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# The Relationship of Certain Measures of Creativity to Achievement in Selected Science and Related Coursework

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THE RELATIONSHIP OF CERTAIN MEASURES OF CREATIVITY TO  
ACHIEVEMENT IN SELECTED SCIENCE AND RELATED COURSEWORK

by

Sheryl Oberg Snyder

A THESIS

Presented to the Faculty of  
The Graduate College in the University of Nebraska  
In Partial Fulfillment of Requirements  
For the Degree of Master of Arts  
Department of Educational Psychology and Measurements

Under the Supervision of Dr. Warren R. Baller

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S. O. S.

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## CHAPTER I

### INTRODUCTION

The purpose of the present study is to determine whether a relationship exists between certain factors of creativity and intellect and some specified measures of achievement in high school and college. Specifically, the factors in the first grouping are ingenuity, visualization in two dimensions, visualization in three dimensions, and reasoning; those in the achievement classification are high school science, high school mathematics, high school science-related courses, college science, college mathematics, and college science-related courses. Stated differently, the purpose is to determine whether any relationship exists between the several combinations.

#### Background of the Study

For many years, psychologists have relied largely on measures of intelligence or scholastic aptitude as a predictor of achievement in academic pursuits. Recently, however, the thinking has been that traditional intelligence tests have shown pronounced limitations such as inadequate attention to divergent thinking as contrasted with much emphasis on convergent thinking. This view was expressed by Torrance (1962) who also noted that the popular multiple-choice tests denied the opportunity for creative answers and penalized those who were perceptive of subtle points. Getzels and Jackson (1962) comment that the development and usage of

intelligence tests is very commendable, but that the IQ-metric is not the only measure which should be considered in assessing the abilities of the student. It has become increasingly apparent that intelligence is a multidimensional affair wherein components of creative talent can be regarded as components of intelligence. (Guilford, 1959)

The above is one of many reasons for the intensive studies of creativity being carried on currently by Guilford, Getzels and Jackson, Torrance, Taylor, MacKinnon, Lowenfeld, and others in an attempt to define creativity, measure it, and relate it to other factors and areas.

Leese (1961) has compiled a group of attributes of the creative mind, some of which are fluency, flexibility, originality, capability of restructuring and reorganizing, sensitivity to problems, extending and elaborating. Canisia (1962) has stated that scientific and mathematical thinking seems to be characterized by fluency and flexibility. Brandwein (1960) characterizes the scientist as intelligent, original, imaginative and analytical. Taylor (1963) has recognized the importance of creativity as it is related to science and has organized several conferences on creativity in general and on creativity in science specifically.

Scientific activity has been defined as being basically creative by Mooney. (1954) Mallinson (1960) has stated that science goes further than logical analysis of holes in knowledge, further than logical searches for logical materials to be logically ordered. Science involves broader dimensions

of analysis, synthesis and recombination--all of which are a part of creativity. The atmosphere in science would be sterile without creativity according to Malinson.

From the foregoing statements it can be concluded that the attributes of persons in science are similar to those attributes involved in creativity. Research has not yet shown that these attributes are identical, but surface inspection does show similarities.

Research in creativity is taking many avenues in addition to those mentioned above. Personality development, interests, values, attitudes, memory, thought processes, and motivation are being probed to determine what effects or relations are present with creativity.

#### Focus of the Study

The main question of the present study concerns the relationship of creativity and achievement in science and related areas. Specifically, does the ingenious person, as determined by certain measures, excel in high school and college science, mathematics and science-related courses? Does the person with two- and three-dimensional visualization abilities, as determined by certain measures, likewise excel in these areas? Also, does the person with reasoning abilities similarly determined excel in these areas?

These questions lead to a question of predictability, such as: Would knowledge of ingenuity, visualization ability, and reasoning ability aid in predicting achievement in science and related fields in high school and college? As will be



more fully explained in a later chapter, the principal questions of this study will be examined in the light of data deriving from the Project Talent study.

### Definitions

Ingenuity is the ability to find ingenious solutions to practical problems as measured by the Creativity test in the Project Talent battery. (Flanagan, 1962)

Visualization in two- and three-dimensions is the ability to visualize how an object, pattern, or configuration would appear when viewed from various angles in various positions as measured by the test of Visualization in Two Dimensions and the test of Visualization in Three Dimensions in the Project Talent battery. (Flanagan, 1962)

Reasoning is the ability to determine a logical relationship among elements of the pattern and to apply this relationship in order to identify an element that belongs in the pattern as measured by the test of Abstract Reasoning in the Project Talent battery. (Flanagan, 1962)

Science courses include all physical and biological course offerings.

Mathematics courses include all mathematics courses.

Science-related courses refers to all such courses as have a relationship to any applied or technical field of science and/or mathematics such as health, industrial arts, engineering, architecture, pharmacy, dentistry, logic, scientific languages, accounting, statistics, etc.

### Relevance of the Study

In 1960 a battery of tests was administered to a large group of high school students throughout the United States. This testing, Project Talent, was aimed at determining the status of American youth, at assessing the educational situations in which they were involved, and at determining how talents could be most effectively utilized for the national welfare. (Flanagan, 1962) Included in this battery were measures of ingenuity, visualization and reasoning which are considered to be factors in the structure of the total abilities of the individual. Little is known of their effects on success in educational pursuits.

The person with ingenuity, visualization and reasoning abilities may excel in his classroom endeavors or he may tend to think too deeply, see more than is actually involved and be aware of other possibilities to the extent that his classroom performance is interpreted as being below that of high achievers. Studies have shown that the more creative students tend to be more out of favor with teachers, (Getzels and Jackson, 1962; Torrance, 1962) and subjective grading procedures would tend to reflect lower achievement for these students.

### Restatement of Purpose

The purpose of the present study, as indicated above, is to determine whether a relationship exists between measures of ingenuity, visualization, and reasoning and measures of achievement. The measures of achievement include the areas

of high school science, high school mathematics, high school science-related courses, college science, college mathematics, and college science-related courses.

## CHAPTER II

### REVIEW OF RELEVANT LITERATURE

The topic of creativity, as a topic for research, is relatively new. Among those who early gave attention to the importance of the topic were Poincare (1913) and Spearman, (1931) the latter devoted a book to the topic.

Wertheimer (1945) explored the area of productive thinking, producing an initial idea for increasing creative thought. Terman's work with the gifted indicated some aspects of creativity in connection with giftedness.

In 1950 Guilford (1950) set the stage for the current trend of research in the area of creativity when he stated his hypotheses about creativity and indicated the necessity of research to determine the factors involved. During the ensuing years writers and researchers have concerned themselves with several areas pertaining to the subject. Some addressed their persuals to defining creativity and theorizing as to its attributes. (Wilson, 1958; Stoddard, 1959; Anderson, 1959; Maslow, 1959; Guilford, 1950, 1956; Hilgard, 1959; MacKinnon, 1962; Lowenfeld, 1958) Others have attempted to develop and validate instruments to measure creativity. (Guilford, 1953; Torrance, 1962; Getzels and Jackson, 1962; Flanagan, 1963) Still others are concerned with the relation of creativity to various fields of endeavor, perception, and personality. (Getzels and Jackson, 1962; Torrance, 1962; Cline, 1963; Roe, 1959; Cattell, 1959)

This review will be limited to definitions and theories of creativity, measures of creativity, and creativity related to achievement, and also the relevant writings on Project Talent.

### Definitions and Theories of Creativity

Many writers on the topic of creativity choose to define the term before proceeding with further discussion of theory or research so as to have a definition which will give support to their elaborations. Thus definitions of creativity abound. In general, these definitions have a common implication of something new, novel, or an innovation. Several representative definitions are presented below. It will be noted that various approaches to the term are employed. Some discuss creativity as an entity, others call it a product or process, while others refer to it as thinking.

Creativity as an entity is defined by Haimowitz and Haimowitz (1960) as a capacity to innovate, to invent, to place elements together in a way in which they have never before been placed. Fromm (1959) extends this idea by saying that creativity is an attitude and can exist regardless of whether or not anything is added to the world of things.

Creativity as a process has items of sensing gaps or disturbing missing elements, forming ideas or hypotheses concerning them, testing these hypotheses, communicating the results, and possibly modifying and retesting the hypotheses as defined by Torrance (1962). Stein (1963)

also calls it a process which results in a novel work that is accepted as useful or satisfying by a group at some point in time. Trow (1950) states that the creative process is very elusive and compares it to insight. The taking of components from a familiar pattern and recombining for a new organization would be a creative act even though the outcome is not a work of art according to Trow.

A product-oriented definition is expressed by Flanagan (1963) as he terms it the bringing of something new into being. May's (1959) definition of creativity is only slightly different from Flanagan's. May substitutes the word "birth" for Flanagan's "being." Drevdahl (1956) defines creative capacity as the production of compositions, products, or ideas which would have been previously unknown to the producer.

Wilson (1958) has compiled a listing of several definitions of creativity which include these ideas: an outflow of energy through which a product is structured (Rasey); an action of the mind to produce a new idea (Gerard); manipulation of environment by mental processes in the production of new ideas (O'Brien); rearrangement of past experiences into new patterns (Arnold); and a process by which something new is produced (Harmon).

Stoddard (1959) proposes an unusual definition:

To be creative, in short, is to be unpredictable; it is to be decidedly suspect in the world of affairs. The creative aspect of life is rightly viewed as action. Never simply

contemplative, the creative act at its highest brings about notable differences in things, thought, works of art, and social structures. What is to be changed fights back, perhaps with success. Even in science, the truly novel or radical person has a hard time of it. (p. 183)

Anderson (1959) compiled a paragraph which summarizes many of the ideas of creativity:

. . . creativity is life itself. . . . it is a way of life. . . . it is optimum growth in social interaction. . . . it is maximum of self-actualizing. We could extend the range and fill in details with examples from others. If creativity is a broad way of life, then the characteristics of the creative person would be those characteristics which describe a person in the full vigorous adventure of living. (p. 237)

The definitions of creativity are many and varied, with some common ground of originality. Each author, however, has chosen to define it as his definition will meet his needs. Implicit in each definition is the theory of the author concerning creativity. It is the definition and the implied theory which form the structure of the research and writing each author does on the topic.

In regard to theories of creativity, credit must be given to Guilford who stimulated current emphasis on the subject and who has done extensive writing and research to arrive at a meaningful and operative theory. Guilford's early theory included the following: 1) all individuals possess to some degree all abilities including that of creativity, 2) creativity is bound to intelligence, and 3) creativity is one of the factors of the total personality. (Guilford, 1950)

In 1953, a report was made of the results of an attempt to develop an instrument to measure originality where originality was placed on a continuum of the uncommon, the remote, and the clever. (Wilson, et. al., 1953) One year later, a factor analysis of creativity was presented by Guilford and his associates. (Wilson, et. al., 1954) The factors found included verbal comprehension, numerical facility, perceptual speed, visualization, general reasoning, sensitivity to problems, word fluency, associational fluency, ideational fluency, adaptive flexibility, spontaneous flexibility, originality, closure, redefinition, and judgment.

Guilford (1956) then proceeded to tie his ideas and factors of creativity into a structure of intellect. He felt that previous views of intellect were too narrow and that it should include two major parts, Thinking and Memory. The thinking category was divided into 33 areas grouped under cognition, production and evaluation. Memory contained seven areas. Creativity was included in the area of productive thinking.

A cubical model developed by Guilford (1959) of 120 intellectual factors included the above structure on one of the faces. This face was labeled operations; the other faces, content and products. He then stated that creativity arises from the intellect. Thus Guilford has proceeded to show how the specific idea of creativity fits into the broad perspective of the total intellect.



Gough (in Hilgard, 1959) has been doing work similar to Guilford's in factor-analytic studies of creativity. His list of factors is as follows: intellectual competence, inquiringness of mind as a habit, cognitive flexibility, aesthetic sensitivity, sense of destiny. Hilgard (1959) calls attention to Gough's last two factors as being important because Guilford does not include them. Hilgard states that the discovery of factors is limited by the battery of tests used and the people tested, therefore, Guilford's work should be viewed as limited and evidence of these limitations are found in Gough's factors. Hilgard also states, however, that although Gough found additional items, this does not mean they are important factors in creativity until further research is accomplished.

Several of Guilford's comments are pertinent to the present study. Considering the factor of visualization in creativity, he says:

There is a factor of visualization which seems to be to the figural column what redefinition is to the conceptual column. The factor of visualization is the ability to think of changes or transformations of a figural kind in visually perceived objects or in objects visually thought of. The relation of such an ability to work in the visual arts can be readily imagined. (Guilford, 1957, p. 116)

In considering the various cubes in his model of intellect, Guilford states this of two of them: 1) "To visualize what a perceived pattern would look like if rearranged," (Guilford, 1963, p. 104) and 2) "To use logical relationships to test the correctness of a solutionn." (Guilford, 1963, p. 106)

MacKinnon (1962) identified eight characteristics of the creative person. They are intelligence, originality, independence, highly developed interests, open to experience, intuitiveness, theoretical and aesthetic interests, and a strong sense of destiny. Lovelace (1963) has drawn on these characteristics for the formation of his theory of creativity emphasizing the aspects of independence, originality, perceptiveness and curiosity, intuitiveness, and values. Cook (1960) theorized that creativity is not different from problem solving in that it must be an original accomplishment of the mind and a deliberate attempt to create. He believes that most persons do not have a strong desire to create and often their attempts at free-wheeling thought are stifled by mathematics. Guilford (1964) also believes creativity is much like problem solving, but he warns that all creativity is not problem solving.

Taylor (1963) believes that a certain group of traits are involved in creativity, especially as related to scientific creativity. These are 1) a high degree of autonomy, 2) preference for mental manipulations, 3) high ego strength and emotional stability, 4) liking for method, precision, exactness, 5) personal dominance, 6) control of impulses, 7) liking for abstract thinking, 8) independence of judgment, and 9) superior intellect.

The process of creativity is viewed as an important item in the theory of creativity. Two major methods in the process are listed by Sinnott. (1959) One is deductive,

direct frontal assault. The other is closely akin to insight wherein a new idea might rise almost spontaneously in the mind. Sinnott believes this second method to be the most common, but he hastens to comment that such inspirations do not appear unless the individual is well immersed in a subject with a rich background of knowledge and experience. This brings Sinnott to the postulation that the unconscious mind is at work selecting, arranging, and correlating ideas and images into a pattern, but he follows this with the caution that true unconscious creativity is relatively rare.

Dienes (1961) puts the creative process into the role of mathematical thinking and gives three stages. These are: 1) begin with a structure, 2) construct a super structure using abstractions, and 3) analysis to evaluate work. Here again, the apparent relation of creativity and the sciences is theorized.

Lowenfeld (1958) summarized the current thinking in the area of creativity by enumerating eight attributes of creativity. These are: 1) sensitivity to problems, 2) fluency of ideas, 3) flexibility, 4) originality, 5) redefinition or ability to rearrange, 6) analysis or ability to abstract, 7) synthesis or closure, and 8) coherence of organization. Most of the theorists, regardless of the direction of their work, have arrived at postulations that include one if not several of the attributes listed above.

### Measuring Creativity

Development of instruments to measure creativity has been done by several researchers, but the work of four has attained prominence. The four are Torrance, Getzels and Jackson, Guilford, and Flanagan. The instruments of Torrance, Getzels and Jackson, and Guilford are similar in many respects. These present a stimulus situation and require the subject to respond according to instructions. The response consists of an oral or written statement or a performance which is unique to the individual subject. No sample responses are provided from which the subject could choose.

Typical items in the instrument developed by Torrance (1962) are a Picture Construction where the individual is given paper shapes from which to assemble a picture; Incomplete Figures which are designed to measure closure; a Circle Task in which 35 circles would be presented and the subject must sketch objects of which the circles would be a part; Ask-and-Guess in which a picture is shown to the subject who must ask questions about it, then guess as to the situation involved; Product Improvement in which the subject is instructed to state what could be done to make the product better; and Unusual Uses in which the subject is asked for other uses of an object.

Some of Torrance's items appear to be adaptations of Guilford's which include such items as 1) Consequences in which a sample question would be 'What would happen if all the iron in the world would disappear?' which involves the factors of originality and ideational fluency; 2) Word

Association involving synonyms to measure the factor of associational fluency; 3) Brick Uses test calls for the uses for a brick to measure the factors of ideational fluency and spontaneous flexibility; 4) Hidden Figures measures the figural redefinition factor by the selection of a simple figure in a complex one; and 5) Match Problems which presents matches in a configuration with instructions to remove a certain number to leave another configuration to provide a measure of the factor of adaptive flexibility.

Getzels and Jackson (1962) include items of Word Association, Uses for Things, and Hidden Shapes which are similar to those of Guilford. They also use an item called Fables in which a fable is presented with the last line missing and the subject is required to provide lines for a moralistic, a humorous, and a sad solution respectively. Another item is Make-Up-Problems wherein a paragraph is presented which contains many numerical figures. The subject is required to make up as many arithmetic problems concerning the figures as he can in a time limit.

Torrance, Guilford, and Getzels and Jackson have developed instruments which are similar in many ways, including the items themselves and the response mode required. Flanagan's test of creativity is somewhat different from these.

Flanagan (1963) outlined his method for measuring ingenuity as providing problem situations for which ingenious solutions can be found. He feels that a time factor is not important, because if the subject is truly clever and

ingenious, he will come up with an appropriate answer. He has six criteria for the design of ingenuity items. They are: 1) Presentation of a clear-cut problem which has an ingenious solution; 2) Deductive reasoning can be used to determine the solution; 3) The solution must be thought of rather than recognized; 4) The problem situation should not be a definition of the solution; 5) Detailed knowledge of a specific field should not be necessary; and 6) A key word should provide pat and unique solution, so subject has a feeling of closure. These criteria form the basis for the design of his ingenuity test.

Flanagan's FACT (Flanagan Aptitude Classification Test, 1953) battery is a twenty-one test battery which includes measures of originality and visualization. Two of these tests as described by Flanagan (1957) are pertinent here.

**FACT #18 Ingenuity:** This test measures creativity or inventiveness in devising ingenious procedures, equipment, or presentations. Each test item contains a description of a problem situation calling for an ingenious solution. Some aspects of the solution are given in the item, but in each case the key word or words which include the crucial idea are left blank. Five choices for filling in this word or words are shown in skeleton form. Each choice has a space for each letter in the word and also includes the first and last letter of a series of words, one of which is the key word. Thus the individual is required to think of the solution rather than recognize it but is usually able to get immediate confirmation or correction by noting whether it fits in with the letters and spaces given in one of the choices. (p. 500)

**FACT #5 Assembly:** This test measures ability to 'see' how an object would look when put together according to instructions without having an actual

model to work with. The test samples ability to visualize the appearance of an object from a number of separate parts. The items consist of a picture of a number of disassembled parts required for a small piece of equipment. This picture is followed by a series of pictures of completed objects. The task is to identify the object which is assembled in accordance with directions given in the first picture. All of the assemblies use the pieces shown, but there is just one object in the series which assembles them in the correct way. This is a measure of the type of spatial visualization required for certain types of engineering and mechanical operations. (p. 500)

Flanagan's test differs from the others chiefly in the response mode in that Flanagan's subject must choose the correct response from among a group of foils presented in skeleton form. Super (1957) calls this a most ingeniously constructed test.

The response mode, however, has been questioned. Mosing (1959) found that items with a completion type of response were significantly related to creativity, while items requiring the selection of responses were not related to creativity.

All of these persons have done and are doing validation studies on their instruments. Because of the relative youth of the measurements, ample data is not yet available as to the validity of them.

Thorndike (1963) expressed some doubts as to the worth of creativity tests. His basic premise is based on the low correlations between the tests themselves. He, therefore, is not certain that all the tests are measuring the same thing and research using these tests may not be meaningful. Thorndike's emphasis is that the field is young

and he wishes to warn that research has not yet proven the value of the creativity tests.

Various other tests of creativity are being devised, some to be used in specific areas. Some of these which are related to science and technical fields include a measure of creativity in engineers by Sprecher (1958, 1963) and Harris, (1960) a test for creativity in industrial engineers by Harris, (1955) and creativity predictors for industrial scientists by Jones. (1964)

#### Creativity as Related to Achievement

In comparative research with creativity, much work has been done with intelligence, the theory being that creativity is as important to determining scholastic aptitudes as is intelligence. (Torrance, 1962, 1963; Getzls and Jackson, 1962) A logical area for comparison is creativity and achievement in various areas. This has been approached in many ways; some of the more pertinent will be reviewed below.

In connection with validation studies on Guilford's tests, some comparisons have been made of creativity and achievement. Guilford (1959) stated that a great deal of predictive validity for test scores representing the factor of originality should not be expected in connection with course grades. Hills (in Guilford, 1959) found an average correlation of  $-.02$  for an originality test in connection with grades in several small classes in upper division and graduate mathematics. Guilford (1959) found an average



Getzels and Jackson made many comparisons of the two groups including a comparison of scholastic achievement. Standardized achievement tests were used in the investigation, and the results showed that the highly creative group was equally superior in achievement to the highly intelligent group. Getzels and Jackson expressed concern over this finding because the students in the highly creative group would be those classed as 'overachievers.' As such, Getzels and Jackson felt this group might be influenced by some questionable counseling procedures. Also, they noted that the achievement of this group gives a clue as to the motivation involved in a highly creative student.

The investigators, Getzels and Jackson, also surveyed the attitudes of the teachers of the subjects of the study. The results showed that the highly intelligent students were more favored by teachers than were the highly creative students.

Torrance (1963) investigated creativity and intelligence in much the same manner as did Getzels and Jackson. His subjects were Minnesota school children who were divided into groups of the highly creative and the highly intelligent by the same procedure as Getzels and Jackson. The results of this study were similar to Getzels and Jackson's results showing that intelligence measures are not the total answer for achievement prediction, and that the highly creative student is less favored by teachers than the highly intelligent.

correlation of .27 between a test of originality and average grades in science and mathematics for two groups of engineering students of about a hundred each. These results tend to confirm Guilford's hypothesis that there is little relation between originality and achievement.

Guilford (1959) continues to state that little evidence has been presented to show that factors of verbal fluency have general predictability for academic or technical performances. Guilford (1959) found a score for expressional fluency correlated .25 with grades in an astronomy course. A factor of adaptive flexibility has shown consistent small relationships to performance in mathematics. (Guilford, 1959) Hills (in Guilford, 1959) found the average correlation with achievement in mathematics and adaptive flexibility to be .33 and Guilford (1959) found the relation to grades in physics to be .23.

Getzels and Jackson (1962) selected 292 boys and 241 girls in grades six through twelve from a private school in Chicago. Their purpose was to compare the highly intelligent student with the highly creative student. The average IQ in the selected school was 132.

Getzels and Jackson selected the highly creative students as the top twenty percent on their creativity measures and below the top twenty percent in intelligence. The highly intelligent group was chosen similarly, in the top twenty percent by intelligence and below the top twenty percent in creativity.

Torrance also showed that those in the highly intelligent group were better in study skills and arithmetic while the highly creative students were better in reading and English. Torrance (1963) makes the comment that if students are termed gifted on the basis of intelligence alone, seventy percent of the top twenty percent on the basis of creativity would be missed.

Richards, et. al. (1964) studied 119 high school students with respect to intelligence and creativity and the students' self-judgments in this area. A major purpose of this investigation was to obtain data on teacher favoritism for creativity or intelligence. No evidence was found to confirm Getzels and Jackson's and Torrance's findings that teachers prefer the highly intelligent over the highly creative.

A study by Cline, et. al. (1963) attempted to answer the question, Does a creativity battery predict performance in high school science as well as or better than conventional intelligence tests? Their subjects were 114 students in a Salt Lake City high school. As predictor measures of creativity, Guilford's consequences, word association, hidden figures, brick uses and match problems were used. The students must have completed two courses in science and the criteria was the grade point average in the courses with no adjustment made for the number of courses. The Sequential Test of Educational Progress (STEP) science achievement score was also used.

The correlations in Cline's study were as follows: science achievement and word association .27; science achievement and hidden figures .47; science achievement and consequences (immediate) .02; science achievement and consequences (remote) .35; science achievement and brick uses .24; science achievement and match problems .47; STEP and word associations .43; STEP and hidden figures .39; STEP and consequences (immediate) .03; STEP and consequences (remote) .43; STEP and brick uses .13; and STEP and match problems .36.

The conclusion arrived at by Cline was that the creativity battery has predictive validity for the criteria which is in disagreement with Guilford's hypothesis. An earlier study by Cline, et. al. (1962) using the same experimental approach and conditions found the same results.

A study by Ornstein (1961) in an experimental physics course using an analytical intuitive thinking approach, found that those students with average School and College Ability Test (SCAT) scores made gradually higher scores on physics tests and that they were considered more 'gifted.' Ornstein hypothesized that students with high SCAT scores that did not correlate with their physics test scores were much better at memorizing facts and formulas and learning by authority, therefore, they were unsuited for the more 'creative' approach in the physics class.

Morgan (1959) investigated the reasoning abilities of students as compared to their achievements in science.

Her subjects were 80 Westinghouse National Science Talent Search finalists who were administered the Morgan Test of Logical Reasoning. She concluded that the ability to reason at a high level is a distinguishing characteristic of students who have demonstrated high achievement in science.

Banghart (1963) used a group approach in the teaching of some classes in the new mathematics and compared these students with a control group that studied the same materials but were restricted to doing all their work individually. The purpose in this investigation was to determine the influence of group work on creativity, and the results showed the group approach to be overemphasized and not too effective. The subjects were administered Guilford's tests for creativity. A Pearson "r" for creativity and achievement in the mathematics course was .66 with 180 students involved.

### Project Talent

Project Talent originated in 1958 at the University of Pittsburgh and received the support of the United States Office of Education in 1959. Seven areas of inquiry were included as follows: 1) available talent, 2) relations among aptitudes, interests and other factors, 3) limiting effects resulting from lack of interest and motivation, 4) factors affecting vocational choice, 5) predictors of creativity and productivity, 6) effectiveness of various types of educational experience, and 7) procedures for realizing individual potentials. (Flanagan, 1960, 1962)

John C. Flanagan developed the design for a nationwide investigation to determine the information necessary in the above areas. In March, 1960, 444,000 students in 1353 private, parochial, and public schools were administered the tests. (Flanagan, 1962) These tests would provide 2000 items of information per student. The selection of schools was made to include a random sampling of schools of all sizes and in all areas of the United States. The tests were specifically constructed for the Project Talent battery to include general information, interests, motivational factors, attitudes, noninformation areas, memory, use of knowledge, comprehension, creativity, reasoning, aptitudes, personality, vocational aims, and background experiences. (Flanagan, 1962) Regional coordinators were appointed to assist with the administration of the tests.

Data were processed by the use of the Iowa Electronic Test Scoring Machine and the Iowa Document Reader. (Flanagan, 1961) Extensive plans were made for the use of the data and much of this is currently in process. Raw scores and percentile ranks of the students are available to the schools concerned and other authorized persons. Results of studies will be available concerning descriptions of the American students and follow-up studies at intervals of one, five, ten and twenty years. (Orr, 1961) The scope of the study is one of the largest ever attempted.

While one of the purposes of Project Talent was to investigate creativity and related areas, the investigation

involves general factors and is not yet completed. It is the purpose of the present study to relate creativity and other factors of intellect to the specific area of science and related fields of study. More specifically, the present study is attempting to show the correlation between creativity and factors of intellect as measured by Project Talent and achievement in high school and college science, mathematics, and science-related courses.

### CHAPTER III

#### METHODOLOGY OF THE STUDY

The purpose of this study, as earlier indicated, is to determine whether a relationship exists between measures of ingenuity, two- and three-dimensional visualization, and reasoning on the one hand, and measures, on the other hand, of achievement in high school science, in high school mathematics, in high school science-related courses, in college science, in college mathematics, and in college science-related courses.

As defined earlier, the science-related courses cover a wide variety of fields. Because this is so, it is not expected that meaningful results will be found in the science-related categories, particularly at the college level where a large diversity of courses are involved, but the science-related category is included to give a perspective to the total field of science.

The questions of concern in this study are included in twenty-four hypotheses. Earlier mention of the variables to be examined indicated ingenuity, visualization in two dimensions, visualization in three dimensions, and reasoning as measured by the Creativity, Visualization in Two Dimensions, Visualization in Three Dimensions, and Abstract Reasoning tests in the Project Talent battery.

#### Hypotheses

The hypotheses in this study have been constructed in the null form. They are:



1. There is no significant relationship between ingenuity and achievement in high school science courses.
2. There is no significant relationship between ingenuity and achievement in high school mathematics courses.
3. There is no significant relationship between ingenuity and achievement in high school science-related courses.
4. There is no significant relationship between ingenuity and achievement in college science courses.
5. There is no significant relationship between ingenuity and achievement in college mathematics courses.
6. There is no significant relationship between ingenuity and achievement in college science-related courses.
7. There is no significant relationship between visualization in two dimensions and achievement in high school science courses.
8. There is no significant relationship between visualization in two dimensions and achievement in high school mathematics courses.
9. There is no significant relationship between visualization in two dimensions and achievement in high school science-related courses.
10. There is no significant relationship between visualization in two dimensions and achievement in college science courses.
11. There is no significant relationship between visualization in two dimensions and achievement in college mathematics courses.

12. There is no significant relationship between visualization in two dimensions and achievement in college science-related courses.
13. There is no significant relationship between visualization in three dimensions and achievement in high school science courses.
14. There is no significant relationship between visualization in three dimensions and achievement in high school mathematics courses.
15. There is no significant relationship between visualization in three dimensions and achievement in high school science-related courses.
16. There is no significant relationship between visualization in three dimensions and achievement in college science courses.
17. There is no significant relationship between visualization in three dimensions and achievement in college mathematics courses.
18. There is no significant relationship between visualization in three dimensions and achievement in college science-related courses.
19. There is no significant relationship between reasoning and achievement in high school science.
20. There is no significant relationship between reasoning and achievement in high school mathematics courses.
21. There is no significant relationship between reasoning and achievement in high school science-related courses.

22. There is no significant relationship between reasoning and achievement in college science courses.
23. There is no significant relationship between reasoning and achievement in college mathematics courses.
24. There is no significant relationship between reasoning and achievement in college science-related courses.

### Subjects

The members of the graduating class of 1960 at Lincoln High School, Lincoln, Nebraska comprised the group from which the sample was taken. All members of the class had taken the Project Talent battery of tests and their scores were available. From this class 97 were chosen on the basis of their completing four or more semesters at the University of Nebraska. All 97 had completed high school science and mathematics courses, 95 had completed high school science-related courses, 84 had completed college science courses, 62 had completed college mathematics courses, and 78 had completed college science-related courses.

### Testing Instruments

The data from four tests in the Project Talent battery were used. These four tests were Creativity, Visualization in Two Dimensions, Visualization in Three Dimensions, and Abstract Reasoning.

The Creativity test was patterned after Flanagan's Ingenuity test in the FACT battery. It was designed to measure the ability to find ingenious solutions to problems. The examinee is given a problem situation and required to

devise the solution. The response mode in this test is unique among creativity tests. The test offers choices in terms of the first and last letter of possible right answers with the proper number of blanks for letters between the two given letters. By this method, the examinee can not simply choose the correct answer, but must think of a plausible solution, then find the letters and blanks in which the answer would fit. This response format has the advantage of being machine scorable.

Flanagan suggests that this test titled Creativity is to be interpreted as a measure of creative ingenuity. (Flanagan, 1962) This measure is herein referred to as Ingenuity.

The tests of Visualization in Two Dimensions and Visualization in Three Dimensions were assembled specifically for the Project Talent battery. Their purpose was to measure spatial visualization. Care was taken to insure that spatial visualization was measured, not visual acuity. In the Visualization in Two Dimensions test there were two types of items, 1) figures rotated in a plane, and 2) figures reversed for mirror images.

In the Visualization in Three Dimensions test, five abilities were measured, including 1) conversion of a two-dimensional figure to a three-dimensional figure, 2) conversion of a three-dimensional figure to a two-dimensional figure, 3) rotation of solids, 4) solids from various projections, and 5) hidden parts of solids (as cubes in irregular solids). (Flanagan, 1962)

The authors of the visualization tests suggest that the results of these tests would be helpful in determining which students would profit in technical, mechanical, and engineering training. (Flanagan, 1962) However, some theorists have specified visualization as a factor of creativity (Wilson, Guilford, et. al., 1954) and the scores derived here will be considered as a factor of creativity.

The Abstract Reasoning test was designed for the Project Talent battery to measure nonverbal, abstract, inductive reasoning. The type of item used was the pattern matrix. The solution of such an item depends on the finding of a logical relationship among the elements of the pattern. Generally, this type of item is included in a test of scholastic aptitude. (Flanagan, 1962) Wilson, Guilford, et. al. (1954) specified general reasoning as a factor of creativity, and Guilford (1963) also includes finding logical relationships in creativity. In this study it will be regarded as an aspect of creativity and referred to as Reasoning.

#### Sources of Data

The Ingenuity, Visualization in Two Dimensions, Visualization in Three Dimensions, and Reasoning raw scores of the subjects were available to the writer from data sheets furnished to the Lincoln Public Schools by Project Talent. Grade records of the subject's high school science courses, high school mathematics courses, and high school science-related courses were available from the Office of the Principal, Lincoln High School. Grades in college science courses,

college mathematics courses, and college science-related courses were available from the Registrar's Office, University of Nebraska. The science-related courses that were selected were those relating to health, industrial arts, statistics in business or economics, engineering, architecture, logic, scientific Greek, geography, pharmacy, dentistry, accounting, agriculture, and miscellaneous others related to applied sciences, applied mathematics, and technical fields.

### Method of Data Analysis

Since the testing of the hypotheses of this study requires, without exception, a determination of correlation between different pairs of variables, the method of data analysis is correlational throughout. The Pearson Product Moment correlation method was employed.

The statistical formula for the Pearson Product Moment Correlation is:

$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{\left[ \sum X^2 - \frac{(\sum X)^2}{N} \right] \left[ \sum Y^2 - \frac{(\sum Y)^2}{N} \right]}}$$

where  $\sum XY$  is the summation of the products of the two factors X and Y,  $\sum X$  is the summation of the factor X,  $\sum Y$  is the summation of the factor Y, and N is the total number in the sample.

The correlation coefficient necessary to be significant at the .05 and .01 level for each N was derived from the following formula:

$$r = t \sqrt{\frac{1}{t^2 + (N - 2)}}$$

where N is the number in the sample. The "t" value for the .05 level of significance is 2.000; the "t" value for the .01 level of significance is 2.660.

A note of explanation regarding the treatment of students' grades in the various high school and college courses follows. An arithmetic average of the subject's grades in the various high school and college areas respectively was found and these used as the measure of achievement in the course areas. No adjustment was made for the number of courses for which grades were received.

## CHAPTER IV

### PRESENTATION OF RESULTS

Twenty-four hypotheses were presented in the previous chapter as bases for determining the relationship of measures of creativity and achievement in high school and college science, mathematics, and science-related courses. The results of the data analysis are presented in this chapter in the same order as the earlier listing of the hypotheses.

#### Relationship Between Ingenuity and Achievement in Various Subject Matter Areas

Table I shows the correlation coefficients between ingenuity, as measured by the test of Creativity in the Project Talent battery, and achievement in high school and college science, mathematics, and science-related courses.

TABLE I

#### RELATIONSHIP BETWEEN INGENUITY AND ACHIEVEMENT IN VARIOUS SUBJECT MATTER AREAS

<u>Courses</u>	<u>N</u>	<u>Correlation Coefficient</u>
High school science	97	$r = .35^{**}$
High school mathematics	97	$r = .42^{**}$
High school science-related	95	$r = .21^{*}$
College science	84	$r = .33^{**}$
College mathematics	62	$r = .20$
College science-related	78	$r = .13$

\*Significant at the .05 level.

\*\*Significant at the .01 level.



The correlation coefficients necessary for significance at the .05 level are .201, .203, .214, .250, and .224 for "N" of 97, 95, 84, 62, and 78 respectively. For significance at the .01 level, correlation coefficients of .263, .266, .282, .324, and .292 for "N" of 97, 95, 84, 62, and 78 respectively are necessary.

Of the correlation coefficients between ingenuity and achievement in high school and college science, mathematics, and science-related courses, those between ingenuity and achievement in high school science courses, ingenuity and achievement in high school mathematics courses, and ingenuity and achievement in college science courses are significant at the .01 level. The correlation between ingenuity and achievement in high school science-related courses is significant at the .05 level.

On the evidence displayed above, the following comments would appear to be appropriate regarding the data described. Four null hypotheses relative to ingenuity may be rejected. They are: 1) There is no significant relationship between ingenuity and achievement in high school science courses; 2) There is no significant relationship between ingenuity and achievement in high school mathematics courses; 3) There is no significant relationship between ingenuity and achievement in high school science-related courses; and 4) There is no significant relationship between ingenuity and achievement in college science courses.

The following hypotheses cannot be rejected: 1) There is no significant relationship between ingenuity and achievement in college mathematics courses; and 2) There is no significant relationship between ingenuity and achievement in college science-related courses.

Relationship Between Visualization in Two Dimensions  
and Achievement in Various Subject Matter Areas

Table II shows the correlation coefficients between visualization in two dimensions, as measured by the test of Visualization in Two Dimensions in the Project Talent battery, and achievement in high school and college science, mathematics, and science-related courses.

TABLE II

RELATIONSHIP BETWEEN VISUALIZATION IN TWO DIMENSIONS  
AND ACHIEVEMENT IN VARIOUS SUBJECT MATTER AREAS

<u>Courses</u>	<u>N</u>	<u>Correlation Coefficient</u>
High school science	97	$r = .11$
High school mathematics	97	$r = .42^{**}$
High school science-related	95	$r = .23^{*}$
College science	84	$r = .25^{*}$
College mathematics	62	$r = .06$
College science-related	78	$r = .02$

\*Significant at the .05 level.

\*\*Significant at the .01 level.

The correlation coefficients necessary for significance at the .05 level and at the .01 level are the same as for Table I.

One correlation coefficient between visualization in two dimensions and achievement is high enough to be significant at the .01 level. This is the correlation between visualization in two dimensions and achievement in high school mathematics. Correlations between visualization in two dimensions and achievement in high school science-related courses, and visualization in two dimensions and achievement in college science courses are sufficient to be significant at the .05 level.

Accordingly, three hypotheses regarding visualization in two dimensions and achievement may be rejected. They are: 1) There is no significant relationship between visualization in two dimensions and achievement in high school mathematics courses; 2) There is no significant relationship between visualization in two dimensions and achievement in high school science-related courses; and 3) There is no significant relationship between visualization in two dimensions and achievement in college science courses.

The remaining three null hypotheses regarding visualization in two dimensions and achievement cannot be rejected. They are: 1) There is no significant relationship between visualization in two dimensions and achievement in high school science courses; 2) There is no significant relationship between visualization in two dimensions and achievement in college mathematics courses; and 3) There is no significant relationship between visualization in two dimensions and achievement in college science-related courses.

Relationship Between Visualization in Three Dimensions  
and Achievement in Various Subject Matter Areas

Table III shows the correlation coefficients between visualization in three dimensions, as measured by the test of Visualization in Three Dimensions in the Project Talent battery, and achievement in high school and college science, mathematics, and science-related courses.

TABLE III

RELATIONSHIP BETWEEN VISUALIZATION IN THREE DIMENSIONS  
AND ACHIEVEMENT IN VARIOUS SUBJECT MATTER AREAS

<u>Courses</u>	<u>N</u>	<u>Correlation Coefficient</u>
High school science	97	$r = .31^{**}$
High school mathematics	97	$r = -.04$
High school science-related	95	$r = .08$
College science	84	$r = .65^{**}$
College mathematics	62	$r = .21$
College science-related	78	$r = .14$

**\*\*Significant at the .01 level.**

The correlation coefficients necessary for significance at the .05 level and at the .01 level remain the same as for the entries in Tables I and II.

The correlation coefficients in two areas are sufficient for significance at the .01 level. These are the correlations between visualization in three dimensions and achievement in high school science courses, and between visualization in three dimensions and achievement in college science courses.

On the basis of the above evidence, the following comments are presented. Two null hypotheses may be rejected. They are: 1) There is no significant relationship between visualization in three dimensions and achievement in high school science courses; and 2) There is no significant relationship between visualization in three dimensions and achievement in college science courses.

The following hypotheses cannot be rejected: 1) There is no significant relationship between visualization in three dimensions and achievement in high school mathematics courses; 2) There is no significant relationship between visualization in three dimensions and achievement in high school science-related courses; 3) There is no significant relationship between visualization in three dimensions and achievement in college mathematics courses; and 4) There is no significant relationship between visualization in three dimensions and achievement in college science-related courses.

Relationship Between Reasoning and Achievement  
in Various Subject Matter Areas

Table IV shows the correlation coefficients between reasoning, as measured by the test of Abstract Reasoning in the Project Talent battery, and achievement in high school and college science, mathematics and science-related courses.

TABLE IV

RELATIONSHIP BETWEEN REASONING AND ACHIEVEMENT  
IN VARIOUS SUBJECT MATTER AREAS

<u>Courses</u>	<u>N</u>	<u>Correlation coefficient</u>
High school science	97	$r = .15$
High school mathematics	97	$r = .28^{**}$
High school science-related	95	$r = .08$
College science	84	$r = .33^{**}$
College mathematics	62	$r = .50^{**}$
College science-related	78	$r = .25^*$

\*Significant at the .05 level.

\*\*Significant at the .01 level.

The correlation coefficients necessary for significance at the .05 level and at the .01 level are again the same as for the previous tables.

Three correlation coefficients in this grouping are high enough to be significant at the .01 level. They are between reasoning and achievement in high school mathematics, reasoning and achievement in college science, and reasoning and achievement in college mathematics. The correlation between reasoning and achievement in college science-related courses is significant at the .05 level.

In light of the findings described above, the following four hypotheses may be rejected: 1) There is no significant relationship between reasoning and achievement in high school mathematics courses; 2) There is no significant relationship

between reasoning and achievement in college science courses; 3) There is no significant relationship between reasoning and achievement in college mathematics courses; and 4) There is no significant relationship between reasoning and achievement in college science-related courses.

Two hypotheses cannot be rejected: 1) There is no significant relationship between reasoning and achievement in high school science courses; and 2) There is no significant relationship between reasoning and achievement in high school science-related courses.

## CHAPTER V

### DISCUSSION AND SUMMARY

Results of Project Talent tests Creativity, Visualization in Two Dimensions, Visualization in Three Dimensions, and Abstract Reasoning were correlated respectively with course grades in high school and college science, mathematics, and science-related courses. The correlations were used to test twenty-four hypotheses stated in Chapter III. In summary, these hypotheses were: 1) There is no significant relationship between ingenuity (Project Talent Creativity) and achievement in high school and college science, mathematics, and science-related courses, 2) There is no significant relationship between visualization in two dimensions (Project Talent Visualization in Two Dimensions) and achievement in high school and college science, mathematics, and science-related courses, 3) There is no significant relationship between visualization in three dimensions (Project Talent Visualization in Three Dimensions) and achievement in high school and college science, mathematics, and science-related courses, and 4) There is no significant relationship between reasoning (Project Talent Abstract Reasoning) and achievement in high school and college science, mathematics, and science-related courses.

As shown in the preceeding chapter, thirteen of the null hypotheses were rejected at either the .05 or the .01 level of significance. The remaining eleven hypotheses



were not sustained, but several of the findings in these areas indicate a trend in a positive direction.

The discussion which follows will be divided into four categories which correspond to the four groupings of the null hypotheses: 1) The relationship of ingenuity and achievement in high school and college science, mathematics, and science-related courses; 2) The relationship of visualization in two dimensions and achievement in high school and college science, mathematics, and science-related courses; 3) The relationship of visualization in three dimensions and achievement in high school and college science, mathematics, and science-related courses; and 4) The relationship of reasoning and achievement in high school and college science, mathematics and science-related courses.

Relationship of Ingenuity and Achievement  
in Various Subject Matter Areas

Four correlations in this area were found to be significant, namely, 1) ingenuity related to high school science, 2) ingenuity related to high school mathematics, 3) ingenuity related to high school science-related courses, and 4) ingenuity related to college science. It can be noted that ingenuity is significantly related to all three areas in high school and only one of the college areas.

The ingenuity test involved is the Creativity test in the Project Talent battery. It consists of problem situations presented with the requirement of a solution. The examinee chooses the correct solution from among a group of skeleton

responses. Criticisms of this type of test have been registered, as that of Mosing cited in an earlier chapter, in that requiring the examinee to select a response is not as good a measure of creativity as a completion-type response.

In typical high school science, mathematics, and science-related courses (which generally consists of health and industrial arts), the emphasis is most often on the learning of facts and the application of these facts in rather stereotyped situations. Achievement in these courses is frequently measured by an objective test which requires the selection of a response or the reproduction of a method or explanation. Those students with interest and aptitude in these areas generally can "figure out" which response is the correct one on the basis of their classroom background.

The items in the Project Talent Creativity test which was used as a measure of ingenuity are in some respects very similar to the typical test given in high school science, mathematics, and science-related courses. A certain answer is required; the student knows this and attempts to make the best selection from among the possibilities given. This similarity would perhaps account for the high correlations between ingenuity and the high school courses of science, mathematics, and science-related.

Ingenuity was also found to be significantly related to achievement in college science courses. The above discussion with respect to high school courses is appropriate also, especially for the lower level courses in college sciences.

College science courses differ from high school science courses in that more material is usually included, the material is more difficult, and more laboratory work is required. The inclusion of more laboratory work and the type of laboratory work in college science courses is a salient point in the discussion of the relation of ingenuity to this area. In college science laboratories, particularly those in higher level sciences, the student is given only a skeleton outline of what he is to accomplish. It is up to him to determine his materials, his procedure, and his applications. It follows that the more ingenious student would be quicker in determining what he was going to do, would have his equipment assembled more rapidly, and therefore could go through the procedure with more care and have time to attempt further investigations on the side. The care with which his experiments are done and his attempts at individual experimenting can influence his achievement in the courses and consequently his grades.

The relation between ingenuity and college mathematics is positive and is close to being high enough for significance. In college mathematics courses, the student is expected to learn many mathematical procedures, equations, formulas, etc. Evaluation of the student's progress is often a group of problem situations where the student is required to apply his knowledge to work out a solution. Frequently, the exact numerical solution carries less weight in the exam total than does the procedure used in arriving at the answer. The

creative student would draw upon his background to select solution procedures which quite probably would be novel and unique combinations of formulas and equations to serve the purpose. Regardless of the arithmetic involved, the procedure developed to reach the solution would have a large influence on the grades received in the course. Thus the ingenious student would perhaps be successful in some mathematics courses as the positive correlation indicates.

A rather low positive correlation was found between ingenuity and college science-related achievement. Science-related courses at the college level were chosen to include a large number of areas. Because of the diversity of areas included, it was not expected that significant relationships would be found.

In regard to the relation between ingenuity and achievement in the areas of high school and college science, mathematics, and science-related courses, it can be said that the more ingenious student is more likely to do better than his less ingenious counterpart. The results have shown that this is not a rule that is applicable to all situations, but the significant trend is apparent.

In general, the results described in the section just concluded confirm those of Cline, Getzels and Jackson, Torrance, Guilford, Hills and Banghart as cited in an earlier chapter.

#### Relationship of Visualization in Two Dimensions and Achievement in Various Subject Matter Areas

Three of the six null hypotheses relative to this area were rejected at the .01 or the .05 level of significance.

These hypotheses included the relationship between visualization in two dimensions and achievement in high school mathematics, the relationship between visualization in two dimensions and achievement in high school science-related courses, and the relationship between visualization in two dimensions and achievement in college science courses.

Concerning achievement in high school mathematics, one fact seems best to explain the relationship with visualization in two dimensions. At Lincoln High School where the subjects of this study were enrolled, plane geometry is a course required of all students selecting a college preparatory curriculum. Since the subjects of this study all attended college, they completed the college preparatory coursework including plane geometry. The course in plane geometry, as the title suggests, deals with two-dimensional figures with occasional references to comparable figures in three dimensions. Those students who achieve well in this course are postulated to be those who have the ability to work with two-dimensional figures. This ability would be reflected in the Project Talent test of Visualization in Two Dimensions and also in their course grade in plane geometry.

Visualization in two dimensions was also found to be significantly related to achievement in high school science-related courses. As mentioned earlier, the science-related category in high school included mainly health and industrial arts courses. It is in the area of industrial arts that the

most plausible explanation lies for this high correlation. Industrial arts courses at the high school level include such areas as mechanical drawing, blue print reading, and the like along with the construction of simple wood and metal objects. Drawings and blue prints involve the manipulation of objects with two dimensions only. It seems probable that those students who perform ably with such items would receive higher achievement ratings and would also score higher on a two-dimensional visualization test. It should be noted, however, that industrial arts is only one of the course areas included in the high school science-related category. Other courses, such as health, contributed to this correlation, but their aspects lend less plausible explanations.

Achievement in college science courses also correlated highly with visualization in two dimensions. One aspect of college science courses allows a reason for this. In college science courses, the student often finds himself in the position of taking a text or laboratory manual drawing and interpreting it or making his own drawings of laboratory objects for class purposes. As noted above, all drawings are two dimensional and the student's ability to interpret and perceive the two-dimensional form would be reflected in the Project Talent test of Visualization in Two Dimensions.

The area of high school science achievement correlated positively with the measure of visualization in two dimensions

but was not high enough to be significant at the .05 level. Reasons for this positive correlation in high school science would be similar to those involving college science course achievement although the typical high school science course is not as rigorous with laboratory work as the college courses with similar titles.

College mathematics and college science-related courses correlated positively but very low with visualization in two dimensions. The result involving college mathematics seems unusual as many of the mathematics courses above an initial course in algebra contain work with the positioning of mathematical equations on two-dimensional graphs. The wide variety of science-related courses at the college level, as earlier mentioned, would be unlikely to correlate highly with any other measures. Apparently other factors are decisive in achievement in such areas.

Generally speaking, it can be concluded that students with visualization abilities in two dimensions can expect relative success with high school science, mathematics and science-related courses, but this generalization does not hold for all similarly titled areas at the college level.

#### Relationship of Visualization in Three Dimensions and Achievement in Various Subject Matter Areas

Only two areas were found to correlate significantly with visualization in three dimensions. These were achievement in high school science and achievement in college science.

The Project Talent test of Visualization in Three Dimensions included items which required the examinee to convert three-dimensional figures to figures in two dimensions and conversely. It also required the rotation of solid, three dimensional figures and identification of parts of solid, three-dimensional figures and identification of parts of solid, three-dimensional figures. These tasks are extremely like those involved in any course in the biological or physical sciences. As mentioned earlier, students in science courses are frequently required to begin with a text or laboratory manual drawing and convert it to an actual object. Also they are required to make two-dimensional drawings or laboratory objects and apparatus. This requires the ability to convert two dimensions to three and three to two, and such ability should be apparent not only in a three-dimensional visualization test but also in the record of achievement of the science student.

The only negative correlation of this study appeared in relating visualization in three dimensions and high school mathematics. Again, it should be noted that a required course of college preparatory students, the subjects of this study, is plane geometry which deals with two-dimensional figures almost exclusively. The student has only rare opportunities to deal with the properties of three-dimensional figures. Since the emphasis in high school mathematics is on two-dimensional figures, it follows that the relation of visualization in three dimensions and high school mathematics would not be high.



The area of college mathematics correlates positively with visualization in three dimensions, but the correlation is not high enough to be significant at the .05 level. College mathematics courses differ from those in high school in that a much broader spectrum is attended to. As noted in the preceding paragraph, high school mathematics is generally limited to two-dimensional figures, whereas college courses in mathematics consider not only three-dimensional solids but also the graphing of three unknowns on three-dimensional axes. The broader area of content perhaps accounts for the positive but low correlation of visualization in three dimensions with college mathematics.

Positive, but low, correlations were also found for the relationship between visualization in three dimensions and science-related courses in high school and college. Again, the wide range of courses included in this category perhaps accounts for the low correlations.

The test of Visualization in Three Dimensions in the Project Talent battery has some aspects which are essentially similar to Guilford's Hidden Figures. As such, the results obtained using the Project Talent test compare favorably with the findings of Cline.

#### Relationship of Reasoning and Achievement in Various Subject Matter Areas

The measure of reasoning was determined to be positively related to all areas of achievement investigated. Correlations significant at the .01 level or the .05 level

were found in four areas: 1) reasoning and achievement in high school mathematics, 2) reasoning and achievement in college science, 3) reasoning and achievement in college mathematics, and 4) reasoning and achievement in college science-related courses.

It may be noted that reasoning correlated positively and significantly with all areas of college achievement investigated. This could perhaps best be explained by noting that the college student who does well in these areas is probably inclined toward analytical pursuits, and this inclination results in success in courses where analytical thinking is necessary. The analytical thinker would score high on the Project Talent test of Abstract Reasoning and could possibly receive better than average grades in science, mathematics, and science-related courses on the college level.

High school mathematics achievement correlates positively and significantly with the measure of reasoning. Again, the nature of a required high school mathematics course, plane geometry, shows a possible explanation. Plane geometry forms a framework for the study and use of a system of reasoning. Those students doing well in plane geometry will be accomplished in reasoning and would do well on a reasoning test also.

The measure of reasoning correlated positively but not significantly at the .05 level with high school science achievement. This might be accounted for, in view of the

findings, by noting that the typical high school science course consists of facts to be learned, and little thinking is required to obtain acceptable grade reports. Contrasted with college science where the student is required to derive more information for himself, the high school student need not possess extraordinary reasoning powers to achieve in science.

A low positive correlation was found with the measure of reasoning and high school science-related achievement. High school science-related courses included mainly health and industrial arts, both of which do not require reasoning to any great extent. This lack of necessity of reasoning in these courses probably accounts for the low correlation of the reasoning measure and high school science-related achievement.

The results discussed in this section agree with Morgan, cited earlier, who found that the ability to reason is a characteristic of those who demonstrate science aptitude and achievement. The results of this study also show that the ability to reason is a factor in science and related achievement, particularly at the college level.

#### Research Possibilities

This study has included generalized investigations regarding creativity as it is related to achievement in scientific areas in high school and college. Many possibilities exist for expanding and clarifying the findings found herein.

A pertinent area of investigation would be a comparison of the creativity measures used with those developed by Guilford, Getzels and Jackson, Torrance, and others. As Thorndike (1963) cautioned, it is possible that various creativity measures do not indeed measure the same things; results of this study and of others would be invalidated to the degree that there is ambiguity in the measurement of creativity.

A study similar to the present investigation could perhaps be conducted which would involve pertinent parts of several creativity measures to determine their relation to achievement in scientific areas thereby determining some validity of the various measures and also finding out which measures best serve the purpose for predicting achievement in science.

As was noted elsewhere in the discussion, the categories of science and science-related courses contained a conglomeration of coursework. A meaningful study would involve the relating of physical sciences to creativity, the relating of biological sciences to creativity, and the relating of separate applied and technical fields to creativity, such as engineering, architecture, dentistry, pharmacy, agriculture, etc.

Hilgard (1964) mentioned that teaching by machine tends to suppress creativity. This opens speculation about the area of teaching methods and their relation to creativity. Another research possibility in this area would be to compare teaching methods, achievement, and creativity.

A follow-up study of the individuals involved in this study, as will be carried on by Project Talent, would provide information relating the creativity of these individuals to their achievements beyond formal education.

### Summary

The research reported in this dissertation was for the purpose of determining the relationship between creativity measures and achievement in high school and college science, mathematics, and science-related courses. A brief review of the pertinent literature was presented and included definitions and theories of creativity, measures of creativity, creativity as related to achievement, and Project Talent.

A sample of 97 subjects was drawn from the Lincoln High School graduating class of 1960. The criterion for selection was completion of at least four semesters at the University of Nebraska.

The creativity measures used were four tests included in the Project Talent battery: 1) Creativity, 2) Visualization in Two Dimensions, 3) Visualization in Three Dimensions, and 4) Abstract Reasoning. Measures of achievement included arithmetic averages of the subject's course grades in high school science, high school mathematics, high school science-related courses, college science, college mathematics, and college science-related courses.

Twenty-four null hypotheses were formulated and tested. In summary, they included: 1) There is no significant relationship between ingenuity, as measured by

the Project Talent test of Creativity, and achievement in high school and college science, mathematics, and science-related courses, 2) There is no significant relationship between visualization in two dimensions, as measured by the Project Talent test of Visualization in Two Dimensions, and achievement in high school and college science, mathematics, and science-related courses, 3) There is no significant relationship between visualization in three dimensions, as measured by the Project Talent test of Visualization in Three Dimensions, and achievement in high school and college science, mathematics and science-related courses, and 4) There is no significant relationship between reasoning, as measured by the Project Talent test of Abstract Reasoning, and achievement in high school and college science, mathematics, and science-related courses.

Statistically, thirteen of the null hypotheses were rejected. These included the null formulation of: 1) ingenuity and high school science, 2) ingenuity and high school mathematics, 3) ingenuity and high school science-related courses, 4) ingenuity and college science, 5) visualization in two dimensions and high school mathematics, 6) visualization in two dimensions and high school science-related, 7) visualization in two dimensions and college science, 8) visualization in three dimensions and high school science, 9) visualization in three dimensions and college science, 10) reasoning and high school mathematics, 11) reasoning and college science, 12) reasoning and college

mathematics, and 13) reasoning and college science-related courses.

Although not statistically significant, a trend was noted in the positive relationship of: 1) ingenuity and college mathematics, 2) visualization in three dimensions and college mathematics, and 3) reasoning and high school science.

The results tended to support the findings of other researchers that creativity and achievement in scientific areas are significantly and positively related.

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