of gifted behavior. The studies of Blaeuer and Dodson reveal a conflict concerning the extent to which I.Q. and achievement variables are valid characteristics of persons capable of creativity and problem solving in mathematics. Such a conflict has implications for determining criteria which would be appropriate for identifying students who are gifted in mathematics.

Statement of the Problem

As has been stated, the literature revealed that some measure of I.Q. and often some type of achievement test have been criteria frequently used for the identification of gifted children. In July 1982

the State of Tennessee established the following criteria for identifying and certifying the intellectually gifted child (Rules, Regulations, and Minimum Standards for the Governance of Public Schools in the State of Tennessee, 1982.

(ix) Intellectually Gifted
- (I) Definition--A child whose intellectual abilities and potential for achievement are so outstanding that special provisions are required to meet the established needs is considered intellectually gifted.
- (II) Criteria for Certification--A child must meet two of the following:
  - I. Intellectual functioning and ability which measures at least two standard deviations above the mean, and[1]
  - II. Superior academic or achievement ability which measures the 96th percentile or above in one or more major academic areas, or
  - III. Superior intellectual ability demonstrated by the child's ideas and projects related to one or more academic fields. (p. 92)

Using these criteria, a school psychologist, a licensed psychologist, or a licensed psychological examiner is eligible to "certify" that a child is intellectually gifted. A specific question could be posed here: If a student meets the above criteria with an achievement score in the 96th percentile or above in mathematics, does this imply that the student is truly gifted in mathematics? There is a great deal in the literature concerning the definition of "giftedness." Among the most recent and foremost scholars discussing this subject are H. Laurence Ridge and Joseph S. Renzulli. According to Ridge and Renzulli (1981)

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[1]The word "and" was changed to the word "or" by the Tennessee State Board of Education on April 25, 1986. This change is pending final approval by the State Attorney General at the time of this writing.

mathematical giftedness is well accommodated by the Renzulli three-ring model for giftedness. This model, in the form of a Venn diagram, illustrates that those students with above average ability who exhibit creativity and who are capable of a high degree of task commitment can be identified as gifted.

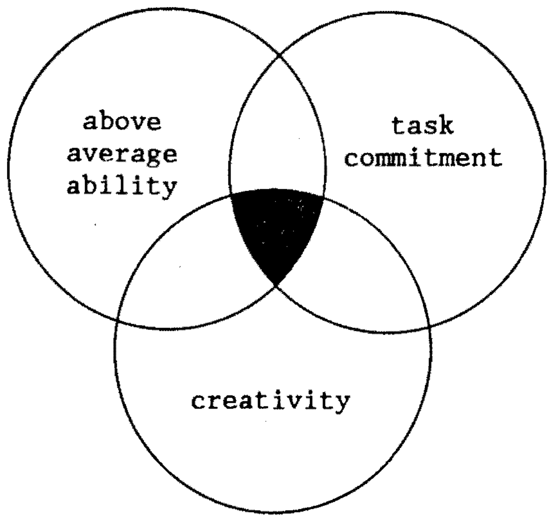

Figure 1. The Renzulli Three Ring Model for Giftedness.

The problem posed is this: Is the identification of students truly gifted in mathematics being realized, given the current criteria and screening procedures prevalent in the existing school programs of today? To elaborate upon the statement of this problem, are high I.Q. and achievement test scores adequate indicators of giftedness in mathematics? Are students who might meet the Renzulli criteria not being identified as gifted because their I.Q. and achievement test scores are not sufficiently high? According to Weaver and Brawley (1959), "If perchance we err in our judgment of any child, it would be much less

damaging to him if we had judged him to be talented when he is not than if we had not judged him to be talented when he is."

The purpose of this investigation is to determine among six groups of sixth grade students, stratified according to I.Q. and mathematics achievement test scores, if there are differences in student performance with respect to (1) the Iowa Problem Solving Project Test (IPSP) and the Creative Ability Mathematics Test (CAMT), (2) the characteristics of task commitment assessed by a team of interviewers and the teachers of the subjects, and (3) the correlation coefficients of each combination of the measures and of each of the measures with the variables of I.Q. and mathematics achievement.

A second purpose as a result of this analysis is to determine if there are students among six categories stratified according to I.Q. and standardized mathematics achievement scores who should be certified as gifted, but who are not able to be because of the State criteria.

Procedures and Sources of Data

Through the use of available school records, students were identified for this study from the sixth grades of three middle schools in the Knox County School System of 26,000 students. These schools are in the same section of the county and have similar demographic characteristics. The population is described as suburban. Six proportional stratified random samples were selected from the three schools according to the following criteria. Achievement test scores are in percentile form.

1. Above average general ability exhibited by a score of 70 or above on the total battery of the California Achievement Test (CAT) administered at grade level 5.8 (required of all members of each of the six groups).
2. An I.Q. score which ranges from 95-115, 116-127, or 128 and above on the Otis Lennon I.Q. Test (OL) which was group administered at grade level 5.8.
3. A total mathematics score with the range of 55 to 95 or 96 and above on the CAT administered at grade level 5.8.

Any student who was already formally certified gifted was not included in this study. Since there were 13 such students and since none of them scored as high as the highest I.Q. score of the selected subjects, they were excluded because of the possible affective variable of their self-perception with respect to being labeled "gifted."

The selected students at grade level 6.8 were given the Iowa Problem Solving Project Test (IPSP) developed for 5th and 6th graders by Schoen and Oehmke (Oehmke, 1979) and the Creative Ability Mathematics Test (CAMT) developed for 6th, 7th, and 8th grade students by Balka (1974). Five experienced teachers, including the investigator of this study, were especially prepared to administer the tests and conduct the student interviews. The interview questions were meant to assess the student's task commitment, rationale for the cognitive responses, and affective reactions with respect to each of the six CAMT test items.

The teachers of these students were asked to respond to a brief questionnaire using a Likert-type scale to procure their perception of the degree of task commitment typically exhibited by each student.

Significance of the Study

The identification of students truly gifted in the subject of mathematics is much more difficult than typically acknowledged. As Greenes (1981) has stated:

> Although many gifted students are good computers, there are a great number of other students who are simply "good exercise doers." These other students "go to school well." They are attentive, willing to help, complete all assignments carefully in the prescribed amount of time, are a "pleasure to have in class," and are frequently incorrectly identified as gifted students in mathematics. . . . we must be sure we have distinguished the gifted student from the good student. (p. 14)

This study attempted to determine if there might be students who indicate high creative and problem solving ability in mathematics, as measured by the instruments cited above, but who would not be identified as gifted according to the criteria now being used in the public schools in this state. Should this be the case, it would suggest that possibly other or additional criteria be used for identifying students gifted in mathematics.

Basic Assumptions

In this study the following assumptions were made:

1. Giftedness in mathematics is characterized by creative ability and insightful problem solving ability when dealing with mathematical content.
2. The two test instruments used were valid measures of (a) problem solving ability and (b) creative ability in mathematics.

3. The test items were readable and the test procedures were understood by all students.
4. The testing procedures and conditions were uniform for all students in each of the three schools.
5. The interview sessions were valid to determine student task commitment with respect to the CAMT test.
6. The classroom teachers provided valid ratings of student task commitment capabilities using the instrument designed for this purpose.
7. The groups of students tested had comparable cultural components since they came from continuous areas in one demographic section of the county.

Scope and Limitations

This study was conducted in three middle schools of the Knox County Public School System. The number of students in each of the six stratified groups ranged from 12 to 16 with a total of 87 subjects.

The study was limited to the extent that the number of students in each group was not particularly large and that the findings reveal information concerning only one grade level of students, the sixth.

Definitions

Giftedness in mathematics. This is an operational definition based primarily on that developed by Renzulli (Ridge & Renzulli, 1981) as part of his theoretical model of giftedness. Giftedness in mathematics

consists of an interaction among (1) above-average general abilities, (2) high levels of task commitment, (3) high levels of creativity, and (4) the ability to solve problems.

Above-average general ability. This is an operational definition and is the ability of persons with at least an I.Q. of 95 to achieve the 70th percentile or above as an overall average score on a standardized achievement test.

Task commitment. This is an operational definition. It is the ability to persist in the accomplishment of certain ends and, in its highest form, to become totally involved in a specific problem or area for an extended period of time.

Creativity in mathematics. This is an operational definition based on criteria of mathematical creativity established by Balka (1974). It is the ability to respond to a mathematically problematic situation with fluency, flexibility, and originality of thought.

Problem solving ability. A problem, in its true sense, is one for which no algorithm is immediately available to the one trying to solve it. The ability to solve such problems successfully is, again, an operational definition of problem solving ability.

Organization of the Study

Chapter I is an introduction to the study of the identification of persons gifted in mathematics. It contains the presentation of the problem, the procedures and sources of data, the significance of the

study, basic assumptions, scope and limitations of the study, definitions, and the organization of the study.

Chapter II is a review of the professional literature related to the characteristics and identification of giftedness with an especial focus on giftedness in mathematics.

Chapter III is a presentation of the design and procedures employed in carrying out the study.

Chapter IV is a presentation and interpretation of the data and findings of the study.

Chapter V is a summary of the procedure, discussion of the results, possible implications of the study, and recommendations for possible further research.

CHAPTER II

REVIEW OF RELATED LITERATURE

If one can consider an individual gifted in mathematical ability as a kind of genius, then the definition of genius quoted by Gallagher (1963, p. 3) might be of interest here--"a person who does easily what no one else can do at all"! Would that the identification of students gifted in mathematics be so simplistic!

Historical Perspective of the Literature

While it may be true that one can find numerous evidences of concern for the identification and education of superior children in the writings of scholars at least as early as the Golden Age of Greece (Glennon, 1956), there has been little research to provide rationale or direction for educational practice. In 1974, Stanley, Keating, and Fox (cited in Moore, Hahn, & Bretnall, 1978) indicated that,

> The instruction of the gifted is a focal point in current educational practice. Unfortunately, there is a paucity of research evidence in many areas of concern to educators of the Gifted. (p. 618)

Moore et al. additionally cited Gowan and Demos who indicated that,

> Those working in this area must frequently rely upon personal experience in instructing the gifted and, in many cases, must depend on little more than intuition and preconceived notions about the characteristics of gifted populations. (p. 618)

According to Weaver and Brawley (1959), relatively little appeared in print prior to 1953-54 regarding effective provisions for the more

capable child in relation, specifically, to the elementary school mathematics program. However, following the incidence of Sputnik, Russia's launch into space, the literature revealed a surge of interest in giftedness for the next few years. Tannenbaum (1981) has given a succinct, albeit editorialized, account of such interest and disinterest on the part of the public, including educators, and offered a rationale for the cyclical nature of attention given to this area as evidenced in the literature. He considered the five years following Sputnik in 1957 and the last five years of the 1970s as "twin peak periods of interest in gifted and talented children" (p. 20). In the late 50s and early 60s, not only were many innovative programs being tried, but also there was an upsurge in research concerning characteristics and education of the gifted. French (cited in Tannenbaum) observed that there were more articles published between 1956 and 1959 than in the previous thirty years. During the 1960s, the John F. Kennedy years, the issue of desegregation in the schools, complete with the increasing demand for social justice, became the priority in education. Special programs for the gifted were viewed as elitist by many and thus became unpopular. There were only thirty-nine research reports from 1969 to 1974 according to Spaulding (cited in Tannenbaum). However, congressional legislation in 1970 to provide better for the gifted indicated federal interest and monetary support for programs for the gifted. Currently there is a renewed interest in providing for the gifted reflected by the number of current articles and reports available. The cause for such a fluctuating pursuit of further

knowledge and development in this field in this country Tannenbaum attributed to the American dilemma of excellence versus egalitarianism.

While literature concerning the specific topic of giftedness in mathematics rather parallels that of giftedness in general with respect to its quantity during various periods of time, it is relatively sparse and reflects the lack of well-defined criteria by which such students with this capability can be identified.

Concern for Adequate Criteria for the Identification of the Gifted

It would appear that the primary criteria traditionally used for the identification of gifted students have been high scores on I.Q. and achievement tests (Greenes, 1981). Gallagher (1975) submitted that in the early 1900s teacher nomination was the primary means of identifying the gifted. Cutts and Moseley and also Pegnato and Birch (cited in Renzulli, Hartman, & Callahan, 1981) considered I.Q. and achievement tests as the major criteria used, but they also considered that the use of teacher judgment was becoming more prevalent. In any case, Gallagher was very critical of the effectiveness of teacher judgment and suggested a very cautious approach supplementing such a criteria with more objective measures (cited in Renzulli et al.). Also, Benbow and Stanley (1983) found teacher recommendation to be ineffective. After 1950, however, the work of Torrance in creativity and that of Guilford in divergent thinking have caused a modification of the definition of giftedness

among the professional community (Greenes, 1981). In fact, Gallagher (1966) stated:

> It is likely that Guilford, as much as any other single person, is responsible for the rebirth of interest in cognitive processes . . . during the past decade. (p. 2)

Greenes stated that potential and creativity have been added to achievement for a more adequate definition of giftedness, although I.Q. has historically served as an indicator of potential. Renzulli (1981) augmented the definition further by introducing the component of task commitment as an integral part of giftedness. The question is, then, what are the implications for developing adequate identification criteria in light of this modified definition of giftedness which includes the components of creativity and task commitment as well as intelligence (I.Q.) and achievement? While the study of Grossman and Johnson (1983) showed that the Otis Lennon and the Slosson I.Q. Tests were definitely valid as predictors of achievement of gifted students, it expressed the reservation, "if one is defining giftedness in terms of school-related ability and achievement" (p. 618). Weaver and Brawley (1959), because of the results of their study which showed low correlation between achievement in arithmetic reasoning and achievement in arithmetic computation and between each of these aspects of arithmetic achievement with general intelligence, stated, "we realize the impossibility of making a highly reliable identification of the mathematically superior or talented child on these bases alone" (p. 6). Torrance (1965) stated that

> As with preschool, elementary school, and high school subjects, studies involving college and adult subjects have shown uniformly rather low relationships between measures of

> creative ability and measures of intelligence and scholastic aptitude. (p. 32)

Adding to this concern, it would seem that if one wishes to assess the creative ability of a student, testing instruments designed to elicit only one correct response for each item are quite inadequate in the determination of divergent thinking capability which is characterized by fluency, flexibility, and originality of response (Goldberg, 1965). In fact, Torrance (1962) considered intelligence tests deficient with the most obvious weakness being that the emphasis is on convergent, conforming thinking and cited Guilford, Thurstone, and Getzels and Jackson to substantiate his position. Taylor (1959) stated that intelligence tests

> essentially concern themselves with how fast relatively unimportant problems can be solved without making errors. In another culture, intelligence might be measured more in terms of how adequately important problems can be solved, making all the errors necessary and without regard for time. (p. 54)

Task commitment, which is the ability to involve oneself totally in a specific problem or area for an extended period of time, also is hardly a component of giftedness which lends itself to assessment by mere test items requiring convergent responses.

In consideration of the giftedness components of intelligence, achievement, creativity and task commitment with respect to the particular subject of mathematics, another complication arises, that of the use of standardized achievement tests. Such tests are typically objective and have a multiple-choice type of format. Torrance (1962) took particular note of the "devastating attacks" found in the literature on

multiple-choice tests. He cited Hoffman (1961) who identified the following defects of such tests:

> 1. They deny the creative person a significant opportunity to demonstrate his creativity.
> 2. They penalize those who perceive subtle points unnoticed by less able people, including the test-makers.
> 3. They are apt to be superficial and intellectually dishonest, with questions made artificially difficult by means of ambiguity, because <u>genuinely searching questions do not readily fit into the multiple-choice format</u> [emphasis added].
> 4. They too often degenerate into subjective guessing games in which the examinee does not pick what he considers the best answer out of a bad lot but rather the one he believes the unknown examiner would consider best.
> 5. They neglect skill in disciplined expression. (p. 21)

Krutetskii (1976) also is especially critical of research based on product rather than process tests in evaluating mathematical abilities. He stated,

> A basic defect in test research is the bare statistical approach to the study and evaluation of abilities--the fetishistic mathematical treatment of test results, with a complete absence of interest in studying the solution process itself. (p. 13)

It would appear, then, that the time-honored criteria of intelligence tests, achievement tests, and teacher recommendation are insufficient and may even hamper the identification of gifted students.

The Uniqueness of Mathematical Giftedness

Another matter to consider is the question whether there is something unique about giftedness in mathematics, or can anyone with exceptionally high general ability fit that category? The work of Fox (cited in Ridge & Renzulli, 1981) indicated that although a high I.Q. does

indicate a high learning potential, it provides little information about specific subject achievement. On the other hand, Aiken (1973) stated the finding that children who excel in mathematics tend to score high on tests of general intelligence. The observation can be made that above-average general ability is necessary but not sufficient for mathematical giftedness. Further elaboration on this topic can be found in Krutetskii (1976).

> How can we argue for our view that the ability to generalize mathematical material is a specific ability? First, we note that this ability is manifested in a specific sphere and cannot be correlated with the manifestation of corresponding ability in other provinces. Biographical data on many prominent talents--mathematicians and nonmathematicians--and the views of specialists, especially the research mathematicians we questioned, testify to this. The academician M. A. Lavrent'ev emphasized: "Time and again in my life I have had occasion to meet persons who were very able in one province and ungifted in another. Perhaps such a contrast shows up most strikingly in those with pronounced abilities in science, which is very close to me--in mathematics." . . . The mathematicians Poincare and Mordukhai-Boltovskii have asserted that the specific nature of mathematical ability makes mathematics not accessible to everyone. . . . In other words, a person who is generally talented might be ungifted in mathematics. D. I. Mendeleev was noted in school for great success in mathematics and physics and got zeros and ones in linguistic subjects. . . . A. S. Pushkin, judging from the biographical data, when attending the Imperial Lyceum shed many tears over mathematics and put forth great effort, but showed "no perceptible success." (pp. 353-354)

A psychological study done by McCallum, Smith, MacFarlane, and Eliot (1979) to extend the work of Baraket and Wrigley, who found evidence of a nonverbal factor closely associated with attainment in mathematics, resulted in reinforcing that finding.

> In sum, the finding that the single most important component of mathematical ability is a g/k factor which remains relatively stable in high school years and which shows little relationship to language comprehension is in accord with the findings of Barakat (1951) and Wrigley (1958). The finding of the association of spatial ability with understanding in mathematics is in agreement with the work of Hills (1957), Werdelin (1958), and Bishop (1973). The data of this research should be of interest to those concerned with the nature of intelligence generally, and to those interested in the controversy over the possible unitary group factor of mathematics abilities in particular. (p. 1132)

The Brunel studies, referred to by Rees (1981), described two types of dimension of difficulty characteristics. One relates to general intellectual ability (the g factor) as measured by intelligence tests. A "g" type mathematics task is a problem that can be solved if some previous set of algorithms or operations has been learned. The second type of dimension of difficulty relates to a specific ability to make valid inferences with respect to a mathematical context. An inference type task which requires this kind of ability means that the student must be able to conceptualize the problem so that relevant operations can first be identified and then applied in appropriate sequence for the solution. This is referred to as an "inferential" mode of thinking.

> We may summarize by saying that the second type relates to an ability to map out a strategy whilst the first relates simply to the ability to apply mathematical processes. (p. 21)

While the above observations strongly suggest a specificity of mathematical ability, this does not preclude the fact that there are persons endowed with both a combination of mathematical and literary giftedness (Krutetskii, 1976).

Characteristics of the Mathematically Gifted

As has been stated earlier, Greenes (1981) cautioned educators to differentiate between "good exercise doers" and those students truly gifted in mathematics. Krutetskii (1976), in his research of the literature, acknowledged that no fixed definition of mathematical ability would satisfy everyone, but indicated that most investigators would agree that there is a difference between "'school' ability for mastering mathematical information" and that of "creative mathematical ability, related to the independent creation of an original product" (p. 21). As a result of over twelve years of work in studying the mathematical abilities of school children, Krutetskii described a mathematical cast of mind which characterizes the mathematically able child.

> It is expressed in a striving to make the phenomena of the environment mathematical, . . . to notice spatial and quantitative relationships, bonds, and functional dependencies everywhere--in short, to see the world "through mathematical eyes." (p. 302)

Krutetskii also identified two types of mathematical minds, the analytic and the geometric. Aiken (1973) contributes further to the idea of a particular type of mind.

> In contrast, or perhaps supplementary, to Krutetskii's notion of a "mathematical frame of mind" is the idea that there are several different types of mathematical minds. In a survey of the educational philosophies of fourteen eminent mathematicians, Carlton (1959) found that the writings of many of these famous men refer to more than one kind of mathematical mind. One type of mind is said to be logical and formal, whereas another is more intuitive; one type is fast, and another is slow. The distinction between these types of mathematical minds was dealt with most extensively by Poincare (1952), who maintained that geometers are more intuitive and analysts more logical in their thinking. (p. 2)

Given that students gifted in mathematics may indeed possess some unique "cast of mind," what are some of the particular characteristics of such students that can be observed and possibly used as a basis for criteria for identification? Although Weaver and Brawley (1959) stated that I.Q. and arithmetic achievement are not sufficient criteria, but that these can be helpful when combined with some or more of the following attributes:

> 1. Sensitivity to, awareness of, and curiosity regarding quantity and the quantitative aspects of things within the environment.
> 2. Quickness in perceiving, comprehending, understanding and dealing effectively with quantity and the quantitative aspects of things within the environment.
> 3. Ability to think and work abstractly and symbolically when dealing with quantity and quantitative ideas.
> 4. Ability to communicate quantitative ideas effectively to others, both orally and in writing, and readily to receive and assimilate quantitative ideas in the same ways.
> 5. Ability to perceive mathematical patterns, structures, relationships, and interrelationships.
> 6. Ability to think and perform in quantitative situations in a flexible rather than a stereotyped manner; with insight, imagination, creativity, originality, self-direction, independence, eagerness, concentration, and persistence.
> 7. Ability to think and reason analytically and deductively; ability to think and reason inductively and to generalize.
> 8. Ability to transfer learning to new or novel "untaught" quantitative situations.
> 9. Ability to apply mathematical learning to social situations, to other curricular areas, and the like.
> 10. Ability to remember and retain that which has been learned. (pp. 6-7)

One cannot help but realize the components of creativity and task commitment inherent in attribute 6 of Weaver and Brawley.

Of additional interest is the comparison of the list of "component mathematical abilities that arise from the basic characteristics of

mathematical thought," developed by the work of Krutetskii (1976) in Russia with Weaver and Brawley's list developed in this country.

> 1. An ability to formalize mathematical material, to isolate form from content, to abstract oneself from concrete numerical relationships and spatial forms, and to operate with formal structure--with structures of relationships and connections.
> 2. An ability to generalize mathematical material, to detect what is of chief importance, abstracting oneself from the irrelevant, and to see what is common in what is externally different.
> 3. An ability to operate with numerals and other symbols.
> 4. An ability for "sequential, properly segmented logical reasoning" . . . which is related to the need for proof, substantiation, and deductions.
> 5. An ability to shorten the reasoning process, to think in curtailed structures.
> 6. An ability to reverse a mental process (to transfer from a direct to a reverse train of thought).
> 7. Flexibility of thought--an ability to switch from one mental operation to another; freedom from the binding influence of the commonplace and the hackneyed. This characteristic of thinking is important for the creative work of a mathematician.
> 8. A mathematical memory. It can be assumed that its characteristics also arise from the specific features of the mathematical sciences, that this is a memory for generalizations, formalized structures, and logical schemes.
> 9. An ability for spatial concepts, which is directly related to the presence of a branch of mathematics such as geometry (especially the geometry of space). (pp. 87-88)

Other lists of characteristics can be found in the literature including Greenes (1981) and Heid (1983), but they tend to duplicate or draw from the lists already given.

While this information is certainly significant, there is the very pragmatic question of how can this be translated into usable criteria, which is reliable, for identification of gifted students? As Weaver and Brawley (1959) stated with respect to the list of attributes they developed,

> It is evident immediately that the above characteristics are things that cannot be measured as easily or objectively as we measure general intelligence or arithmetic achievement. (p. 7)

At this point the literature was reviewed which related to the specific behaviors and attributes which characterize creativity and problem solving ability in mathematics.

Creativity and Problem Solving Ability in Mathematics

Kilpatrick (1969) observed that "the topics of problem solving and creative behavior are not being investigated systematically by mathematics educators" (p. 154). The difficulty seems to lie in the lack of an adequate description or definition of these two abilities. Just what is "creativity" with respect to mathematics? Certainly there has been much ado about trying to determine what is meant by creativity in general (Torrance, 1963; Getzels, 1969; Taylor, 1959; Guilford, 1950, to mention a few). In fact (Treffinger, Renzulli, & Feldhusen, 1981) stated,

> As a result of the lack of a unified, widely-accepted theory of creativity, then educators have been confronted with several difficulties; establishing a useful operational definition, understanding the implications of differences among tests and test administration procedures and understanding the relationship of creativity to other human abilities. (p. 145)

Torrance (1965) did attempt to describe a conceptualization of creative thinking abilities, drawn from Guilford's theory, when he stated that the following factors are included:

> sensitivity to problems, flexibility (figural spontaneous, figural adaptive, and semantic spontaneous), fluency (word, expressional, and ideational), originality, elaboration, and redefinition (figural, symbolic, and semantic). (p. 5)

Aiken (1973) and Balka (1974) did an extensive review of the literature as a basis for developing some kind of understanding for creativity in mathematics. Gutman (cited in Balka) felt that creativity appears in its purest form in mathematics. Laycock (cited in Aiken) stated that,

> Creative mathematics is the ability to analyze a given problem in many ways, observe patterns, see likenesses and differences, and on the basis of what has worked in similar situations decide on a method of attack in an unfamiliar situation. (p. 7)

This definition sounded very similar to the problem solving model of Polya (1957), which has the four stages of (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) looking back, in that students who are successful in the process of these four stages could be considered creative in mathematics. While Laycock's definition may have described the use of creativity in solving a problem, Polya did not equate problem solving ability with creative ability in that creativity lies in the thinking process which may or may not provide success in achieving the solution to a problem. Aiken and Balka both cited Poincare and Hadamard as also stressing that creativity is a thinking process which involves a subjective factor of sudden insight in dealing with some problem. Oehmke (1979) also discussed this and described Wallas' model of the stages of creative thinking (Aiken referred to this as well).

> preparation: the first stage during which the problem is investigated and all the facts gathered.
> incubation: the second stage during which one rests from any conscious thought about the problem at hand and/or consciously thinks of another problem.
> illumination: the third stage during which the idea and/or solution appears as a "flash" or "aha".

> verification: [the stage] during which the validity of the idea is tested. (pp. 14-15)

It would appear that one might have the ability to think creatively but not be able to solve a problem, yet, can one solve a problem without the ability to think creatively? It would depend on the nature of the problem, but it is still a question. According to Rees (1981), pupils eleven and fifteen years old can cope with routine concepts and skills, but show a sharp decline in performance as soon as understanding (with respect to mathematical development) is more deeply probed. In any case, the literature supported the fact that the ability to think creatively does enhance the ability to solve problems and that a particular feature of such creativity is some flash of insight or sudden illumination which offers a unique approach to the problem's solution.

In the identification, then, of students gifted in mathematics, the component of creativity coupled with problem solving ability might well serve as a criterion. The observation made by Aiken (1973) would indicate that such students also would be characterized by high general intelligence. The measurement of high general intelligence is usually attempted by the use of I.Q. tests and possibly by standardized achievement tests. In fact, if the phrase "general ability" is used interchangeably with "general intelligence," as Ridge and Renzulli do (1981), the measurement of both I.Q. and achievement could be another possible criterion for identifying students gifted in mathematics. These criteria lend themselves to the consideration of the Renzulli model for giftedness with respect to the subject of mathematics. The third component,

that of "task commitment," would complete the theoretical model (Ridge & Renzulli, 1981).

CHAPTER III

PROCEDURE AND DESIGN FOR THE STUDY

An Overview

This study is an attempt to assess the mathematical creativity and problem solving ability of sixth grade students in the middle schools of the Knox County School System of Tennessee. In the field study, a problem solving test and a creative ability test in mathematics were administered to 87 sixth grade students in Cedar Bluff, Farragut, and Karns Middle Schools. All students were interviewed with respect to the strategies they used during the creative ability test. Teachers of these students were asked to respond to a survey form prepared to determine the extent of task commitment typical of each student from their point of view. One year later the seventh grade teachers of a random sample of these students were asked to respond to the identical survey form. The data procured from this field work is the basis for this study.

The three schools selected are in the same area of Knox County (west) and during the time of the field work were more alike demographically than any other three of the seven available middle schools. The academic backgrounds of the students were alike in that:

1. All were current sixth grade students who had been in the Knox County System at least since the beginning of the fifth grade, if not all their school years.

2. All were being taught the same county-wide mathematics curriculum developed for students in grades K through 8.

3. All students used the same textbooks which were the McGraw Hill series published in 1981.

4. All students ranked in the 70th percentile or above as a total score result on the California Achievement test administered in March of 1983, their fifth grade year.

The students were different in that they were selected by I.Q. scores and by mathematics achievement scores to form six distinct categories for the purpose of comparison using the testing instruments identified. Of the total number of subjects meeting the criteria for the study and for whom parental consent notes were obtained, 57 were male and 30 were female.

Design of the Study

The purpose of this study was to explore how effective is the use of I.Q. and achievement in determining giftedness in mathematics. The use of these criteria, described in Chapter I for the State of Tennessee, determines whether or not a child can be certified as intellectually gifted. It should be noted, however, that while a test score from a standardized achievement test, such as the California, administered to a group of students is an acceptable instrument, the Tennessee State Rules and Regulations specify that the I.Q. test must be an individual one administered by a certified psychologist. While test scores from

the Otis Lennon group intelligence test are not usable for actual gifted certification, they are used by the schools, along with other data, to screen students who might be eligible for such certification. The determination of the score of 128 or above, although 132 is two standard deviations above the mean for the Otis Lennon, is considered justifiable for this study since it is, in fact, a group test.

Concerning the "label" of "intellectually gifted," there seems to be no clear statement of what this implies. Whatever major subject area is assessed with an achievement score in the 96th percentile or above, in actual practice the presumption tends to be made that the student, if certified gifted, is gifted in all subject areas. Since the concern of this study was the subject of mathematics, attention was given only to achievement scores in mathematics to avoid confusion and complication of other subject area scores.

In light of the operational definition of giftedness established in this study, i.e., "an interaction among (1) above-average general abilities, (2) high levels of task commitment, (3) high levels of creativity, and (4) the ability to solve problems," six different categories for subjects were arbitrarily determined based on the Otis Lennon I.Q. Test (OL) and the California Achievement Test (CAT), both administered at grade 5.8 county-wide in 1983. To fulfill the first component of the definition, which is above-average general abilities, only students who scored at the 70th percentile or above on the total battery of the CAT were considered eligible subjects. Using three stratified

levels of I.Q. scores and two stratified levels of achievement scores the following specific categories are described below:

Group I: an I.Q. of 128 or above and a total mathematics achievement score of 96 or above,

Group II: an I.Q. of 128 or above and a total mathematics achievement score of 50-95,

Group III: an I.Q. of 116-127 and a total mathematics achievement score of 96 or above,

Group IV: an I.Q. of 116-127 and a total mathematics achievement score of 50-95,

Group V: an I.Q. of 95-115 and a total mathematics achievement score of 96 or above,

Group VI: an I.Q. of 95-115 and a total mathematics achievement score of 50-95.

Figure 2 offers a more graphic description of the stratified sample categories used in this study.

Using the framework of these I.Q. and mathematics achievement categories, students selected as being above average in general abilities were then given the Iowa Problem Solving Project Test (IPSP), the Creative Ability Mathematics Test (CAMT), and were assessed by their teachers and the team of interviewers each using a different Likert-type scale in an attempt to determine the degree of task commitment characteristic of them. By stating the null hypothesis that there are no significant differences among the means of the six groups with

California Mathematics Achievement Subtest			
96-99	Group V	Group III	Group I
50-95	Group VI	Group IV	Group II
	95-115	116-127	128-150

Otis Lennon I.Q. Test

Figure 2. Diagram of Student Stratification Sample According to Three Levels of the Otis Lennon I.Q. Test and Two Levels of the California Achievement Total Mathematics Subtest Scores.

respect to student performance using these three measures, the following statistical treatments of the data were determined:

1. Use of a one way analysis of variance for the six samples with
   (a) IPSP scores as the dependent variable,
   (b) CAMT scores as the dependent variable.
2. Use of the Pearson Product Moment Coefficient of Correlation to determine for each sample the correlation between
   (a) the IPSP and the CAMT,
   (b) the IPSP and the OL,
   (c) the IPSP and the CAT,

(d) the CAMT and the OL,

(e) the CAMT and the CAT.

3. Use of the Kruskal-Wallis one-way analysis of variance for the six samples with the results of a Likert-type task commitment scale completed by the teachers combined with one completed by the interviewers as the dependent variable. The combined results are referred to as TASK.

4. Use of Spearman's rank correlation coefficient with the six samples to determine the correlation between

(a) TASK and the IPSP,

(b) TASK and the CAMT,

(c) TASK and the OL,

(d) TASK and the CAT.

The Subjects

Using the data from the administration of the Otis Lennon and the California Achievement Test to all Knox County fifth grade students in the school year 1982-83, a listing was made of all students from the total of 783 6th grade students enrolled in the Cedar Bluff, Farragut, and Karns Middle Schools who (1) achieved at least the 70th percentile on the total battery of the CAT, (2) achieved at least the 50th percentile on the mathematics subtest of the CAT, and (3) achieved a school ability index (SAI) of at least 95 on the OL.

These lists were cross-matched to form a list of all students who fell into the six categories described above. A tabulation of possible subjects available for study is shown in Table 1.

Table 1

Frequencies and Percentages of Possible Subjects Grouped by Categories

Group	Cedar Bluff	Farragut	Karns	Total	Percent of identified students	Percent of total number of students from the three schools
I	30	19	14	63	14	8.0
II	10	9	3	22	5	3.0
III	19	13	17	49	11	6.3
IV	35	46	31	112	25	14.3
V	5	8	11	24	5	3.0
VI	58	58	66	182	40	23.3
Totals	157	153	142	452	100	57.9

It should be noted that all students who were already certified gifted were not included in these lists.

Because of the limited number of subjects available for groups 2 and 5, and because of the attempt to keep the groups as nearly the same size as possible, it was decided to identify groups of 15 each.

Based on the number of students from each school falling into each category a proportional number of students was determined for each school. Using a table of random numbers, names of students were identified for each school for each group with a list of alternates also selected at random from each group of possible subjects.

A letter (Appendix A) was sent to the principals of the schools, who had already agreed to participate in this study, asking them to delete from the proposed list of subjects from their school the names of students who might have been certified gifted since the time information had been procured from the Knox County Schools Pupil Personnel Office. With information from the principals concerning recently certified gifted students and also students who moved or changed schools the lists of students were revised.

A letter was sent to parents (Appendix B) asking their permission for their children to participate in this study. With the cooperation of the Middle School Principals, permission slips were received and where negative, parents of alternate subjects were sent permission slips. The groups of students in the final selection are shown in Table 2.

Table 2

Distribution of Subjects in This Study by School and Group

Group	Cedar Bluff	Farragut	Karns	Total	Percent of original grand total
I	10	4	2	16	2.0+
II	5	7	1	13	1.6
III	5	3	6	14	1.7
IV	7	7	2	16	2.0+
V	3	6	3	12	1.5
VI	3	7	6	16	2.0+
Totals	33	34	20	87	11.0

The total group of 87 subjects was composed of 57 males and 30 females.

The Iowa Problem Solving Project Test

The Iowa Problem Solving Project Test (see Appendix D) is a multiple-choice, pencil and paper test for middle grade students developed by Schoen and Oehmke as a part of the Iowa Problem Solving Project (IPSP), a three-year project, directed by Immerzeel of the University of Northern Iowa and funded under ESEA, Title IV, C (Oehmke, 1979). The three major constraints in the development of the test were that (1) the format be multiple-choice for machine scoring, (2) the items should measure problem solving subskills, not just the ability to get an answer, and (3) the test should be based on the IPSP testing model. That model is essentially based on the work of Polya (1957) and is composed of four steps:

1. Understanding the problem: The student tries to understand the problem by examining the information given.

2. Devising a plan: The student formulates some kind of strategy to arrive at a solution.

3. Carrying out the plan: The student proceeds to do the necessary computation and/or arrangement of data to determine the solution.

4. Looking back: The student inspects the solution by checking the results and methodology in light of the given problem.

The actual testing model devised by the IPSP team is:

1. Get to Know the Problem

    (a) Determine insufficient information

    (b) Identify extraneous information

    (c) Write a question for the problem setting

2. Choose What to Do from a List of Strategies

3. Do It

    (a) Choose the necessary computation

    (b) Estimate from a diagram

    (c) Compute from a diagram

    (d) Use a table

    (e) Compute from an equation

4. Look Back

    (a) Identify problems that can be solved in the same way as a given one

    (b) Vary conditions in a given problem

    (c) Check a solution with the conditions of the problem.

However, according to Oehmke, "After nearly two years of effort, no viable way to test skills in step 2 in a multiple-choice format was found." Consequently the test deals only with steps 1, 3, and 4. The final forms of the IPSP test consist of two forms for grades 5 and 6 and two forms for grades 7 and 8. Each is a 30-item test with 10 items addressing each of the three steps which can be assessed. It was the purpose of Oehmke's doctoral dissertation to validate this test. Her study showed the test to have a reliability coefficient of .86 for the entire test, well within the range of acceptable reliability.

Statistical measures used showed, that, while concurrent validity was somewhat weak for step 4 of the model, the use of two different measures and the overall results provided concurrent validity. Discriminant validity was determined and the study also indicated that the test was judged to have content validity. The implication of the results of this study is that a psychometrically sound test based on three steps from the problem solving model has been constructed. Permission was obtained from Oehmke to administer this test for the purpose of this study (Appendix C).

The scoring of this multiple-choice test amounted to the tabulation of the number correct out of the 30 items. While a break-down was made for each subject to determine the number of items correct based on each of the problem solving steps, i.e., understanding the problem, doing it, and looking back, the decision was made to use the total combined score in this study.

The Creative Ability in Mathematics Test

The Creative Ability in Mathematics Test (see Appendix E) is the result of the doctoral dissertation work of Balka when at the University of Missouri (1974). It was the purpose of his study to explore the nature of creativity in mathematics, to develop a pencil and paper instrument for measuring creative ability in mathematics at the junior high school level, and to establish the construct validity of the instrument. After a compilation of criteria for measuring creative ability and using it as a basis for developing a total of 25 criteria

for measuring creative ability in mathematics, mathematical problems appropriate for each criterion were then developed and subjected to a validation procedure to determine the most exemplary problems. Then a randomized partial list of all the problems was submitted to a panel of ten judges, consisting of faculty and graduate students in Mathematics Education at the University of Missouri-Columbia, who were asked to match each criterion with a sample problem best exemplifying that criterion. At least 80% agreement was required for acceptance that a problem measure a given criterion. A survey was then conducted to determine whether or not a given criterion was regarded as important in measuring creative ability in mathematics by sending the list of criteria to a random selection of 100 mathematicians, 100 mathematics educators, and 100 secondary teachers. Using the requirement of 80% agreement, six of the original criteria were identified. The problems, two convergent and four divergent, for these six criteria are the six items that form the Creative Ability in Mathematics Test. The six criteria are:

1. The ability to formulate mathematical hypotheses concerning cause and effect in a mathematical situation.
2. The ability to determine patterns in mathematical situations.
3. The ability to break from established mind sets to obtain solutions in a mathematical situation.
4. The ability to consider and evaluate unusual mathematical ideas, to think though their possible consequences for a mathematical situation.

5. The ability to sense what is missing from a given mathematical situation and to ask questions that will enable one to fill in the missing mathematical information.

6. The ability to split general mathematical problems into specific subproblems.

Balka found the reliability of this test to be high, $\underline{r}$ = .72, and determined construct validity using achievement in mathematics, intelligence, and general creativity in the construct validation procedure. Implications of this study are that it was concluded that creative ability can, to a certain extent, be isolated, identified, tested, and measured and that creative ability in mathematics can be measured by a pencil and paper instrument. Permission was obtained from Balka to administer the CAMT test for the purpose of this study (see Appendix C).

The scoring of this test followed the pattern developed by Balka (see Appendix E). Items I and IV are convergent items with either a correct or incorrect response. If correctly answered, the value was one point. Items II, III, V, and VI are divergent items. Each was scored by:

1. Fluency: One point for each relevant response.
2. Flexibility: One point for each category expressed.
3. Originality: Zero, one, or two points for each category expressed, weighted according to a schedule of categories.

The schedule of categories for each item was determined by listing the different kinds, or categories, of responses obtained from a testing of 490 subjects in grades 6, 7, and 8, tabulating the number of responses

for each category, and then weighting the categories by allowing 0 points for those categories receiving responses from 5% or more of the subjects, one point for those categories receiving responses from 2% to 4.99% of the subjects, and two points for those categories receiving responses from less than 2% of the subjects. The total score for each divergent-type item was the sum of the fluency, flexibility, and originality scores. The total test score was the sum of the item scores, both convergent and divergent. While a break-down was tabulated for each student with respect to convergent items and the fluency, flexibility, and originality of divergent items, it was decided that the total CAMT score would be used for the purpose of this study.

Instruments Measuring Task Commitment

Two different instruments constructed with a Likert-type scale were used to assess student task commitment from two different perspectives. One was the Individual Interview form (see Appendix F) which was used by members of the team who conducted the testing. Each student was interviewed by a member of the team following the administration of the Creative Ability in Mathematics Test in an attempt to assess the degree of task commitment exhibited by the student with respect to that particular test. The student was asked five different questions about the test. The interviewer recorded the responses and made a judgment as to whether the student showed no interest, some interest, strong interest, or intense involvement.

The Student Task Commitment Inventory (see Appendix F) was sent to the teachers of each of these students at the time of the testing with the request that they respond to each of five questions in an attempt to characterize the student's behavior with respect to task commitment (see Appendix G). There was a 100% return of these inventory forms by the sixth grade teachers. However, only questions 4 and 5 were used because of the investigator's judgment that the complete instrument might be inappropriate. It was decided that questions 1 and 2 might only reflect student conformity and that question 3 might not imply task commitment. This very same inventory was sent to the teachers of a representative sample of the student subjects one year later when they were in the seventh grade. Using questions 4 and 5 of the 28 responses (32% of the total number of subjects) from the seventh grade teachers matched with those of the sixth grade teachers for the same students, a significant correlation, $\underline{rho} = .432$, $\underline{p} < .025$, was found which indicates the reliability of the instrument.

A Spearman Rank Order Correlation was used also to determine if there was any correlation between the two task commitment instruments. Although these two instruments were meant to measure two different things, i.e., task commitment with respect to the particular CAMT test and task commitment with respect to behavior observed to be characteristic over an extended period of time, a comparison of these seemed in order. A slight correlation, $\underline{rho} = .22$, $\underline{p} < .025$, was determined by this measure.

The scoring of each task commitment instrument was accomplished by allowing a score of zero points for no interest, one point for some interest, two points for strong interest, and three points for intense involvement for the interview and for each of the two items used on the task commitment survey submitted to teachers.

The Testing Procedure

Five experienced teachers who serve the Knox County School System as traveling mathematics teachers assisted the investigator in the administration of the two tests and in doing the interview sessions. These teachers were well briefed on the purpose of the study, the instruments to be used, and great care was taken to establish consensus concerning the kinds of student responses which would indicate which of the four choices, i.e., no interest, some interest, strong interest, or intense involvement, should be made. Both the Iowa Problem Solving Project Test and the Creative Ability in Mathematics Test were given to selected sixth grade students at schools other than those used in this study. The testing team did this as a way of practice before the administration of these tests for the purpose of the study.

Arrangements were made with the principals at each of three middle schools for the date and time of the test. None of the subjects were aware of which of the six groups they were in and at each school all the subjects, with 5 exceptions, took each test at the same time and under the same testing conditions.

During three days of one week the testing team visited each of the three schools and administered the Iowa Problem Solving Test. The following week the team again visited each school and administered the Creative Ability in Mathematics Test which was followed by the individual student interview conducted by the team members. Because of absenteeism, one of the subjects was tested individually and four of them were tested in a group on the CAMT at a later time in order to procure a complete set of data.

CHAPTER IV

PRESENTATION AND INTERPRETATION OF THE DATA

Introduction

The data presented in this study were obtained from three sources: (1) the results of the Iowa Problem Solving Project Test (IPSP), (2) the results of the Creative Ability in Mathematics Test (CAMT), and (3) the results of the teacher survey and student interview concerning task commitment (TASK).

With respect to statistical evaluation of this data, the level of significance selected for the purpose of this study is that of .05. At times, when a lesser $\underline{p}$ value was found, it has been included for the purpose of additional information.

Based on the theoretical model of giftedness which requires above average general ability, creative and problem solving ability, and task commitment on the part of the student, this study statistically explored the comparison of the test results from problem solving, creativity and task commitment measures of six groups of sixth grade students having above average general ability. The data are presented by examining first the IPSP (problem solving) and the CAMT (creativity) using a one-way analysis of variance. Then the results of the task commitment instruments were analyzed using the Kruskal-Wallis one-way analysis of variance. Next there was an inspection of the possible correlation between the results of the testing instruments used, and

finally an examination of the possible correlation between the results of the testing instruments and the given criteria of I.Q. and mathematics achievement scores.

The null hypothesis was stated that there are no significant differences among the means of the six groups stratified according to I.Q. and standardized mathematics achievement scores. However, using the Group I criteria of an I.Q. of 128 or above and a score in the 96th percentile or above in mathematics achievement, one might expect that the students in this group would show means significantly different from the other five groups with respect to giftedness in mathematics. This is the group that theoretically might be eligible to be certified gifted according to the guidelines used by many educators including those practicing in the State of Tennessee.

For purposes of referral, the identification of the students for each group is restated here:

Group I: an I.Q. of 128 or above and a total mathematics achievement score of 96 or above,

Group II: an I.Q. of 128 or above and a total mathematics achievement score of 50-95,

Group III: an I.Q. of 116-127 and a total mathematics achievement score of 96 or above,

Group IV: an I.Q. of 116-127 and a total mathematics achievement score of 50-95,

Group V: an I.Q. of 95-115 and a total mathematics achievement score of 96 or above,

Group VI: an I.Q. of 95-115 and a total mathematics achievement score of 50-95.

Problem Solving and Creativity

Using the one-way analysis of variance with the results of the Iowa Problem Solving Project Test, a significant difference was found among the means of the samples, $F(5,81) = 10.171$, $p < .001$. By applying Scheffe's Test for Multiple Comparisons for samples of unequal size, a significant difference was found between Group VI ($M = 21.563$) and each of Groups I ($M = 27.875$), III ($M = 27.786$), and V ($M = 26.667$), $p < .01$. (See Tables 3 and 4.)

As is evident, with respect to the IPSP Test, no significant differences were found between the mean scores of Groups II, III, IV, and V with respect to Group I. In fact Group III and Group V can be likened to Group I in that there was a significant difference found between each of them and Group VI. Since Groups I, III, and V have in common the variable that the students achievement score in mathematics was in the 96th percentile or above, yet with each having students at the different designated ranges of I.Q., it would appear that there is a relationship between high scores in mathematics achievement and high scores in problem solving ability.

A determination of excellent scores on the Iowa Problem Solving Project Test was made by identifying all subjects who scored 29 or 30

Table 3

Summary for Analysis of Variance of Mean Scores for The Iowa Problem Solving Project Test

Source of variation	Sum of squares	*df*	Mean square	*F*
Between groups	444.198	5	88.840	
Within groups	707.480	81	8.734	
Total	1151.678	86		10.171

$p < .001$.

Table 4

Differences Among Group Means for the Iowa Problem Solving Project Test

Mean	21.563	24.500	25.308	25.667	27.786	27.875
Group	VI	IV	II	V	III	I
N	16	16	13	12	14	16

Note. Any means not under the same line are significantly different.

$p < .01$.

on the 30-item measure. There were 14 subjects in this category, less than 2% of the total sixth grade population of the three schools. There were four scores of 30 and one of 29 in Group I and also four scores of 30 and one of 29 in Group III. The common criterion of these two groups is mathematics achievement with I.Q. being the differentiating one. Statistically and by individual inspection of the scores, Group III contains subjects that did equally as well as subjects in Group I in this problem solving measure. In Group II there was one 30 and one 29 and in Group V there were 2 scores of 29. While Group II is characterized by the same I.Q. range as Group I, its differentiating criterion is that of the lower range of mathematics achievement. Group V, on the other hand, characterized by the higher range of mathematics achievement and the lowest range of I.Q. still had two scores in the top 14.

When an analysis of variance was applied to the CAMT results, a significant difference was also found among the means of the samples, $F(5, 81) = 4.538$, $p < .01$. Scheffe's Test indicated a significant difference between Group I ($M = 37.125$) and Groups IV ($M = 21.813$), $p < .01$, and VI ($M = 22.750$), $p < .05$. (See Tables 5 and 6.)

With respect to the CAMT test, the only significant differences indicated were between Groups I and IV and Groups I and VI. The inference can be made that among students with above average general ability, students with high I.Q. and high mathematics achievement scores

Table 5

Summary for Analysis of Variance of Mean Scores for the Creative Ability in Mathematics Test

Source of variation	Sum of squares	*df*	Mean square	*F*
Between groups	2450.883	5	490.177	
Within groups	8749.347	81	108.017	
Total	11200.230	86		4.538

$p < .01$.

Table 6

Differences Among Group Means for the Creativity Ability in Mathematics Test

Means	21.813	22.750	25.462	28.000	29.071	37.125
Groups	IV	VI	II	V	III	I
N	16	16	13	12	14	16

Note. Any means not under the same line are significantly different.

$p < .05$.

indicate higher creativity in mathematics than do students with mid upper range and average I.Q. scores and lower mathematics achievement scores. However, the findings also indicate no significant differences of mean scores of student performance on the mathematics creativity measure between Group I and Groups II, III, or V. It can be inferred that students in the highest I.Q. and mathematics achievement range will have creativity scores not significantly different from students with mid upper range and average I.Q. scores and high mathematics achievement scores. Nor do the highest I.Q.-highest mathematics achievement students score significantly higher in creativity than students with equally high I.Q. scores but lower mathematics achievement scores.

Using the guideline of the top 14 scores identified for the IPSP, a determination was made of the highest scores on the CAMT (Table 7). Only 13 scores were considered for the CAMT because four subjects had the fourteenth top score of 38. The range for the highest 13 scores was 39 to 72. The subject who scored 72, which was 16 points higher than the next highest score, was a member of Group III. The second

Table 7

Distribution of the Highest Iowa Problem Solving Project Test Scores and the Highest Creative Ability in Mathematics Test Scores

Group	VI	IV	II	V	III	I	Total
IPSP	0	0	2	2	5	5	14
CAMT	0	1	1	2	2	7	13

highest score, 56, was found in Group I and the third highest score, 49, was from Group V. Group I contained seven of the top scores, Groups III and V each contained two, Groups II and IV each had one, and Group VI had none.

WHile Group I contained the highest number of top CAMT scores, the fact remains that there were nearly equally as many students in the other groups combined that indicated high mathematics creativity scores. Group III had equally as many top IPSP scores as Group I. One subject in Group V had a top score on both the IPSP and the CAMT. (Only three of the subjects in Group I scored high on both the IPSP and the CAMT.) This information indicated that fourteen top scoring students on either the IPSP or the CAMT would not be eligible to be certified gifted under existing guidelines in much educational practice.

Task Commitment

To examine the comparison of the six groups with respect to task commitment, the Kruskal-Wallis One-Way Analysis of Variance by Ranks was used. A significant difference was found, $\underline{H}(5) = 23.402$, $\underline{p} < .001$. To determine where the difference of means occurred, the Mann-Whitney U-Test was applied to each combination of samples. There was found a significant difference between Group I ($\underline{M} = 5.938$) and Groups II ($\underline{M} = 4.077$), IV ($\underline{M} = 3.500$), V ($\underline{M} = 4.250$), and VI ($\underline{M} = 3.250$), $\underline{p} < .01$. There was also a significant difference found between Group III ($\underline{M} = 5.071$) and Groups IV and VI, $\underline{p} < .01$. It is especially interesting to

note that no significant difference was found between Group I and Group III. (See Table 8.)

Table 8

Differences Among Group Means for Task Commitment Measures

Means	3.250	3.500	4.077	4.250	5.071	5.938
Groups	VI	IV	II	V	III	I
N	16	16	13	12	14	16

Note. Any means not under the same line are significantly different.

$p < .01$.

As has been stated, the reliability of the Student Task Commitment Inventory was established, rho = .432, $p < .025$, by comparing a sample of responses from seventh grade teachers of 28 of the subjects with the responses of the sixth grade teachers of those same subjects. Also, when the Spearman Rank Order Correlation Coefficient was used to compare the Student Interview ratings with those from the Student Task Commitment Inventory using 30 subjects randomly selected, no significant correlations were found. However, when the Spearman was used for all 87 subjects, a slight correlation was found, rho = .22, $p < .025$.

With the exception of Group III (I.Q. 116-127; Mathematics Achievement 96-99) Group I did appear to be superior with respect to the measure of task commitment.

As for the IPSP and the CAMT, the highest 13 scores were identified. There were eight scores of 8 and five scores of 7. In Group I there were four scores of 8 and two of 7, in Group II, one 8, in Group III, two 8's and one 7, in Group IV, two 7's, and in Group V, one 8. There were no scores of 7 or 8 in Group VI. Again, the observation was made that while nearly half the high scores for task commitment were found in Group I, over half the high scores were found throughout the other groups except for Group VI. (See Table 9.)

Table 9

Distribution of the Highest Task Commitment Scores

Group	VI	V	II	IV	III	I	Total
N	0	1	1	2	3	6	13

An inspection was made to determine if any of the subjects could be found who had top scores for each of the three measures, the IPSP, the CAMT and the TASK. There were none, but Groups I, III, and V did contain members who scored high in two of the three measures. Three from Group I and one from Group V scored high in the IPSP-CAMT measures; one from Group I and two from Group III scored high in the IPSP-TASK; and three from Group I scored high in the CAMT-TASK. With the consideration that either the IPSP or the CAMT represent measures for the one component of problem solving and creativity in the theoretical

triad for giftedness, that the second component of above average ability is satisfied because this was a prerequisite for all subjects, then the third component, that of task commitment, would have measures represented by TASK. In light of this, there are four such subjects in Group I and two in Group III. Members of Group III, however, who may well be gifted in mathematics, are not eligible for certification of giftedness by many criteria being used in the schools today.

Relationship of IPSP, CAMT, and TASK Scores

When a study was made, using the Pearson Product-Moment Coefficient of Correlation, of the individual groups to determine if there was a relationship between the IPSP and the CAMT mean scores, there were some notable positive correlations for Group V and for Group VI. For Groups II and IV the correlation was negligible as it was for Group I. The correlation for Group III, while not statistically significant, was a correlation coefficient of -.450. When a Pearson measure was used for the total number of 87 subjects, a slight correlation was found, $r = .354$, $t(85)$, $p < .005$. In Group V, with the third highest mean for each test, the subjects who did well on one test did well also on the other. In Group VI, with the lowest mean scores for each test, the same relationship was found, but might be more accurately stated from the other end of the continuum. If a subject did poorly on one test, he/she did poorly on the other. (See Table 10.)

It would appear that the test instruments used do measure different abilities. While the IPSP and CAMT scores did show a positive

Table 10

Relationship of the IPSP and CAMT Mean Scores for Groups: Pearson Product-Moment Correlation Coefficient

Group	I	II	III	IV	V	VI
r	-.098	.262	-.450	.132	.551*	.713**
t	-.367	.900	-1.748	.498	2.089	3.800
df	14	11	12	14	10	14

*$p < .05$. **$p < .005$.

correlation for Group V, where both sets of scores were fairly high, and for Group VI, where both sets of scores were relatively low, the correlation for the total set of scores is not particularly high considering the large number of subjects. In fact it indicates only a 12.5% association between the two measures for the 87 subjects.

When the relationship between the task commitment (TASK) mean scores and those of the IPSP and the CAMT were examined by group, no significant correlation was found for any of the combinations of samples using the Spearman Rank Order Correlation Coefficient. When the Spearman was applied to the total number of subjects, a slight correlation was found between TASK and IPSP, $rho = .294$, $p < .005$, and also between TASK and CAMT, $rho = .218$, $p < .025$. (See Table 11.)

Table 11

Relationship of the TASK Group Mean Scores to those of the IPSP and the CAMT

Group	I	II	III	IV	V	VI
TASK-IPSP *rho*	-.014	.061	.067	-.132	-.043	-.125
Sum of D squares	670.5	331	405.5	751.5	277.5	756.5
TASK-CAMT *rho*	-.078	.246	-.204	-.053	-.229	.071
Sum of D squares	714.5	268.5	453.5	708	333	625
N	16	13	14	16	12	16

Again, the fact that no significant correlation was found with respect to TASK and each of the other measures within the individual samples, the positive correlation found using the total number of subjects can be considered slight. The study indicates an 8.6% association between the TASK and the IPSP scores and a 4.7% association between the TASK and the CAMT scores for the 87 subjects. These results indicate that the task commitment measures assess aspects of student performance different from those assessed by the IPSP and the CAMT measures.

Relationship of I.Q. and Mathematics Standardized Achievement Scores to the Field Study Measures

This part of the study was made to determine the relationship of I.Q. and mathematics achievement scores with each of the types of data obtained, i.e., the IPSP, CAMT, and the TASK scores, for each of the six sample groups. To examine the relationship of I.Q. and achievement scores with the IPSP and the CAMT scores, the Pearson Product-Moment Correlation Coefficient was employed. The Spearman Rank Order Correlation Coefficient was used for the inspection with the TASK scores.

With respect to I.Q. and the Iowa Problem Solving Project Test, close to a zero correlation was found for each group with the exception of Group IV. With this group the level of scores achieved on the IPSP showed a 33.3% association with the level of I.Q. scores, $\underline{r} = .577$, $\underline{p} < .01$. Group IV is characterized by mid upper range I.Q. and the lower range of mathematics achievement scores. The mean score of this group on the IPSP was next to the lowest. A look at the total set of subjects combined from all groups indicated an 18.9% association between I.Q. and the IPSP, the problem solving test, $\underline{r} = .435$, $\underline{p} < .0005$.

The findings of the study with respect to I.Q. and the Creative Ability in Mathematics Test were somewhat different. A negative correlation was found for Group I with respect to the I.Q. and CAMT mean scores, $\underline{r} = -.472$, $\underline{p} < .05$. This negative correlation indicated a 22.3% negative association. It would appear the higher the I.Q., the lower the score on the creativity test for those with the high I.Q./high mathematics achievement characteristics of this group.

There was a positive correlation shown for Group VI, $r = .478$, $p < .05$. For this group, with an association of 22.9% between the mean scores, students with the higher I.Q.'s tended to do better than others in their group on the creativity test. Group VI is characterized by the lowest I.Q. and lowest mathematics achievement ranges used in this study. The CAMT mean score for this group was higher only than that of Group IV.

When the Pearson was applied to the scores of the total group, a slight correlation was found, $r = .239$, $p < .025$. This means that out of 87 subjects there was only a 5.7% correlation between I.Q. and creativity as measured by the CAMT.

No significant correlation was found for any of the six groups between I.Q. scores and the task commitment scores. When the Spearman was applied to the total group, a slight positive correlation was found, $rho = .353$, $p < .005$. This indicated that of the 87 subjects there was a 12.5% association between I.Q. and task commitment as measured by the instruments of this study. (See Table 12.)

With respect to mathematics standardized achievement test scores and their relationship to the IPSP scores, there was only a significant correlation found in Group IV, $r = .593$, $p < .01$, with the inspection of the individual samples. This indicated a 35% association between the achievement scores and the IPSP scores for Group IV. It should be noted that Group V revealed a correlation of .456 which, if it had been .459, would have been significant at the .05 level. When the Pearson was applied to the total group, a rather different statistic was obtained. There was a positive correlation of .617, meaning that there

Table 12

Correlation of Group I.Q. Mean Scores with Group Mean Scores of the IPSP, CAMT and the TASK Measures

Sample	N	IQ-IPSP	IQ-CAMT	IQ-TASK
I	16	.246	-.472*	-.237
II	13	-.070	.054	-.097
III	14	.165	-.130	-.009
IV	16	.577**	-.018	-.116
V	12	.048	-.367	.260
VI	16	.162	.478*	.284

*$p < .05$. **$p < .01$.

was a 38% association between achievement scores and those of the IPSP. One possible explanation for this is the fact that the stratification of the achievement score percentiles is very narrow for three of the samples (96 and above) and very wide for the other three samples (50-95).

An examination of the relationship of the mathematics achievement scores and those obtained from the Creative Ability in Mathematics Test indicated that there was a significant correlation found with both Group II and Group VI. Both of these groups are characterized by the mathematics achievement range of from 50th through the 95th percentile. The findings for Group II, $r = .492$, $p < .05$, indicated over a 24% association between the sets of scores and for Group VI, $r = .515$, $p < .025$, indicated a 26.5% association between the variables. In other words, those students with lower achievement scores tended to have

comparably low scores on the creativity test. This did not appear statistically, however, for Group IV which is also characterized by the same stratification of mathematics achievement level designed in the study. When the Pearson was applied to the total group of subjects a significant correlation was found, $r = .428$, $p < .0005$.

An inspection of each sample with respect to mathematics achievement and task commitment scores revealed no correlation between the two variables in any group. Because Group I TASK scores showed a significant difference between those of all other groups except III, one might have expected that a correlation of TASK and achievement, if not I.Q., would have been found for Group I. When the statistical measure was applied to the total group of subjects, a correlation of .452, $p < .0005$, or an association of 20% between the variables. Again, when a sample of this large is used, some correlation is expected between two given variables. (See Table 13.)

Table 13

Correlation of Mathematics Achievement Group Mean Scores with the Group Mean Scores of the IPSP, the CAMT and the TASK

Group	N	MA-IPSP	MA-CAMT	MA-TASK
I	16	.099	-.091	.377
II	13	.445	.492*	.350
III	14	.456	-.344	.377
IV	16	.593***	.348	-.200
V	12	-.219	.159	.399
VI	16	.233	.515**	-.268

$*p < .05$. $**p < .025$. $***p < .01$.

Summary

The results of this study indicate that there is no clear substantiation for the use of an I.Q. score of 128 or above for identifying students gifted in mathematics. There is some indication that a mathematics achievement score in the 96th percentile or above might well be a factor to consider in such identification. However, even when the achievement score was limited to mathematics achievement for the purpose of this study, there were many instances where no significant differences were found between the group means of the samples stratified according to I.Q. and achievement. It is true that Group I contained more top scoring students than any other, but the educational problem posed here is that of the neglect of other students who do not happen to meet the established criteria for giftedness and who may well be gifted students, especially in mathematics.

The findings of this study were:

1. No significant differences were found between Group I and

   (a) Group III for <u>any</u> of the measures,

   (b) Groups II and V except for the TASK measure.

2. Groups I, III, and V were all significantly different from Group VI on the Iowa Problem Solving Project (IPSP) measure.

3. A significant negative correlation was found between I.Q. and the Creative Ability in Mathematics Test (CAMT) measure for Group I.

4. No significant correlation was found between Task Commitment (TASK) and the IPSP, the CAMT, I.Q., or Mathematics Achievement (MA) for any of the groups.

5. Other significant correlations with respect to the variables I.Q. and MA, and the test measures IPSP and CAMT were found only in:

(a) Group II for MA-CAMT,

(b) Group V for IPSP-CAMT,

(c) Group IV for IQ-IPSP and MA-IPSP,

(d) Group VI for IPSP-CAMT, IQ-CAMT, and MA-CAMT.

6. Fourteen top-scoring students on either the IPSP or the CAMT would not be eligible to be certified gifted under prevailing existing criteria.

7. With respect to the Renzulli model, only four members of Group I could be considered gifted in mathematics while two members in Group III, ineligible for gifted certification, could also be considered gifted in mathematics.

CHAPTER V

OBSERVATIONS AND IMPLICATIONS

Summary of the Procedure

Using the theoretical model for mathematical giftedness which is a triad requiring the intersection of the characteristics of (1) above average general ability, (2) problem solving or creative ability, and (3) task commitment capability, the design for this study was developed to assess sixth grade students for these criteria. The component of above average general ability was defined as those students who had a score on a standardized achievement test of the 70th percentile or above for the total battery. Of the 783 sixth grade students from three middle schools, 452 students met this criteria. From these students, subjects were selected to form six groups based on high, mid upper, and average I.Q. scores coupled with either a mathematics achievement score of the 96th percentile or above or a mathematics achievement score of the 50th through the 95th percentile. A total of 87 subjects were identified for the study.

The criterion of problem solving and creativity was measured by the administration of the Iowa Problem Solving Project Test (IPSP) and the Creative Ability in Mathematics Test (CAMT). The criterion of task commitment was assessed using a structured post-CAMT-test interview conducted by the investigating team and a Student Task Commitment Inventory completed by the teachers of the subjects in the study.

Statistical measures were used not only to compare group means, but also to determine the relationship, if any, between the different test instruments used with respect to group performance.

Based on the fact that many students are certified as gifted on the basis of a combination of a high I.Q. score and a high achievement score in a major subject, the outcome of this study might be the expectation that the sample group with these attributes, Group I, would have mean scores from the testing measures that would be significantly different from those of the other groups. This did not prove to be quite true, however.

Discussion of the Results

With respect to the test instruments and the task commitment measures, it would appear that each assessed different student abilities or characteristics. While it is true that a positive correlation was found between the IPSP and the CAMT scores for Group V and also Group VI, there were non found for the other four groups. Only a 12.5% association was shown when the total number of scores from all groups was examined. There were no significant correlations between the TASK score means and those of the IPSP and the CAMT for any of the groups.

With respect to student performance on the three investigative measures, there were indeed significant differences found between the group means of Group I (high I.Q./high achievement) and Group VI (average I.Q./average-mid upper mathematics achievement) on all three measures; and between Group I and Group IV (mid upper I.Q./average-mid

upper mathematics achievement) on two of the measures (CAMT and TASK), but not on the third (IPSP). However, no significant difference was found at all between the means of Group I and Group III (mid upper I.Q./high mathematics achievement) for any of the three measures. Also the only significant difference found between the group means of Group I and Groups II (high I.Q./low mathematics achievement) and V (average I.Q./high mathematics achievement) was with respect to the TASK measure. In other words, when it came to student performance on the Iowa Problem Solving Project Test there was no significant difference between Group I and Groups II, III, IV, and V and with respect to the Creative Ability in Mathematics Test there was no significant different between Group I and Groups II, III, and V.

It should be noted that Groups I, III, and V, each with a different I.Q. range (high, mid upper, and average, respectively), but with the same high mathematics achievement scores, all differed significantly from Group VI with respect to the IPSP. Apparently the level of I.Q. had no bearing on student performance with respect to this measure. In looking at Groups II, IV, and VI which also each have a different I.Q. range comparable to Groups I, III, and V respectively, but which are all characterized by the average-mid upper mathematics achievement range, there was not one significant difference found between any of these groups for any of the measures.

Now, looking at the groups in pairs having the same I.Q. range, but having different mathematics achievement scores, significant differences were found only between Groups I and II with respect to TASK,

between Groups III and IV with respect to TASK, and between Groups V and VI with respect to the IPSP. One can only speculate on what inherent student characteristics might have contributed to these differences.

An inspection of the individual performance of the subjects with respect to the application of the theoretical model for mathematical giftedness indicates that six subjects meet the stated criteria. Based on an arbitrary determination of what constitutes a high score on each of the measures of this study, these students scored in the top 14 on the IPSP or in the top 13 on the CAMT and in the top 13 on the TASK. Four of these subjects were in Group I and two were in Group III. The Group III students would not be eligible for gifted certification under existing guidelines which require the high I.Q. range. One student from Group V scored high on both the IPSP and the CAMT, but had only an average TASK score. Is it possible that he/she, too, might be considered mathematically gifted? Of the total number of 87 subjects, a Group III student made the highest score on the CAMT, sixteen points above the next highest score. Although this student had only an above average TASK score and a slightly below average IPSP score, yet might not this student have some potential for mathematical giftedness?

Conclusions

With respect to this study, it has been shown that the variables of I.Q. and mathematics achievement differentiate only between the two ends of the continuum. Students with an I.Q. of 128 or above and a

mathematics achievement percentile of 96 or above performed consistently and significantly higher than those students with an I.Q. of 95-115 and a mathematics achievement percentile score of 50-95. Of the total number of students used in the study, all of whom have above average general ability, those in Group I can be described as more mathematically gifted than about 18% of the subjects studied. However, the fact that no significant differences were found between Group I students and Group III students (I.Q. of 116-127/mathematics achievement 96 or above) indicates that the arbitrary selection of a particular I.Q. range for the purposes of identifying students as gifted appears to be inadequate. In fact, Group V (I.Q. of 95-115/mathematics achievement 96 or above) differed significantly from Group I students only on the TASK (task commitment) measures.

In consideration of the students in Group II (I.Q. of 128 or above/mathematics achievement 50-95), it should be noted that these students might become certified gifted if they demonstrate a standardized achievement percentile score of 96 or above in some other major subject area. Yet, the group means of these students were consistently below not only those of the Group I students having the same I.Q., but also below Group III and Group V students having mid upper (116-127) and average (95-115) range I.Q. scores, respectively. Also, since no significant difference was found between the Group II subjects and those of Group IV (I.Q. of 116-127) and Group VI (I.Q. of 95-115), all of whom are characterized by average-mid upper mathematics achievement scores, if such Group II students were to become certified gifted, it

should be perceived that they have given no evidence of being certified gifted in the subject area of mathematics.

In summary, then, the conclusions drawn from this study are:

1. It is inadequate to use a particular I.Q. range, arbitrarily selected, as a criterion for identifying students gifted in mathematics.

2. A particular mathematics achievement range, arbitrarily selected, might well be a factor to consider for identifying students gifted in mathematics.

3. It cannot be assumed that students who become certified gifted by the criteria of high I.Q. scores and high achievement scores in some major subject other than mathematics are necessarily gifted in mathematics.

4. Because some students who indicate giftedness in mathematics are being overlooked by traditional measures of gifted identification, such measures as the Iowa Problem Solving Project Test, the Creative Ability in Mathematics Test, and a Student Task Commitment Inventory/ Student Interview should be used in addition to the mathematics achievement measure for the identification of students gifted in mathematics.

Implications

At this time, in the field of education in the United States of America, great emphasis is being placed on the identification of students considered by society as superior to other students. Special curricula, programs, and activities have been and are being developed

for such children. There are many persons who feel this special consideration is long overdue. Be that as it may, the fact remains that the labeling of students as "gifted" or "not-gifted" can have not only immediate, but far-reaching, social and psychological implications as well.

If, in fact, such labeling is to be done, it would behoove educators to be as cautious and as accurate as possible. This study has shown that there are students, ineligible for gifted certification, who perform highly on measures designed to assess giftedness in mathematics. Such students are not given the preferred treatment of the gifted, and may well be neglected when they need instructional nurture and encouragement.

One way to assist in the more accurate identification of students, at least for the middle grades, who are gifted in mathematics, would be to employ the test and task commitment measures used in this study. It is recommended that all students who score in the 96th percentile or above on a standardized mathematics achievement tests be given the Iowa Problem Solving Test, the Creative Ability in Mathematics Test, and be assessed by the Student Task Commitment Inventory/Student Interview Measures, especially if they do not qualify for giftedness because of their I.Q. scores. The test scores used to identify the top performing 13 or 14 students in this study, or some modification of them, could be used to identify students with unusually high ability, i.e., 28 or above on the IPSP or 39 or above on the CAMT and 7 or above on the

TASK. With respect to the TASK, care should be taken that conformity not be mistaken for task commitment.

Recommendations for Further Research

The replication of a study such as this is essential. Should this occur, it might be prudent to use a 3 x 3 matrix with nine groups instead of a 2 x 3 with six by subdividing the mathematics achievement percentile range of 50-95 into 50-69 and 70-95. The number of subjects in each group should remain at least as large as those in this study. A study such as this could be conducted with older subjects, such as eighth or ninth grade students, using instruments appropriate for that age level.

Further research on the nature of the problem solving ability and creativity in mathematics could cause the refinement of existing tests such as the IPSP and the CAMT and the development of new forms of assessment.

For the purpose of better identification of all youngsters who might be gifted in some area other than mathematics, the Renzulli model could be applied to characterize giftedness in other major disciplines with appropriate test measures either selected or developed to measure the three components of the triad, i.e., above average general ability, creativity, and task commitment.

In general, further research is needed to ensure that all students who are truly gifted are not being neglected or discriminated against because of educational practices which exclude them from instructional

programs which could provide them better opportunities to maximize their potential as individual human beings and as productive members of the total society.

Conclusion

It is hoped that this study offers some contribution to the educational practice of identifying children as gifted, especially in the area of mathematics. Perhaps, even more important, is the author's hope that this study will provide an impetus for further research for a more accurate definition of giftedness and a more accurate assessment of children who may be gifted.

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APPENDICES

APPENDIX A

LETTER TO PRINCIPALS

DEPARTMENT OF PUBLIC INSTRUCTION
KNOX COUNTY
EARL F. HOFFMEISTER, SUPERINTENDENT
P.O. Box 2188
KNOXVILLE, TENNESSEE 37901

April 23, 1984

Susan and George,
Dear Brenda and Jim,
Pat and Don,

During the month of May, I would like very much to conduct a study involving some of your sixth grade students. The purpose of this study is to determine if there are any differences between six particular groups of students, classified in terms of I. Q. and mathematics achievement test scores, with respect to their performance on two tests designed to measure creativity and problem solving in mathematics. The students will be divided into 6 proportionally stratified random samples with approximately 30 from each of the three middle schools; Cedar Bluff, Farragut and Karns.

This is what would be involved:

1. Distribution of a letter, prepared by me, to the parents of these children. (Preferably the week of April 23). The response will be mailed to me.

2. Allow me to ask the 6th grade teachers of these students to administer a 35 minute problem solving test to selected students during the regular mathematics period preferably on May 2, 3 or 4. I would provide them with testing directions, tests, etc.

3. Arrange for these students to be tested by a TMT or me during a 35-40 minute period followed by a brief ($\approx$15 minute) personal interview sometime during that same day.

Tentative schedule:

May 7	Karns
May 14	Cedar Bluff
May 21	Farragut

Students might possibly be able to use an activity period for this testing. We will do it in groups of 5 to 8 students per person administering the test, but there will be as many as 5 of us doing the testing so we could accomodate up to 45 at a time if necessary. I shall be in touch with you April 30 or May 1 concerning this.

It should be noted that we could also administer the problem solving test, if you prefer, but it would mean additional "pull-out" time for the students. If the 6th grade teachers are willing, it seemed the least complicated just to use mathematics class time.

Please call Wilma Myers (521-2407) as soon as possible if you are willing to facilitate the work of this study. She will send you a list of the students' names and copies of the letter to be sent home to procure parental approval.

I am sorry I have not talked with you directly concerning the particulars of this study, but much of the detail for this work has been worked out during my vacation time.

If you have immediate questions, or you wish to discuss this study further, please call Brenda Latham during the week of April 23. I shall be available from April 30 on and shall be talking with you.

Sincerely,

Charleen bl

Charleen DeRidder
Mathematics Supervisor

DeR/wkm

Copy: Sarah Simpson
Bob Goff
Dr. Sam Bratton

APPENDIX B

LETTER TO PARENTS

DEPARTMENT OF PUBLIC INSTRUCTION
KNOX COUNTY
EARL F. HOFFMEISTER, SUPERINTENDENT
P.O. Box 2188
KNOXVILLE, TENNESSEE 37901

To the Parents of ______________________________

As partial fulfillment of the requirements for a doctoral degree in mathematics education, I would like to conduct an investigation to determine if creative and problem solving ability in mathematics is correlated with student IQ and mathematics achievement as measured by standardized test scores.

Students have been identified from three Knox County middle school sixth grades. The study would require that your child be administered the Iowa Problem Solving Test (35 minutes), the Creative Ability in Mathematics Test (6 items for about 40 minutes) and the California Achievement Test for sixth graders. This testing would occur during the month of May at such times during the school day as deemed appropriate by the principal and the child's teachers.

This study will involve group comparisons and no individual scores will be made public nor be detrimental to the student in any way.

If you wish to have your child participate in this study, would you complete the form below and return to me by mail.

Thank you,

Charleen DeRidder

To Whom It May Concern:

My child ______________________________ has my permission to participate in

a doctoral study concerning creative and problem solving ability in mathematics.

______________________ ______________________________________

Date Parent Signature

APPENDIX C

PERMISSION TO USE TESTS

The University of Iowa

Iowa City, Iowa 52242

Division of Mathematical Sciences
Department of Computer Science
Department of Mathematics
Department of Statistics and Actuarial Science
Program in Applied Mathematical Sciences

1847

April 11, 1984

Ms. Charleen DeRidder
218 Claxton Building
College of Education
University of Tennessee
Knoxville, Tennessee 37916

Dear Charleen:

In response to our telephone conversation of this past week I am enclosing a copy of the IPSP test booklet and pertinent data for your use.

I am requesting that you use the materials only as part of a research effort and that you cite us should you use any part of them. I am also interested in hearing about any results obtained from the use of the IPSP test.

The cost of the enclosed materials is $6.50 which includes postage.

Sincerely,

Theresa Oehmke

Theresa Oehmke
Associate Director
Mathematics Tutorial Laboratory

Enc.

le

May 2, 1986

Ms. Charleen M. DeRidder
2904 Barber Hill Lane
Knoxville, Tennessee 37920

Dear Charleen,

Thank you for your phone call of Thursday, May 1. This letter is to confirm our conversation at the NCTM meeting in Detroit (1983). At that time I gave you permission to use the Creative Ability in Mathematics Test. At this time I also give you permission to print pages 195-199 and 201-212 from my dissertation concerning the test and the test scoring procedures in the appendixes of your study. It is my understanding that my work has been cited and fully acknowledged in your study.

Best wishes in your work.

Sincerely,

Dr. Don S. Balka

APPENDIX D

IOWA PROBLEM SOLVING TEST

IPSP PROBLEM SOLVING TEST

Copyright by

Harold L. Schoen
Theresa M. Oehmke

1979

All Rights Reserved

Name ____
Last First

School______________________________Date____________________

Mike enjoys guessing the weight of his classmates. Here is a chart he made. Refer to it in items 1 - 5.

Name	Mike's Guess	Actual Weight
Tim	89	91
David	100	97
Kate	79	79
Larry	71	66
Lynn	98	101

1. Whose actual weight was less than Mike's guess?
   1) Kate and Lynn
   2) Tim, Kate and Lynn
   3) Kate and Larry
   4) David and Larry

2. Who actually weighed the most?
   1) David 3) Tim
   2) Lynn 4) Larry

3. Who did Mike guess weighed the most?
   1) David 3) Tim
   2) Lynn 4) Larry

4. Whose weight did Mike guess correctly?
   1) Larry 3) Kate
   2) Tim 4) Lynn

5. Whose weight was exactly 3 pounds more than Mike guessed?
   1) Lynn 3) Tim
   2) David 4) Larry

---

6. You threw a baseball 5 meters farther than Tom did. You want to know how far your throw went. You could solve the problem if you knew:
   1) Tom's throw was 5 meters shorter than yours.
   2) A meter is a little more than a yard.
   3) A baseball is 8 inches around.
   4) Tom's throw was 34 meters.

7. In baseball it is 90 feet from home plate to first base. To find how many yards it is from home plate to first base divide 90 by 3 and the answer is 30 yards. Which problem below can be solved using exactly the same steps?
   1) Three identical baseball gloves cost $90 together. How much does one glove cost?
   2) A baseball costs $3. How much do 90 baseballs cost?
   3) There were 90 baseballs in a large box. The coach put in 3 more. How many are now in the box?
   4) There were 90 baseballs in a large box. The coach took 3 out. How many are left in the box?

8. Two children together had $5.00. They paid $2.80 for candy and a book. They each took half of the remaining money. Which question below could be answered using this information?
   1) How much did the book cost?
   2) How much money did each child have left?
   3) How much did the candy cost?
   4) Could the children buy another book at the same price?

9. A motorist drove 250 miles. She found that she had used 13 gallons of gasoline. Which question below could be answered using this information?
   1) How long did it take her to drive the 250 miles?
   2) What was her average speed over the 250 miles?
   3) How much gasoline did she have left at the end of 250 miles?
   4) How many miles did she drive per gallon of gasoline?

(Go on to next page)

HOMEWORK PROBLEM

Jill made these scores on 4 homework lessons.

Lesson	Score
1	8
2	6
3	9
4	10
Total	33

Use the above information to answer items 10 - 12.

10. In the Homework Problem, suppose Jill's score on Lesson 2 was changed to 8. How could her total be found?
    1) Add 6 and 8
    2) Subtract 8 from 33
    3) Add 2 to 33
    4) Add 8 to 33

11. In the Homework Problem, suppose Jill lost Lesson 4 and had to change that score to 0. How could her total be found?
    1) Subtract 10 from 33
    2) Subtract 9 from 33
    3) Subtract 8 from 33
    4) Subtract 6 from 33

12. In the Homework Problem, suppose Jill needed to hand in one more lesson. Her total score on all 5 lessons was 40. How could her score on the last lesson be found?
    1) Add 5 to 40
    2) Divide 40 by 5
    3) Subtract 5 from 40
    4) Subtract 33 from 40

13. Fred wants to buy a sweater for $13 including tax. He has $2.50 plus the $5.20 he borrowed from his mother. Which question below could be answered using this information?
    1) How much more money does Fred need to buy the sweater?
    2) How much is the tax on the sweater?
    3) What is the price of the sweater before tax is added?
    4) Can Fred afford to buy a baseball glove?

14. I have 3 books. One has 126 pages, the second has 53 pages and the third has 295 pages. To find the number of pages in the 3 books, I added 126 + 53 + 295 and got 474 pages. My brother gave me a fourth book for my birthday. It has 110 pages. How many pages are in the 4 books altogether?
    1) 474 + 110
    2) 474 - 110
    3) 110 x 4
    4) 584 ÷ 4

15. A bag contains 25 marbles. You want to buy 125 marbles and wonder what the cost will be. Which choice below would you need to know?
    1) The marbles cost 19¢ per bag.
    2) The marbles are the XL-50 brand.
    3) The marbles come in 5 different colors.
    4) If you buy 10 bags of marbles, you get one bag free.

Library Problem

Trevor checked out 8 books from the library. He returned them 2 days after they were due. The library charged him 5¢ per day for each book. The bill looked like this.

8 books x 5¢ per book x 2 days late

Cost: 80¢

Use the above problem to answer items 16 - 18.

16. In the Library Problem, suppose Trevor had checked out only 6 books instead of 8. What could be done to find the cost?
    1) Multiply 8 x 6¢ x 2.
    2) Multiply 6 x 80¢.
    3) Multiply 6 x 5¢ x 2.
    4) Subtract 6 from 80.

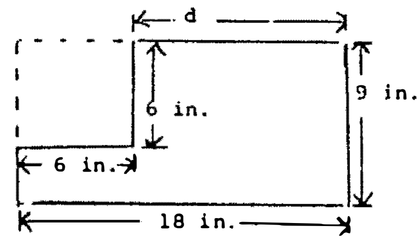
17. In the Library Problem, suppose Trevor had returned the 8 books just 1 day late. What could be done to find the cost?
    1) Divide 8 by 2.
    2) Multiply 8 x 5¢ x 1.
    3) Multiply 8 x 5¢ x 4.
    4) Multiply 2 x 80¢.

18. In the Library Problem, suppose the library charged 10¢ per day for each book. What could be done to find the cost?
    1) Multiply 2 x 80¢.
    2) Multiply 8 x 10¢ x 1.
    3) Add 10¢ to 80¢.
    4) Multiply 10 x 80¢.

---

19. The school cafeteria had 230 kg of milk to be shared by 46 children. The cook wanted to know how many glasses of milk each child could have. The cook could solve the problem if he <u>also</u> knew:
    1) There are 1000 grams in a kilogram.
    2) Each glass holds 0.2 kg of milk.
    3) The children all like milk.
    4) Each glass is 8 cm high.

20.



A 6 inch square was cut from the corner of the above rectangle. How long is d?

1) 3 in.
2) 6 in.
3) 12 in.
4) 15 in.

21. A farmer wishes to plant a row of trees 982 yards long for a windbreak. He will start at the old family tree and plant a tree every 2 feet. To find the number of trees he will need to plant he multiplied 982 yards by 3 and got 2946 feet. He then divided 2946 by 2, getting 1473 trees. Which problem below could be solved using exactly the same steps?
    1) The length of your step is 2 feet. How many yards will you walk in 982 steps?
    2) If the length of your step is 2 feet, how many steps must you take to walk 982 yards?
    3) You walk 982 yards in 2 minutes. On the average, how many yards do you walk each second?
    4) If the length of a very tall man's step is 2 yards, how many steps must he take to walk 982 feet?

22. Andy has a one-dollar bill and several coins. Tim has a 5 dollar bill and 31 cents in coins. The boys want to find out how much they have together. What else do they need to know?
    1) Andy has 43¢ in coins.
    2) Tim has a quarter, a nickel and a penny.
    3) Andy has exactly 7 coins.
    4) Together Tim and Andy have less than $10.

Use this information to answer items 23-25.

In football a touchdown is worth 6 points, the point after touchdown is 1 point and a field goal counts 3 points.

23. North High scored 2 touchdowns and one field goal in a game with East High, while East High scored one touchdown, a point after touchdown and 2 field goals. What was the final score?

    1) East High won 15 - 13.
    2) North High won 15 - 12.
    3) It was a 13 - 13 tie.
    4) North High won 15 - 13.

24. The Vikings scored 8 points by scoring a touchdown and a safety. How many points are given for a safety?

    1) 1 3) 5
    2) 2 4) 8

25. The Bears scored 3 touchdowns, 3 points after touchdown and some field goals. They scored a total of 30 points. How many field goals did they score?

    1) 2 3) 9
    2) 3 4) 10

---

26. A car can carry 6 children or 5 adults. The school principal wants to know how many cars are needed to drive to a football game. She could solve the problem if she also knew:

    1) 36 people are going to the game.
    2) 24 children and 15 adults are going to the game.
    3) 18 adult drivers are going to the game.
    4) 48 children are going to the game.

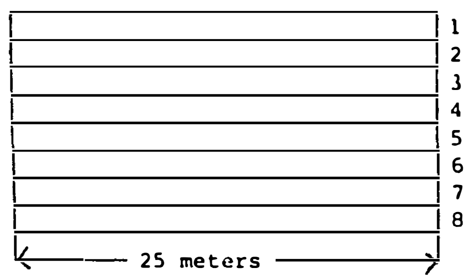
27. The price of a calculator was $12.99. Julius wanted to find out how much the calculator was reduced during a sale. What else would Julius need to know?

    1) It was an SR-18 calculator.
    2) It was a 5 function calculator.
    3) A 9-volt battery is included in the price.
    4) The sale price was $7.83.

28. Phil bought 2 pounds of peanuts for 98¢ a pound and 1 pound of lemon drops for 79¢ a pound. To find the total cost, Phil multiplied 2 times 98¢ and got $1.96. He then addeJ $1.96 + $.79 and got $2.75. Which problem below can be solved using exactly the same steps?

    1) I sold an Old Superman comic book for 79¢ and 2 Batman comic books for 98¢ each. How much money did I get altogether?
    2) I sold one Superman comic book for 79¢. How much more money do I need to buy 2 comic books at 98¢ each?
    3) I paid 98¢ for 2 comic books and sold them for 79¢ each. How much profit did I make on the sale?
    4) I sold 2 Superman comic books for 79¢ each and a Batman comic book for 98¢. How much money did I get altogether?

29. City Swimming Pool



The life guard at City Swimming Pool wants to find the width of the pool. She could find the width if she knew:

1) The pool is 25 meters long.
2) The water in the pool is 6 inches from the top.
3) The pool is 8 feet deep at one end.
4) There are 8 lanes each 7 feet wide.

30.

The distance from A to B is 4 Cm. About how far is it from B to C?

1) ½ cm. 3) 2 cm.
2) 1 cm. 4) 3 cm.

APPENDIX E

CREATIVE ABILITY IN MATHEMATICS TEST AND SCORING PROCEDURES

CREATIVE ABILITY IN MATHEMATICS

Name:____

School:____

Grade:______________________________Age:___________________

****

DIRECTIONS

The items in this booklet give you a chance to use your imagination to think up ideas and problems about mathematical situations. We want to find out how creative you are in mathematics. Try to think of unusual, interesting, and exciting ideas--things no one else in your class will think of. Let your mind go wild in thinking up ideas.

You will have the entire class time to complete this booklet. Make good use of your time and work as fast as you can without rushing. If you run out of ideas for a certain item, go on to the next item. You may have difficulty with some of the items; however, do not worry. You will not be graded on the answers that you write. Do your best!

Do you have any questions?

Do not open the booklet until you are told to do so.

****

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ITEM I

DIRECTIONS

Patterns, chains, or sequences of numbers appear frequently in mathematics. It is fun to find out how the numbers are related. For example, look at the following chain:

2 5 8 11 ____ ____

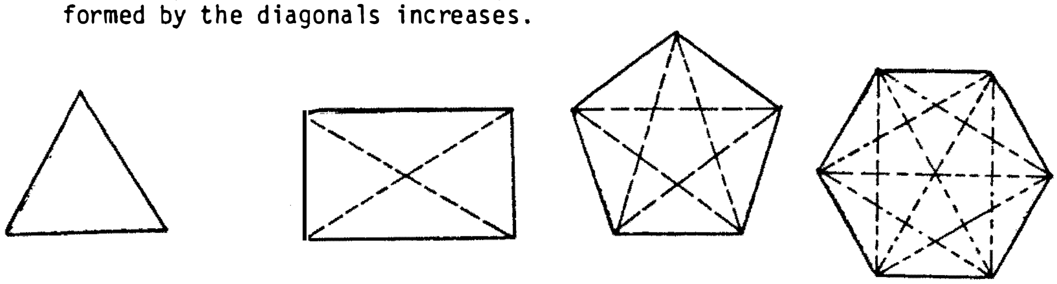
The difference between each term is 3; therefore, the next two terms are 14 and 17. Now look at the chain shown below and supply the next three numbers.

1 1 2 3 5 8 13 21 ____ ____ ____

ITEM II

DIRECTIONS

Below are figures of various polygons with all the possible diagonals drawn (dotted lines) from each vertex of the polygon. List as many things as you can of what happens when you increase the number of sides on the polygon. For example: The number of diagonals increases. The number of triangles formed by the diagonals increases.



ITEM III

DIRECTIONS

Suppose the chalkboard in your classroom was broken and everyone's paper was thrown away; consequently, you and your teacher could not draw any plane geometry figures such as lines, triangles, squares, polygons, or any others. The only object remaining in the room that you could draw on was a large ball or globe used for geography. List all the things which could happen as a result of doing your geometry on the ball. Let your mind go wild in thinking up possible ideas. For example: If we start drawing a "straight" line on the ball, we will eventually end up where we started. Do not worry about the maps of the countries.

ITEM IV

DIRECTIONS

Write down every step necessary to solve the following mathematical situation.

Suppose you have a barrel of water, a seven cup can, and an eight cup can. The cans have no markings on them to indicate a smaller number of cups such as 3 cups. How can you measure nine cups of water using only the seven cup can and the eight cup can?

ITEM V

DIRECTIONS

Suppose you were given the general problem of determining the names or identities of two hidden geometric figures, and you were told that the two figures were related in some manner. List as many other problems as you can which must be solved in order to determine the names of the figures. For example: Are they solid figures such as a ball, a box, or a pyramid? Are they plane figures such as a square, a triangle, or a parallelogram? If you need more space, write on the back of this page.

ITEM VI

DIRECTIONS

The situation listed below contains much information involving numbers. Your task is to make up as many problems as you can concerning the mathematical situation. You do not need to solve the problems you write. For example, from the situation which follows: If the company buys one airplane of each kind, how much will it cost? If you need more space to write problems, use the back of this page.

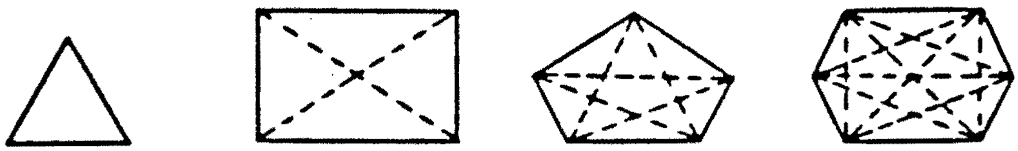
An airline company is considering the purchase of 3 types of jet passenger airplanes. The cost of each 747 is $15 million; 10 million for each DC10; and $6 million for each 707. The company can spend a total of $250 million. After expenses, the profits of the company are expected to be $800,000 for each 747, $500,000 for each DC 10, and $350,000 for each 707. It is predicted that there will be enough trained pilots to man 25 new airplanes. The overhaul base for the airplanes can handle 45 of the 707 jets. In terms of their use of the maintenance facility, each DC10 is equivalent to 1 1/3 of the 707's, and each 747 is equivalent to 1 2/3 of the 707's.

SCORING PROCEDURES AND WEIGHTS FOR CATEGORIES EXPRESSED ON CAMT DIVERGENT ITEMS

ITEM II

DIRECTIONS

Below are figures of various polygons with all the possible diagonals drawn (dotted lines) from each vertex of the polygon. List as many things as you can of what happens when you increase the number of sides on the polygon. For example: The number of diagonals increases. The number of triangles formed by the diagonals increases.



Scoring

Fluency: One point for each relevant response
Flexibility: One point for each category expressed
Originality: Zero, one, or two points for each category expressed, weighted according to the following schedule of categories

Category Expressed	Weight	Number of Subjects Expressing Category	Percent of Sample
Number of shapes, kinds of shapes, designs increases	0	281	56.2%
Number of lines, line segments, folds	0	164	32.8
Number of vertices or corners	0	154	30.8
Number of points of intersection or crosses	0	135	27.0

Category Expressed	Weight	Number of Subjects Expressing Category	Percent of Sample
Size, area of shapes formed in interior change	0	121	24.2
Polygon becomes more dense with diagonal lines, becomes black	0	87	17.4
Number of angles formed by diagonals increases	0	37	7.4
Number of angles formed by sides of polygons increases	0	32	6.4
Lengths of sides, line segments, lines changes	0	30	6.0
Distance (diameter) across polygon changes	1	24	4.8
Name of polygon changes	1	17	3.4
Area of, size of figure might, probably changes, increases	1	17	3.4
Types, kinds of triangles change	1	17	3.4
Number of planes, half-planes increases	1	17	3.4
Number of diagonals from each vertex increases	1	16	3.2
Polygon acquires shape of circle, rounded	1	15	3.0
Parallel diagonals, lines appear	1	12	2.4
Perimeter of figure probably increases	2	9	1.8

Category Expressed	Weight	Number of Subjects Expressing Category	Percent of Sample
Size of interior angles of polygons	2	9	1.8
Symmetry	2	5	1.0
Kinds, types of angles formed	2	5	1.0
Drawing altitude to triangle or figure increases, doubles number of shapes, triangles	2	4	0.8
Center point appears	2	4	0.8
Total degree measure increases	2	2	0.4
Types of lines, horizontal, vertical	2	2	0.4
Size of angles formed by diagonals	2	1	0.2
Number of 3-dimensional figures increases	2	1	0.2
Number of intersecting planes	2	1	0.2
Equations of lines	2	1	0.2
Radius changes	2	1	0.2

ITEM III

DIRECTIONS

Suppose the chalkboard in your classroom was broken and everyone's paper was thrown away; consequently you and your teacher could not draw any plane geometry figures such as lines, triangles, squares, polygons, or any others. The only object remaining in the room that you could draw on was a large ball or globe used for geography. List all the things which could happen as a result of doing your geometry on the ball. Let your mind go wild in thinking up possible ideas. For example: If we start drawing a "straight" line on the ball, we will eventually end up where we started. Do not worry about the maps of the countries.

Scoring

Fluency: One point for each relevant response
Flexibility: One point for each category expressed
Originality: Zero, one, or two points for each category expressed, weighted according to the following schedule of categories

Category Expressed	Weight	Number of Subjects Expressing Category	Percent of Sample
Figures, polygons would be distorted, round, stretched, curved	0	185	37.0
Straight lines would be curved	0	103	20.6
Entire figure could not be seen if very large	0	49	9.8
Figures would overlap, connect, touch if drawn large	0	48	9.6

Category Expressed	Weight	Number of Subjects Expressing Category	Percent of Sample
Measurement of distance, length is different	0	39	7.8
No planes would be present; no plane figures; plane would not be flat	0	34	6.8
Change in line direction would cause spiralling, intersections, unending line	0	29	5.8
Angle measurement would be different	1	19	3.8
Perfect circles could be drawn	1	16	3.2
Area of figures would be different	1	12	2.4
Radius, diameter, circumference could be found	1	11	2.2
Rays of angle would intersect	2	7	1.4
Figures would look 3-D	2	7	1.4
Two straight lines intersect in two points	2	4	0.8
If ball was large enough, geometry would not change much	2	3	0.6
Figures could cover ball	2	3	0.6
Volume is correct	2	2	0.4
Pythagorean Theorem would change	2	2	0.4

Category Expressed	Weight	Number of Subjects Expressing Category	Percent of Sample
Need to establish a new mathematical system	2	1	0.2
Axis of symmetry	2	1	0.2
Largest circle is "equator"	2	1	0.2
Straight angle would become closed curve	2	1	0.2
Imaginary line passing thru ball; three points determine triangle	2	1	0.2
Surface area of ball does not change	2	1	0.2

ITEM V

DIRECTIONS

Suppose you were given the general problem of determining the names or identities of two hidden geometric figures, and you were told that the two figures were related in some manner. List as many other problems as you can which must be solved in order to determine the names of the figures. For example: Are they solid figures such as a ball, a box, or a pyramid? Are they plane figures such as a square, a triangle, or a parallelogram? If you need more space, write on the back of this page.

Scoring

Fluency:	One point for each relevant response
Flexibility:	One point for each category expressed
Originality:	Zero, one, or two points for each category expressed, weighted according to the following schedule of categories

Category Expressed	Weight	Number of Subjects Expressing Category	Percent of Sample
Does it have sides? How many sides?	0	268	53.6%
Are they round, curved, circular, radial?	0	262	52.4
Type of polygon	0	181	36.2
Does it have vertices, points? How many vertices, points?	0	135	27.0
Do they have congruent sides, same length?	0	86	17.2
Are they plane figures, flat, drawn on paper?	0	82	16.4

Category Expressed	Weight	Number of Subjects Expressing Category	Percent of Sample
Does it have depth? Is it 3-D, found in space?	0	81	16.2
Do they have diagonals? How many diagonals?	0	46	9.2
Are they congruent, equal, similar, same size?	0	36	7.2
Kinds of angles, degrees	0	32	6.4
What is volume, area, circumference, perimeter?	1	21	4.2
Open or closed figures, curves	1	20	4.0
Are opposite sides parallel?	1	20	4.0
Number of angles	1	18	3.6
Does it have faces, bases? What type of faces?	1	17	3.4
Does it have straight sides?	1	14	2.8
Number of planes, surfaces	1	11	2.2
How many edges?	2	7	1.4
Can one plane (solid) figure fit inside another?	2	7	1.4
Are they symmetrical?	2	6	1.2
Combination of curved and plane areas	2	4	0.8
Shape of surfaces	2	4	0.8
Does it have a radius?	2	3	0.6
Does it have any arcs?	2	2	0.4

Category Expressed	Weight	Number of Subjects Expressing Category	Percent of Sample
Formula for finding area, volume, perimeter	2	2	0.4
Is it on a line?	2	2	0.4
Mathematical equations	2	1	0.2
Is it concave, convex?	2	1	0.2

ITEM VI

DIRECTIONS

The situation listed below contains much information involving numbers. Your task is to make up as many problems as you can concerning the mathematical situation. You do not need to solve the problems you write. For example, from the situation which follows: If the company buys one airplane of each kind, how much will it cost? If you need more space to write problems, use the back of this page.

An airline company is considering the purchase of 3 types of jet passenger airplanes. The cost of each 747 is $15 million; $10 million for each DC 10; and $6 million for each 707. The company can spend a total of $250 million. After expenses, the profits of the company are expected to be $800,000 for each 747, $500,000 for each DC 10, and $350,000 for each 707. It is predicted that there will be enough trained pilots to man 25 new airplanes. The overhaul base for the airplanes can handle 45 of the 707 jets. In terms of their use of the maintenance facility, each DC 10 is equivalent to 1 1/3 of the 707's, and each 747 is equivalent to 1 2/3 of the 707's.

Scoring

Fluency: One point for each relevant response
Flexibility: One point for each category expressed
Originality: Zero, one, or two points for each category expressed, weighted according to the following schedule of categories

Category Expressed	Weight	Number of Subjects Expressing Category	Percent of Sample
Cost for buying certain number of one type plane	0	138	27.6%
Cost for buying certain number of two or three types of planes	0	127	25.4

Category Expressed	Weight	Number of Subjects Expressing Category	Percent of Sample
Number of planes which can be purchased for $250 million or part of	0	103	20.6
Number of DC 10's or 747's which overhaul base can handle	0	99	19.8
Profits for certain numbers of two or three types of planes	0	76	15.2
Profits for certain number of one type plane	0	44	8.8
Money remaining after purchasing certain number of planes	0	31	6.2
Difference in plane costs	0	30	6.0
Number of planes which overhaul base can handle of two or three types	0	29	5.8
Size, percent, comparison of DC 10 and 747	1	22	4.4
What would be best choice, best buy, most economical purchase of planes	1	17	3.4
Difference in profits	2	9	1.8
Number of years a plane needs to be operated to pay for itself	2	7	1.4
Number of planes which could be purchased from profit of others	2	7	1.4

Category Expressed	Weight	Number of Subjects Expressing Category	Percent of Sample
Purchase of different numbers of two or more types. Which is better deal, investment, more profits?	2	6	1.2
Maximum profit	2	6	1.2
Will there be enough pilots if company purchases certain number of planes?	2	5	1.0
How many of one type plane can be purchased for cost of certain number of different type?	2	4	0.8
Percent of garage used by planes	2	4	0.8
Ratio of costs to profits	2	4	0.8
Profit in certain period of time	2	3	0.6
Expense for certain number of planes	2	2	0.4
Difference, comparison of use of maintenance facility	2	2	0.4
If company purchases certain number of one type, can they purchase another type?	2	2	0.4
Purchase of a certain plane, kept for certain number of years, is there a profit?	2	2	0.4

Category Expressed	Weight	Number of Subjects Expressing Category	Percent of Sample
Number of one type plane which could use maintenance facility if certain number of other types were already using it	2	1	0.2
Number of pilots needed, trained in certain number of years	2	1	0.2
If company wants certain number of planes, what is the best choice?	2	1	0.2
Maximum use of maintenance facility	2	1	0.2
Ratio of profit to size	2	1	0.2
Cost of planes for maximum use of maintenance facility	2	1	0.2
Cost per month for plane	2	1	0.2

APPENDIX F

TASK COMMITMENT MEASURES

Student Task Commitment Inventory

Student______________________School______________________Teacher______________________

Please check the column you think best characterizes the student for each of the following questions.	1 No Interest	2 Some Interest	3 Strong Interest	4 Intense Involvement
1. How does the student generally respond to daily school work assignments?				
2. What is your perception of the student's attitude toward the subject of mathematics?				
3. Does the student prefer to work alone without the help of peers or adults?				
4. Have you observed or known about this student being involved in or preoccupied with some project for an unusually long period of time?				
5. How does this student compare with others with respect to the characteristic of task commitment? (Please consider any and all activities--not just school work assignments. Use the scale of 1 to 4 with 4 being high in task commitment.)				

Task Commitment
Individual Interview

Name________________________________ School____________

1. Of the six questions, which was the <u>easiest</u> to answer and why?

2. Of the six questions, which was the <u>hardest</u> to answer and why?

3. If the answer did not come to you quickly, what types of things did you think about?

4. If the answer did not come to you quickly, how did it make you feel?

5. On which question did you spend the most time and why?

6. What do you like to do during the times you are not in school?

7. (Follow up from 6 . . . attempt to assess depths of involvement in this activity.)

	No Interest	Some Interest	Strong Interest	Intense Involvement
Scale	|	|	|	|

Task commitment with regard to this test.

APPENDIX G

LETTERS TO TEACHERS

M E M O R A N D U M

TO: Sandy Farlow, Ann Moats, Mary Wilson, Cathy Greenley, Jan Jones, Bobbie Lussier, Jill Robbins, Jean Black, Cheryl Galbraith, Janice Stamps

FROM: Charleen DeRidder

DATE: May 15, 1984

Thank you all very much for your interest and willingness to facilitate the mathematics study with your sixth graders. You have been most helpful and your students have been super.

Included with this memo are copies of a student task commitment inventory designed to procure your opinion of each participating student with respect to task commitment characteristics. There is a scale of one to four for you to check in response to 5 questions. The following description of each of the four points is offered as a guide.

1. <u>No Interest</u>: does not perform; performs because he/she has to
2. <u>Some Interest</u>: exhibits a certain amount of interest either consistently <u>or</u> on occasion
3. <u>Strong Interest</u>: seems to have a fairly high level interest either on a consistent <u>or</u> on an occasional basis
4. <u>Intense Involvement</u>: can become so engrossed in some task or productive activity that he/she is oblivious of all else.

The scale and questions are an attempt to assess both the level of commitment of which the student is capable and the frequency that task commitment characteristics seem to occur.

Thank you again for your wonderful help.

Copies: Susan Hutsell
Dr. Patricia Ubben
Brenda Watkins

April 11, 1985

To selected teachers at Cedar Bluff
Middle School:

Last spring several students from your school were selected to participate in an experimental study having to do with the identification of students who may be gifted in mathematics. These students were sixth graders at the time. There was a survey form used in an attempt to determine the sixth grade teachers judgement of the student's capability for task commitment. In order to help determine the validity of this survey instrument, it would be most helpful if you as a seventh grade teacher of some of these students, would complete this same survey form on the students who participated in this study.

If you have any questions about this request, please feel free to call me at any time. If you would return these forms on the truck by April 22 or 23 I would appreciate it very much.

Thanks so much.

Sincerely,

Charleen DeRidder

APPENDIX H

RAW DATA

Table 14

Raw Data of the Measures of This Study

N	G	TB	IQ	MA	PS	CA	TK
1	I	99	131	96	25	38	4
2	I	99	128	99	25	46	8
3	I	99	135	99	28	38	5
4	I	99	129	99	30	29	8
5	I	99	131	99	26	46	3
6	I	97	129	98	26	21	7
7	I	99	135	99	28	34	6
8	I	95	133	99	28	34	6
9	I	99	135	97	29	41	5
10	I	99	133	98	27	28	7
11	I	99	139	99	28	29	5
12	I	99	129	99	28	46	8
13	I	99	131	99	28	56	8
14	I	99	142	99	30	21	6
15	I	99	128	99	30	40	4
15	I	99	129	96	30	47	5
17	II	99	131	94	30	21	5
18	II	73	130	81	21	27	2
19	II	93	128	88	21	29	4
20	II	93	130	85	28	32	3
21	II	90	128	71	27	21	4
22	II	96	133	86	29	38	4
23	II	72	135	55	22	12	2
24	II	97	128	85	26	19	8
25	II	92	129	88	22	22	6
26	II	98	128	93	28	16	1
27	II	98	129	94	27	40	5

Table 14 (continued)

N	G	TB	IQ	MA	PS	CA	TK
28	II	96	135	86	26	34	5
29	II	82	133	74	22	20	4
30	III	99	125	99	26	20	7
31	III	99	124	99	28	38	3
32	III	98	126	96	27	12	3
33	III	99	116	99	27	26	5
34	III	96	120	99	30	25	8
35	III	97	123	98	28	30	4
36	III	85	116	97	26	39	4
37	III	99	116	99	29	19	4
38	III	99	120	99	30	24	5
39	III	95	124	96	28	22	5
40	III	97	121	96	24	72	6
41	III	98	127	98	30	34	4
42	III	99	123	99	26	20	5
43	III	99	127	99	30	26	8
44	IV	89	116	73	17	27	2
45	IV	91	118	83	25	25	7
46	IV	95	120	92	27	36	2
47	IV	95	123	92	23	20	3
48	IV	94	122	86	28	25	3
49	IV	82	127	93	26	14	2
50	IV	95	125	85	26	37	3
51	IV	75	123	85	27	8	3
52	IV	85	118	80	25	12	4
53	IV	89	116	92	24	21	5
54	IV	76	119	64	23	4	7
55	IV	97	120	94	27	40	3
56	IV	87	118	85	23	28	4

Table 14 (continued)

N	G	TB	IQ	MA	PS	CA	TK
57	IV	76	116	58	21	18	2
58	IV	92	119	94	25	17	2
59	IV	91	123	90	25	17	2
60	V	99	112	98	28	24	8
61	V	98	110	99	24	27	5
62	V	92	114	96	24	11	5
63	V	98	111	96	26	16	3
64	V	97	110	98	29	49	5
65	V	89	109	99	25	29	4
66	V	91	111	97	28	21	3
67	V	98	112	97	28	34	5
68	V	85	114	96	29	36	3
69	V	99	114	99	26	18	5
70	V	87	111	97	26	39	2
71	V	92	107	98	27	32	3
72	VI	81	102	80	26	22	3
73	VI	79	108	74	13	12	2
74	VI	73	97	73	19	18	3
75	VI	73	107	80	10	12	3
76	VI	82	106	90	25	24	1
77	VI	83	109	83	25	25	3
78	VI	86	105	71	20	19	4
79	VI	71	104	50	22	20	5
80	VI	75	105	62	23	21	1
81	VI	97	110	94	27	37	2
82	VI	86	110	85	25	30	3
83	VI	73	104	74	24	19	3
84	VI	72	105	78	17	19	3

Table 14 (continued)

N	G	TB	IQ	MA	PS	CA	TK
85	VI	75	114	64	23	19	6
86	VI	85	112	94	25	34	4
87	VI	85	112	74	21	33	6

Note: N = Subject Number
G = Group Number
TB = Total Achievement Battery Percentile
IQ = Otis Lennon I.Q. Score
MA = CA Mathematics Achievement Test Percentile
PS = IPSP Test Score
CA = CAMT Test Score
TK = Score of Task Commitment Measures

APPENDIX I

LETTER OF EXEMPTION FROM REVIEW

THE UNIVERSITY OF TENNESSEE. KNOXVILLE
KNOXVILLE 37996-0140

OFFICE OF THE VICE CHANCELLOR
FOR RESEARCH

404 ANDY HOLT TOWER

AREA 615
TELEPHONE: 974-3466

May 10, 1984

Charleen M. DeRidder
2904 Barber Hill Lane
Knoxville, TN 37920

Dear Ms. DeRidder:

The project which you submitted entitled, "An investigation of the relationship of creative and problem solving ability in mathematics with IQ and achievement test scores of 6th grade students," CRP #A-225, has been reviewed.

This project comes within the guidelines which permit me to certify that the project is exempt from review by the Committee on Research Participation.

The responsibility of the project director includes the following:

1. Prior approval from the Dean for Research must be obtained before any changes in the project are instituted.

2. A statement must be submitted (Form D) at 12-month intervals attesting to the current status of the project (protocol is still in effect, project is terminated, etc.).

The Committee wishes you success in your research endeavors.

Sincerely,

Marla Peterson

Marla Peterson
Dean for Research

scw

cc: Dr. L. Evans Roth
Dr. J. J. Bellon
Dr. Donald J. Dessart

NOTE: Please add a statement that nonparticipation in and/or withdrawal at any time from this project will entail no penalty to the child. This should be in both the body of the cover letter as well as the signature portion at the bottom of the letter.

Please obtain verbal assent from the children that they are willing to participate in this project in addition to the written consent of the parents.

VITA

Charleen Mitchell DeRidder was born in Sweetwater, Texas, on January 7, 1930. Her parents, Eloise Albee and Charles Abram Mitchell, moved to Michigan before she was of school age so she received her elementary schooling in Muskegon and then in Grandville, Michigan. She graduated from Grandville High School in 1947 as class valedictorian. She attended Grand Rapids Junior College and graduated in 1949. She received an alumni scholarship to the University of Michigan where she completed her undergraduate education with a major in English, receiving a Bachelor of Arts degree in 1951.

After teaching one year at Hudson High School in Michigan, she married Lawrence M. DeRidder, now Professor of Educational Psychology and Guidance at the University of Tennessee, Knoxville. She is the mother of six children.

She was employed by the Knox County School System in 1964. She taught junior high mathematics and science until 1967 at which time she transferred to a high school position. She was in the National Science Foundation summer mathematics institutes at the University of Tennessee in 1967 and 1968, and completed her Master's degree in Mathematics Education in 1969. In 1973, she was made Mathematics Supervisor for the Knox County Schools, the position she currently holds. She was Project Director of the Title II Knox County Mathematics Basic Skills Improvement Program in 1980-82. In 1980 she began work on her doctorate at the University of Tennessee, Knoxville, and served as Guest Lecturer in Mathematics Education in 1983-84.

In 1983 she was the recipient of the Ellis and Ogden Recognition of Outstanding Achievement by Alumnae Award and in 1984 she was awarded a NSF-ICME fellowship to represent the United States at the Fifth International Congress on Mathematical Education in Adelaide, Australia.

She serves as a reviewer for Investigation in Mathematics Education and a referee for The Mathematics Teacher and The Arithmetic Teacher. As of 1986, she was appointed to the National Council of Teachers of Mathematics Instructional Issues Advisory Committee. She is also an active participant in the National Council of Supervisors of Mathematics. Other professional affiliations include the Mathematics Association of America, School Science and Mathematics Teachers Association, Association for Supervision and Curriculum Development, Phi Kappa Phi, Phi Delta Kappa, and Pi Lambda Theta.