THE DEVELOPMENT OF A CREATIVITY TEST IN MATHEMATICS AND THE ESTABLISHMENT OF RELIABILITY AND VALIDITY COEFFICIENTS FOR THE TEST

KAREN MITCHELL PENDERGRASS

THE DEVELOPMENT OF A CREATIVITY TEST IN MATHEMATICS AND THE ESTABLISHMENT OF RELIABILITY AND VALIDITY COEFFICIENTS FOR THE TEST

An Abstract

Presented to

the Graduate Council of

Austin Peay State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in Education

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by

Karen Mitchell Pendergrass

August 1971

ABSTRACT

The purpose of this study was to develop a test to measure creativity in mathematics. The test was developed on the premises that creativity in mathematics occurs in both divergent and convergent thinking situations; creativity is related to discovery learning; and creativity in mathematics is the discovery of new relationships existing in patterns and symbols. It was also the purpose of this study to develop both reliability and validity coefficients for the test.

The test was first constructed and given to sixteen students. The purpose of this pilot study was to determine the amount of time needed to complete the test and to determine if any of the questions were incorrectly worded. The test was then revised and given to fifty-one students enrolled in three mathematics classes at Clarksville High School and one mathematics class at Fort Campbell High School. Each student's mathematics teacher was asked to evaluate the student's creative ability in mathematics. The teachers were given a definition of creativity in mathematics and they were asked to use the definition along with their own ideas of creativity in evaluating their students. The students were ranked on a scale consisting of five different levels of creativity ranging from a very low form of creativity to a very high form of creativity.

The test cannot be used to distinguish between differences in individual scores, since the reliability coefficient of 0.77 was not as high as 0.90. The validity coefficient, 0.73, the eta correlation ratio, was significant at the 0.05 level of confidence.

The level of creativity was a significant predictor of the student's score.

THE DEVELOPMENT OF A CREATIVITY TEST IN MATHEMATICS

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To the Graduate Council:

I am submitting herewith a Thesis written by Karen Mitchell Pendergrass entitled "The Development of a Creativity Test in Mathematics and the Establishment of Reliability and Validity Coefficients for the Test." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts in Education, with a major in Mathematics.

William G. Stokes
Major Professor

We have read this thesis and recommend its acceptance:

George M. Rawlins, III
Second Committee Member

James T. Stack
Third Committee Member

Accepted for the Council:

Wayne E. Stamper
Dean of the Graduate School

ACKNOWLEDGEMENTS

This author wishes to express her appreciation to Dr. William G. Stokes, Dr. George Rawlins and Dr. Ernest Woodward for their suggestions and understanding in making this study a reality. Sincere appreciation is also extended to Mr. Dan Burden and Mr. Frank Davis, mathematics teachers at Clarksville High School and Fort Campbell High School, respectively, for their cooperation in this study.

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CHAPTER I

THE NATURE OF THE PROBLEM

INTRODUCTION

During the past two decades creativity has been the center of much research. Many different tests have been developed which have as their goal the measurement of creativity or at least relative creativity. There no longer exists the stereotype of a creative person as an abnormal, unadjusted individual. There are several reasons for this sudden interest in the field of creativity. One reason is that creativity and creative thinking have been neglected in public education for years. Lately it has been discovered that many of the so called "underachievers" and "overachievers" in the schools are very creative individuals.[1] Another reason for the emphasis on creativity is a desire that men must learn to think and have ideas of their own. Razik discussed the reason for the sudden interest in creativity in the following excerpt:

> In the presence of the Russian threat, "creativity" could no longer be left to the chance occurrence of the genius; neither could it be left in the realm of the wholly mysterious and the untouchable. Men 'had' to be able to do something about it; creativity had to be a property in many men; it had to be something identifiable; it 'had' to be subject to the effects

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[1]Jacob W. Getzels and Philip W. Jackson, Creativity and Intelligence Explorations with Gifted Students (London: John Wiley and Sons, Inc., 1962), pp. 26-27.

of efforts to gain more of it. Through necessity, the basic concept of creativity thus changed from something heretofore soft and sentimental to something hard and realistic, closely, connected with hardware and survival, as are the machines of war and industrial production. Research on creativity became legitimized as a properly serious concern of the military, government, and industry.

As work progressed in defining and identifying aspects of creative behavior in adults, the words and conceptions coming to be used could be recognized by educators as those commonly used to characterize the behavior of young children. The similarity was too obvious to be missed and, this time, there was need to see the connection. If children came endowed with creative capacities, then the role of education, in serving the national need, would be to recognize these capacities, and to develop them through the students' growing years into adulthood. In this way, cultivating creativity might be possible to provide for the vast numbers of people needed in the creative developments of the future. This could now be the vision of those educators who wanted to see education in the new role.[2]

Different studies show that intelligence tests and achievement tests do not measure creativity. These traditional tests are tied to the narrow limits of those abilities cultivated by the school.[3] Teachers and educators cannot rely on these traditional measures in testing for creativity.

Educators who have wanted to promote education for creativity have, therefore, come face to face with a formidable problem. Traditional measurements are deeply rooted in school practice, as are the narrow concepts on which they are based. New measures and concepts, sufficiently strong to compete with the old, are required. Tests are needed which include the new dimensions and which are pragmatically useful to classroom teachers in spotting creative behaviors in students and in judging the progress of students (and hence the effectiveness of

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[2]Taher A. Razik, "Psychometric Measurement of Creativity," Explorations in Creativity, eds. Ross L. Mooney and Taher A. Razik (New York: Harper and Row, Publisher, Inc., 1967), p. 302.

[3]Ibid., p. 203.

the teaching) in the development of creative abilities. . .[4]

Little research has been conducted in the field of creativity in mathematics. The existing tests in the field of creativity seem to measure verbal or non-verbal creativity but not mathematical creativity. There is a need for the construction of tests that will measure creativity in mathematics, and these tests need to be of use to the classroom mathematics teacher. The teacher would then be able to evaluate his own effectiveness in teaching his students to think creatively. It was the purpose of this study to develop a test that measured creativity in mathematics and establish reliability and validity coefficients for the test.

THE PROBLEM

A test was first constructed which had as its aim the measurement of creative thinking in mathematics. This test was then given to sixteen seniors enrolled in analytical geometry at Clarksville High School. The purpose of this pilot study was to determine the time needed for completion of the test and to discover if certain test questions were not worded clearly. This test was revised and given to fifty-one juniors and seniors. Six of the subjects were enrolled in advanced mathematics at Fort Campbell High School. The remainder of the subjects were students at Clarksville High School. Eleven of the subjects were enrolled in elementary functions; nine were enrolled in matrix algebra; and twenty-five were enrolled in Algebra II.

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[4] Ibid.

The teachers of the mathematics classes were given forms consisting of a scale numbered from one through five. They rated their students in terms of their creative abilities in mathematics.

The test papers were scored and a reliability coefficient was established through use of the Spearman-Brown formula. The scores of the students and their respective ratings by their teachers were used to establish a form of validity.

DEFINITION OF TERMS

Most of the terminology in this study followed the accepted meanings found in standard reference works in the fields of mathematics and education. However, there are several terms used in this study which require specific definitions. These definitions are given below:

Convergent Thinking. Convergent thinking was defined as a form of productive thinking which begins with given facts and information and proceeds logically to a conclusion. In this paper a question involving convergent thinking abilities involved the ability of a student to take given information and reason toward one correct solution.

Divergent Thinking. Divergent thinking was defined as a form of productive thinking involving a problem which had many possible solutions. Divergent thinking which involved both imagination and fluency occurred on two problem of the test. Another question involved divergent thinking, but only one solution was required.

DELIMITATION OF THE STUDY

There has been much progress in the study of creativity in the past few years, but there is still a large area of creativity that has not been thoroughly investigated. Tests involving creativity have been developed but researchers disagree as to whether they actually measure creativity. Thus, the measurement of creativity is not in itself an exacting field. Another problem is that teacher ratings may not be a good measurement of creativity. There is research which will support the fact that teachers can predict creativity, but there is also research which points to the fact that teachers sometimes are not good predictors of creativity.

CHAPTER II

REVIEW OF RELATED LITERATURE

A GENERAL DISCUSSION OF CREATIVITY

Creativity has been defined in many different ways, but generally creativity is defined as an appropriate but unusual idea or response to a problem. E. Paul Torrance, a well-known researcher in the field of creativity, chose to define creative thinking as "the process of sensing gaps or needed missing elements; of forming ideas or hypotheses concerning them; of testing these hypotheses; and of communicating the results, possibly modifying and retesting the hypotheses."[5] Torrance found that it is natural for man to learn creatively. In each of the four stages in his definition of creativity, vital human needs are involved. When a person senses that something is wrong, he automatically starts to look for an answer to his problem. Humans cannot tolerate uncertainty and, thus, look for solutions to problems even though some of the guesses may not be real solutions to the problem. When he does find an answer, it is only natural for him to tell another person about it. Thus, learning creatively is not something mysterious but something natural. Learning creatively involves questioning, experimenting and manipulating ideas and materials. The act of creative

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[5] E. Paul Torrance, Education and the Creative Potential (Minneapolis, Minnesota: The University of Minnesota Press, 1963), p. 90.

thinking requires abilities measured by a creativity test. These abilities are fluency, flexibility and elaboration. Torrance felt that a person cannot fully function mentally unless these abilities are identified and developed to the fullest.[6]

Getzels and Jackson found that creativity exists in some form and at some level in everyone. Hence a measure of creativity becomes a measure of relative creativity. Their tests measuring creativity involved the ability of their subjects to deal with verbal and numerical symbols in a new, inventive way. The score a subject received was based on number, appropriateness, complexity and originality of the solution.[7] Their studies revealed that there was very little correlation between creativity and intelligence. There was some relation between intelligence and creativity since someone with an extremely low intelligence quotient was not creative, but this did not mean that the higher the level of intelligence the higher the level of creativity. In fact, when the subjects had high average and above intelligence, the correlation between creativity and intelligence in some studies has been negative.[8]

James A. Smith and Alvin M. Westcott stated, "creativity is discovery--discovery of one's self and one's ability to respond uniquely

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[6]Ibid., pp. 46-47.

[7]Getzels and Jackson, op. cit., pp. 15-17.

[8]Ibid., p. 26.

to a stimulus."[9] The process of problem-solving or creative thinking can be divided into four phases. The first is "recognition and definition of a problem, relation to the problem; sometimes called the exposure stage." It is this stage of creativity that sets the highly creative person apart from other less creative people, because the creative person is supersensitive to problems and therefore can recognize more problems. The second phase is the "fact-finding or incubation stage" which consists of gathering information. The creative person sees more relationships and is apt to follow his own intuitions and disregard accepted knowledge in looking for solutions to problems. The third phase consists of "hypothesizing; experimenting; illumination." The fourth phase consists of "selection, verification, and elaboration or solution." In the last two phases the more creative an individual the more solutions he discovers. Hence creativity can be linked to discovery since the steps in creative problem-solving are closely related to the steps in discovery learning.[10]

CREATIVITY AND ITS RELATIONSHIP TO DIVERGENT AND CONVERGENT THINKING

J. P. Guilford and his associates have attempted to analyze the different factors related to intelligence. In their cubical model for intelligence five major groups of mental operations have been classified: factors of cognition, memory, convergent thinking,

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[9] James A. Smith and Alvin M. Westcott, Creative Teaching of Mathematics in the Elementary School (Boston: Allyn and Bacon, Inc., 1967), p. 131.

[10] Ibid., pp. 120-121.

divergent thinking and evaluation. Another face of the cube consists of four different types of content: figural, symbolic, semantic and behavioral. Six different kinds of products have been identified: products of unit, class, relation, system, transformation, and implication. The five mental operations are applied to the four kinds of content and six kinds of products to make possible one hundred twenty different mental abilities.[11] So far, approximately sixty of these mental abilities have been identified. In order to understand the relation between creativity and these operations the five mental operations must be examined. The cognitive operations involve the ability to recognize and to become aware of certain things. Secondly, the operations of memory involve remembering what has been cognized. Divergent and convergent thinking are kinds of productive thinking. Divergent thinking is involved when there is more than one solution to a problem where as convergent thinking is directed toward only one possible solution. Evaluation occurs when something has been cognized, memorized and produced. In the past it was thought that creativity occurred only in divergent production and transformations. Recent research has shown that creative thinking can occur in the convergent production category and in the evaluation category along with redefining abilities.[12]

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[11]Mary Nacol Meeker, The Structure of Intellect-Its Interpretation and Uses (Columbus, Ohio: Charles E. Merrill Publishing Co., 1969), pp. 8-9.

[12]E. Paul Torrance, op. cit., pp. 93-94.

CREATIVITY IN MATHEMATICS

The previous definitions and descriptions of creativity have only defined or described creativity in a general sense. All of the previous discussion can be used to describe creativity in mathematics. Smith and Westcott also discussed the meaning of creativity in mathematics in specific terms.

> Creativity in mathematics is the birth or discovery of number patterns; the development of new relationships between mathematical ideas; the modification and/or variance of existing patterns, symbols, and relationships; the contrivance of new symbolism and organization of symbols; the discovery of new applications of mathematical ideas. As mathematics is in reality a system of related ideas, so creativity in mathematics can simply be defined as the production of new relationships.[13]

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[13] Smith and Westcott, op. cit., p. 210.

CHAPTER III

THE STUDY

THE PILOT STUDY

The Test for the Pilot Study

A test was first developed which had as its purpose the measurement of creativity in mathematics. It was developed on the premises that creativity occurs in both divergent and convergent thinking situations; creativity is related to discovery learning; and creativity in mathematics is the discovery of new relationships existing in patterns and symbols.

The test used in the pilot study is in Appendix A. This test consisted of twenty items; items 1 through 18 were convergent-type thinking questions, and items 19 and 20 were divergent-type thinking questions. Items 1, 2, 4, 5, 7, 8 and 10 tested the ability of the student to find certain patterns in both numbers and abstract symbols. Items 3, 12, 13, 14, 15 and 17 tested the ability of the student to see different geometrical ideas. These questions pertaining to geometry did not involve mathematical proof, but they measured the ability of the student to recognize different geometrical concepts. Items 6, 9, 11, 16, and 18 dealt with general reasoning ability. The only mathematical concepts involved on item 19 were the arithmetic operations of addition, multiplication, division and subtraction. Item 20 involved elementary set theory. The student needed to be aware of the meaning of the terms union, intersection, and the empty set, and he also needed some experience in finding unions and intersections of sets. All of the students who took this test had been introduced to elementary set theory. In this question the definition of a topological space was given and the students were asked to use the definition to list as many topological spaces as possible for a set X.

The Procedure for the Pilot Study

The test was given to sixteen seniors enrolled in analytic geometry at Clarksville High School. It was given in order to establish the time needed for completion of the test and to discover if certain questions were not worded clearly. The students were allowed to ask questions so that the author could determine if particular questions were not clear.

In scoring the test, the convergent-type questions, items 1 through 18, were given a value of one point each for a correct response by the student. The student was not penalized for any incorrect responses. There were many different correct responses to the two divergent-type thinking questions, and the student was encouraged to arrive at several different solutions to each of these questions. Each correct response was given a value of one point. The final score a student received was the sum of all of the points awarded on both the divergent and convergent-type thinking questions. The scores of these students can be found in Table I of Appendix B.

Results of the Pilot Study

It was found that the students completed the test well within the allotted time of one class period of approximately fifty minutes. Since the students had more than enough time to complete the test, two more questions were added. One of these questions was a convergent-type thinking question and the other was a divergent-type thinking question. These two questions are items 19 and 20 on the test used in the study and this test can be found in Appendix A. Items 2, 6, 9, 11, 13, 14, 22 and 23 on the pilot study test were reworded because they were either misunderstood by the students or the wording made the problem extremely easy. Items 1 through 18 on the pilot study test, with the exception of different wording, corresponded to items 1 through 18 on the test used in the actual study. Item 19 on the test used in the study was the newly added convergent-type thinking question and item 20 on the same test was the added divergent thinking question. Items 19 and 20 on the pilot study test corresponded to items 21 and 22 on the test used in the study.

THE STUDY

The Procedure for the Study

The revised test described in the preceding section and located in Appendix A was given to fifty-one juniors and seniors enrolled at Clarksville High School and Fort Campbell High School. The test was given to these subjects in May of 1971.

The procedure for scoring the papers was similar to the procedure used in scoring the pilot study test. One point was awarded for each of the correct responses on items 1 through 19. Although item 20 was a divergent-type thinking question and there were several possible solutions, only one solution was required and one point was given for a correct solution. One point was awarded for each different correct solution to item 21 and to item 22. A subject's score was the total of all of these points. These scores are located in Table II of Appendix B.

The Teacher Evaluation

A student's mathematics teacher was asked to evaluate the student's creative ability in mathematics. The mathematics teachers were given a definition of creativity in mathematics, and they were asked to use the definition along with their own ideas of creativity in mathematics in evaluating their students. The creativity rating form consisted of the numerals one through five. Five represented the highest level of creativity and one the lowest level of creativity in mathematics. The teachers were asked to circle the numeral which best represented a student's level of creativity in mathematics. Both the directions given the teachers and a creativity rating form are located in Appendix C.

CHAPTER IV

THE RESULTS

The reliability coefficient for the test was established by the split-half technique. This was done by correlating the odd-numbered items on the test with the even-numbered items. The product-moment correlation was used to establish the correlation between the odd-numbered and even-numbered items, and this procedure gave the reliability for a test only one half the length of the creativity test. This correlation was 0.62. A t-test was applied to the product-moment correlation in order to test the significance of the correlation, and the value for t was 5.37. Since the value of t at the 0.01 level of confidence for forty-nine degrees of freedom is less than 5.37, the correlation between the odd-numbered and even-numbered problems on the test is significantly different from zero at the 0.01 level of confidence.[14]

The product-moment coefficient was applied to the Spearman-Brown formula to arrive at a correlation coefficient for the entire test. This correlation was 0.77. A test which will be used to differentiate between individuals should have a reliability of 0.90 or better. The reliability coefficient for the creativity test is lower

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[14] G. Milton Smith, A Simplified Guide to Statistics for Psychology and Education (New York: Holt, Rinehart and Winston, Inc., 1962), pp. 96-100.

than recommended in order to differentiate between individual scores. This is due to the low correlation between the odd-numbered test items and even-numbered test items. Although the product-moment correlation was significantly different from zero, its numerical value was not high enough to produce a reliability coefficient of at least 0.90 for the entire test.[15]

The correlation ratio, eta, was used to establish a validity coefficient for the test. Eta can be used to indicate the degree of effectiveness in predicting an interval-scaled dependent variable from a predictor or independent variable. Eta was found to be 0.73. A test for significance of eta is the F ratio. The F ratio of an eta of 0.73 was 14.54. This F ratio is significant at the 0.05 level of confidence with four and forty-six degrees of freedom. Thus the creativity ranking of a student was a significant predictor of the student's achievement on the test.[16]

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[15] Ibid.

[16] Thad R. Harshbarger, Introductory Statistics: A Decision Map (New York: The Macmillan Company, 1971), pp. 403-413.

CHAPTER V

SUMMARY AND CONCLUSION

The purpose of this study was to construct a test which had as its goal the measurement of creativity in mathematics and to establish reliability and validity coefficients for the test. With the recent emphasis on creativity and creative teaching, the study seemed justifiable. There was very little past research on creativity in mathematics.

In March of 1971, the test was given to sixteen students. This test was then revised and given to fifty-one students. The respective mathematics teachers of these fifty-one students then ranked their student's creative ability in mathematics. The students were ranked on a scale consisting of the numerals one through five. The numeral five represented a very high form of creativity and the numeral one represented the lowest form of creativity in mathematics. The numerals two, three, and four represented various levels of creativity between the lowest level, one, and the highest level, five. The reliability coefficient for the test was 0.77 and the validity coefficient was 0.73.

On the basis of the test scores and the reliability and validity coefficients the following conclusions were reached:

1. Since the reliability coefficient was not 0.90 or higher the

creativity test cannot be used to differentiate between individual scores.

2. The creativity rank of a student was a significant predictor of his score on the test at the 0.05 level of confidence.

On the basis of this study, the following are suggested:

1. A test should be developed which is longer in length and covers a variety of different aspects related to mathematical creativity. Lengthening the test could possibly aid in raising the reliability coefficient to at least 0.90. One of the weaknesses of the creativity test used in this study was that it was short and did not deal with a variety of mathematical topics.

2. The use of more divergent-type thinking questions on creativity tests in mathematics should be investigated. Several students answered most of the convergent-type questions correctly, but they did not attempt the divergent questions.

3. The study of creativity in mathematics should be extended to the elementary school. Creativity in mathematics needs to be identified in the lower grades so that creative children can receive special training in mathematics. The test used in this study would not be suitable for identifying creative talent in the elementary grades.

4. A different method of establishing validity of a creativity test should be investigated. As previously stated there is a great deal of disagreement as to the extent to which teachers can identify creative behavior.

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APPENDIX A

APPENDIX A

THE TEST FOR THE PILOT STUDY

NAME_______________

YEAR IN SCHOOL_____

MATH COURSE________

In most of the problems on this test the only mathematics that will be needed is arithmetic. Most of the problems do require thought and reason. If you will read the problem carefully, you will find that many symbols are explained. If you do not know the answer to a problem, you should go to the next problem. Extra paper will be provided but please record your answers on this sheet.

PROBLEMS

1. There is a pattern in the following series of numbers. fill in the missing blanks.

   1 4 7 10 13 16 ___ ___

2. | | |
   |---|---|
   | 15 | 13 |
   | 10 | 8 |

   The numbers in the square are related. Look for sums or differences between the numbers. Fill in the missing blank in the square below using the same relation used in the given square.

8	5
	9

3. Is it possible to draw a line or more than one line which will divide a square into exactly two squares of equal area?

   Circle: Yes No

4. Fill in the following blanks with the appropriate figure in the pattern of figures. △ ○ □ □ △ ○ □ ___ ___

5. Each number in the first row is related to the corresponding number in the second row. Fill in the missing blanks.

1	3	6	7	9	4	5	8
4	10	19	22	28	13	___	___

6. The light goes out as a man is packing for a trip. There are 5 pairs of socks in a drawer. What is the least number of socks that the man will have to pull out of the drawer to assure he will have two pairs of socks?

Answer: ________________

7. Let B be an operation between a set of ordered pairs.

(2,3) B (1,6) = (3,19)
and (3,5) B (4,2) = (13,11)
Then (3,6) B (3,8) = (,)

8. Let + and x be two operations defined as follows:

+	a	b
a	b	a
b	a	b

x	a	b
a	a	b
b	b	a

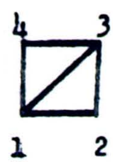
Fill in the blanks. (a+b) x (b+b) = ________________

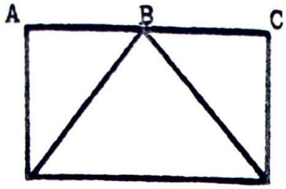
9. Two hours after 3 o'clock it is 5 o'clock. Fifteen hours after 3 o'clock is 6 o'clock. What time is it 340 hours after 3 o'clock?

10. The symbol $\propto$ transforms $(x,y) \xrightarrow{\propto} (x/2,3y)$.
Then $(4,5) \xrightarrow{\propto} (\; , \;) \xrightarrow{\propto} (\; , \;)$.

11. There are 4 committees each with 3 members in a school club. Every member of the club is on 2 and only 2 committees, but the same 2 people cannot serve on more than one committee together. For example, if Tom and Jane are on Committee I, they both cannot be on Committee II. How many people are in the club? ________________

12. If the square below is flipped over along the diagonal from 1 to 3 and then turned 90 degrees clockwise, what number will be in the position marked 1? ________________

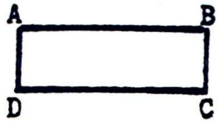


13. 

The figure to the left shows a triangle inscribed in a rectangle. The length from A to B is the same as the length from B to C. What is the relation between the area of the triangle and the area of the rectangle?

14. Is the following statement true?

If the diagonals of a quadrilateral are congruent (equal in length) and bisect each other, then the quadrilateral is a rhombus.

15. 

The rectangle to the left has a perimeter of x. The length from A to B is three times the length from B to C. What is the area of ABCD in terms of x?

16. Is the following argument valid? (Does the last statement follow from the first two statements?)

Everyone who studies will pass.
Mary does not study.
Therefore, Mary will not pass.

Please circle: valid   invalid

17. One angle of a triangle measures 60 degrees. The ratios of the angles in the triangle are 2:3:4. What are the other 2 angles?

18. There are 3 roads from A to B and 4 from B to C and 1 from A to C. How many different ways can a person travel from A to C?

19. Let x, ÷, +, - and = stand for multiplication, division, addition, subtraction and equality, respectively. Using the above symbols and the numbers 3, 4, 12, write as many equations as you can. Y ou may also use parentheses.

20. Let X be a set and T be a collection of subsets of X. T is a topological space for X if and only if

1) The union of each subcollection of T is an element of T.
2) The intersection of each subcollection of T is an element of T.

Let X= {a, b, c} . We know that the subsets of X are φ , {a}, {b}, {c} , {a,b} , { a,c} , {b,c} , {a,b,c} . If T is the set {φ, {a} , {a, b, c}} then T is a topological space for X because the union of each subcollection of T is in T and the intersection of each subcollection of T is in T. List as many T's that are topological spaces for X as you can.

THE TEST FOR THE STUDY

NAME ____________________

YEAR IN SCHOOL _________

MATH COURSE ____________

On most of the problems in this test the only mathematics that will be needed is arithmetic. Most of the problems do require some thought. If you will read the problem carefully, you will find that many symbols are explained. If you do not know the answer to a problem, you should go to the next problem. Do not spend too much time on any one problem. Extra paper will be provided but please record your answers on the test.

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1. There is a pattern in the following series of numbers. Fill in the missing blanks.

   1 4 7 10 13 16 __ __

2. The numbers in the square to the left are related by a certain pattern. Fill in the missing blank in the square below using the same pattern used in the given square.

15	13
10	8

8	5
	9

3. Is it possible to draw a line or more than one line which will divide a square into exactly two squares of equal area?

   Please circle: Yes No

4. Fill in the following blanks with the appropriate figures in the following pattern of figures.

   △ ○ □ □ △ ○ □ __ __

5. Each number in the first row is related to the corresponding number in the second row. Fill in the missing blanks.

1	3	6	7	9	4	5	8
4	10	19	22	28	13	__	__

6. The light goes out as a man is packing for a trip. There are 5 different pairs of socks in a drawer. What is the least number of socks that the man will have to pull out of the drawer to assure he will have two pairs of socks?

Answer: ____________

7. Let B be an operation between a set of ordered pairs.

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and (2,6) B (4,2) = (13,11)
Then (2,6) B (3,8) = (,)

8. Let + and x be two operations defined as follows:

+	a	b
a	b	a
b	a	b

x	a	b
a	a	b
b	b	a

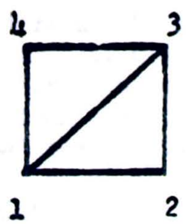
Fill in the blanks. (a+b) x (b+b) = ____________

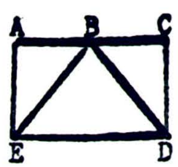
9. Two hours after 3 o'clock is 5 o'clock. Fifteen hours after 3 o'clock is 6 o'clock. What time is it 340 hours after 3 o'clock? ____________

10. The symbol ⟶ transforms (x,y) ⟶ (x/2, 3y).
Then (4,5) ⟶ (,) ⟶ (,).

11. There are 4 committees each with 3 members in a school club. every member of the club is on 2 and only 2 committees, but the same 2 people cannot serve on more than one committee together. For example, if Tom and Jane are on Committee I, they both cannot be on Committee II. How many people are in the club? ____________

12. If the square below is flipped over along the diagonal from 1 to 3 and then turned 90 degrees clockwise, what number will be in the position marked 1? ____________



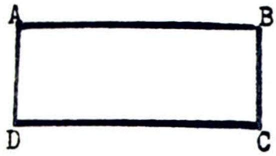
13. 

The figure to the left shows a triangle inscribed in a rectangle. The length from A to B is the same as the sength from B to C. What is the relation between the area of the triangle BED and the area of the rectangle?

14. Is the following statement true?

If the diagonals of a quadrilateral are congruent (equal in length) and bisect each other, then the quadrilateral is a rhombus. (A rhombus is a parallelogram with adjacent sides congruent.)

True or False

15. 

The rectangle to the left has a perimeter of x. The length from A to B is three times the length from B to C. What is the area of ABCD in terms of x?

16. Is the following argument valid? (Does the last statement follow from the first two statements?)

Everyone who studies will pass.
Mary does not study.
Therefore, Mary will not pass.

Please circle: valid invalid

17. One angle of a triangle measures 60 degrees. The ratios of the angles in the triangle are 2:3:4. What are the other 2 angles?

18. There are 3 roads from A to B and 4 from B to C and 1 from A to C. How many different ways can a person travel from A to C?

19. In a survey of 100 students, the numbers studying various math courses were found to be: Algebra, 28; Trig, 30; Geometry, 42; Algebra and Trig, 8; Algebra and Geometry, 10; Trig and Geometry, 5; and all three math courses, 3. How many students are not studying any math?

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20. A balance scale can be used to determine whether one object (or a group of objects) is heavier than another object (or another group of objects). Suppose we had 11 coins. Ten of the coins are equal in weight but one coin is heavier than the other coins. We know that by placing one coin on the balance and then comparing the weight of the other 10 coins to the original coin we could determine the heavy coin. This might take as many as 9 weighings. There are other ways of determining the heavier coin. Explain another way of weighing the coins to determine the heavier coin which will take less than 9 weighings.

21. Let x, ÷, +, -, and = stand for multiplication, division, addition, subtraction and equality, respectively. Let us call 5+2=7 a true

statement. Using the above symbols and the numbers 3, 4, 12 write as many "true statements" as you can. You may also use parentheses.

22. Let X be a set and let T be a collection of subsets of X. T is a topological space for X if and only if

1. T contains ϕ (the empty set) and X.
2. The union of each subcollection of T is an element of T.
3. The intersection of each subcollection of T is an element of T.

Let X = {a, b, c}. We know that the subsets of X are ϕ, {a}, {b}, {c}, {a, b}, {a,c}, {b,c}, {a,b,c}. If T is the set {ϕ, {a}, {a, b, c}} then T is a topological space for X because the union of each subcollection of T is in T and the intersection of each subcollection of T is in T. List as many T's, that are topological spaces for X, as possible.

APPENDIX B

APPENDIX B

TABLE I

PILOT STUDY DATA

SUBJECT	TEST SCORE
1	12
2	12
3	14
4	15
5	15
6	15
7	16
8	16
9	17
10	18
11	18
12	18
13	20
14	21
15	23
16	23

TABLE II

TEST DATA AND CREATIVITY RANKS
FOR THE STUDY

SUBJECT	TEST SCORE	SCORE ON ODD PROBLEMS	SCORE ON EVEN PROBLEM	CREATIVITY RANK
1	5	4	1	1
2	7	5	2	1
3	7	5	2	1
4	8	7	1	2
5	10	5	5	2
6	10	5	5	1
7	11	4	7	1
8	11	7	4	3
9	12	7	5	2
10	12	9	3	3
11	12	6	6	2
12	13	6	7	2
13	13	6	7	1
14	14	7	7	2
15	14	9	5	2
16	14	7	7	3
17	14	6	8	3
18	15	8	7	2
19	15	11	4	2
20	16	13	3	1
21	17	11	6	4
22	17	10	7	3
23	17	10	7	3
24	17	11	6	3
25	18	12	6	2
26	18	12	6	2
27	18	11	7	2
28	20	16	4	2
29	22	12	10	3
30	23	15	8	2
31	24	15	9	3
32	25	17	8	4
33	26	17	9	1
34	26	18	8	2
35	27	13	14	3
36	27	15	12	3
37	28	21	7	3
38	29	14	15	2
39	32	15	17	5
40	32	17	15	4

TABLE II (continued)

SUBJECT	TEST SCORE	SCORE ON ODD PROBLEMS	SCORE ON EVEN PROBLEMS	CREATIVITY RANK
41	32	19	13	3
42	32	24	8	2
43	35	18	17	4
44	35	14	21	4
45	35	20	15	5
46	35	14	21	5
47	36	23	13	4
48	36	19	17	5
49	37	18	19	2
50	41	18	23	5
51	44	20	24	4

APPENDIX C

APPENDIX C

DIRECTIONS

I know that you, as a mathematics teacher, have an idea as to what creativity in mathematics really is. Smith and Westcott discuss what constitutes creativity in mathematics in the following quote.

> Creativity in mathematics is the birth or discovery of new number patterns; the development of new relationships between mathematical ideas; the modification and/or variance of existing patterns, symbols, and relationships; the contrivance of new symbolism and organization of symbols; the discovery of new applications of mathematical ideas. As mathematics is in reality a system of related ideas, so creativity in mathematics can be simply defined as the production of new relationships.[1]

Using the above definition and your own ideas about creativity, you will rate your students in terms of their creative ability in mathematics. The rating form will consist of the numerals one through five. The numeral five will represent the highest level of creativity and the numeral one will stand for the lowest level of creativity. Circle the number which you feel best describes a student's level of creativity.

Thank you for your cooperation in this matter.

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[1]James A. Smith and Alvin M. Westcott, Creative Teaching of Mathematics in the Elementary School, (Boston: Allyn and Bacon, Inc., 1967), p. 210.

NAME ______________________

CREATIVITY RATING FORM

1 2 3 4 5