1968

An experiment in cultivating creative thinking abilities in the classroom

Billy Max Clark

Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/rtd

Part of the Education Commons

Recommended Citation

Clark, Billy Max, "An experiment in cultivating creative thinking abilities in the classroom" (1968). Retrospective Theses and Dissertations. 3653.

https://lib.dr.iastate.edu/rtd/3653

This Dissertation is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Retrospective Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
CLARK, Billy Max, 1929-
AN EXPERIMENT IN CULTIVATING CREATIVE THINKING ABILITIES IN THE CLASSROOM.

Iowa State University, Ph.D., 1968
Education, theory and practice

University Microfilms, Inc., Ann Arbor, Michigan
AN EXPERIMENT IN CULTIVATING CREATIVE THINKING ABILITIES IN THE CLASSROOM

by

Billy Max Clark

A Dissertation Submitted to the Graduate Faculty in Partial Fulfillment of The Requirements for the Degree of DOCTOR OF PHILOSOPHY

Major Subject: Educational Administration

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

Head of Major Department

Signature was redacted for privacy.

Dean of Graduate College

Iowa State University
Ames, Iowa

1968
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTRODUCTION</strong></td>
<td></td>
</tr>
<tr>
<td>The Problem</td>
<td>1</td>
</tr>
<tr>
<td>Need for the Study</td>
<td>2</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>3</td>
</tr>
<tr>
<td>Sources of Data</td>
<td>4</td>
</tr>
<tr>
<td>Delimitations of the Study</td>
<td>6</td>
</tr>
<tr>
<td>Organization of the Study</td>
<td>7</td>
</tr>
<tr>
<td>Summary</td>
<td>7</td>
</tr>
<tr>
<td><strong>REVIEW OF RELATED LITERATURE</strong></td>
<td></td>
</tr>
<tr>
<td>Structure of the Intellect</td>
<td>9</td>
</tr>
<tr>
<td>Recent Developments in Measuring Creativity</td>
<td>12</td>
</tr>
<tr>
<td>The Relationship between Scores on Creativity Tests and Scores on Intelligence and Achievement Tests</td>
<td>16</td>
</tr>
<tr>
<td>Cultivating Creativity in the Classroom</td>
<td>18</td>
</tr>
<tr>
<td>Creative and Critical Thinking</td>
<td>24</td>
</tr>
<tr>
<td>Creativity as an Attitude</td>
<td>25</td>
</tr>
<tr>
<td>Other Related Research</td>
<td>29</td>
</tr>
<tr>
<td>Summary</td>
<td>37</td>
</tr>
<tr>
<td><strong>THE EXPERIMENTAL DESIGN</strong></td>
<td></td>
</tr>
<tr>
<td>Setting</td>
<td>40</td>
</tr>
<tr>
<td>The Research Paradigm</td>
<td>42</td>
</tr>
<tr>
<td>The Experimental and Control Groups</td>
<td>42</td>
</tr>
<tr>
<td>The Experimental Teaching Program</td>
<td>43</td>
</tr>
<tr>
<td>Teacher Inservice Education</td>
<td>50</td>
</tr>
<tr>
<td>The Teaching Program for the Control Group</td>
<td>50</td>
</tr>
<tr>
<td>Measuring Devices Used</td>
<td>51</td>
</tr>
<tr>
<td>Achievement test</td>
<td>51</td>
</tr>
<tr>
<td>Testing for creative thinking ability</td>
<td>52</td>
</tr>
<tr>
<td>Statistical Analysis of Data</td>
<td>53</td>
</tr>
<tr>
<td>Assumptions Applicable to Tests of Significance</td>
<td>54</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

Figure 1 Structure-of-the-intellect model 10
Figure 2 A representation of two main dimensions, content and processes, of the three dimensional model 20
Figure 3 Model for the teaching of productive-divergent thinking through subject matter content 22
Figure 4 Thinking-learning-acting model 44
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Subject-matter achievement means on pre- and post-tests in physical science</td>
<td>56</td>
</tr>
<tr>
<td>Table 2</td>
<td>Difference in mean-gain scores on subject-matter achievement</td>
<td>56</td>
</tr>
<tr>
<td>Table 3</td>
<td>Fluency means on pre- and post-tests of creative thinking</td>
<td>57</td>
</tr>
<tr>
<td>Table 4</td>
<td>Difference in mean-gain score on fluency</td>
<td>57</td>
</tr>
<tr>
<td>Table 5</td>
<td>Flexibility means on pre- and post-tests of creative thinking</td>
<td>58</td>
</tr>
<tr>
<td>Table 6</td>
<td>Difference in mean-gain scores on flexibility</td>
<td>58</td>
</tr>
<tr>
<td>Table 7</td>
<td>Originality means on pre- and post-tests of creative thinking</td>
<td>59</td>
</tr>
<tr>
<td>Table 8</td>
<td>Difference of mean-gain scores on originality</td>
<td>59</td>
</tr>
<tr>
<td>Table 9</td>
<td>Total creativity means on pre- and post-tests of creative thinking</td>
<td>59</td>
</tr>
<tr>
<td>Table 10</td>
<td>Difference in mean-gain scores on total creativity</td>
<td>60</td>
</tr>
<tr>
<td>Table 11</td>
<td>A comparison of the mean numerical ratings on the attitude scale for the experimental and control groups</td>
<td>61</td>
</tr>
<tr>
<td>Table 12</td>
<td>Correlations showing the relationship between scores on creativity, IQ and academic performance measures for 185 eighth-grade students</td>
<td>62</td>
</tr>
<tr>
<td>Table 13</td>
<td>Mean scores on creativity measures according to sex</td>
<td>64</td>
</tr>
<tr>
<td>Table 14</td>
<td>Subject-matter achievement means on pre- and post-tests for the seven groups</td>
<td>93</td>
</tr>
<tr>
<td>Table 15</td>
<td>Differences in mean-gain scores on subject-matter achievement between the experimental and control subgroups</td>
<td>93</td>
</tr>
<tr>
<td>Table 16</td>
<td>Fluency means on pre- and post-tests of creative thinking for the seven groups</td>
<td>94</td>
</tr>
<tr>
<td>Table 17</td>
<td>Differences in mean-gain scores on fluency between the experimental and control subgroups</td>
<td>94</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Table 16</td>
<td>Fluency means on pre- and post-tests of creative thinking for the seven groups</td>
<td>94</td>
</tr>
<tr>
<td>Table 17</td>
<td>Differences in mean-gain scores on fluency between the experimental and control subgroups</td>
<td>94</td>
</tr>
<tr>
<td>Table 18</td>
<td>Flexibility means on pre- and post-tests of creative thinking for the seven groups</td>
<td>95</td>
</tr>
<tr>
<td>Table 19</td>
<td>Differences in mean-gain scores on flexibility between the experimental and control subgroups</td>
<td>92</td>
</tr>
<tr>
<td>Table 20</td>
<td>Originality means on pre- and post-tests of creative thinking for the seven groups</td>
<td>92</td>
</tr>
<tr>
<td>Table 21</td>
<td>Differences in mean-gain scores on originality between the experimental and control subgroups</td>
<td>92</td>
</tr>
<tr>
<td>Table 22</td>
<td>Total creativity means on pre- and post-tests of creative thinking for the seven groups</td>
<td>97</td>
</tr>
<tr>
<td>Table 23</td>
<td>Differences in mean-gain scores on total creativity between the experimental and control subgroups</td>
<td>97</td>
</tr>
</tbody>
</table>
INTRODUCTION

The act of teaching has not kept pace with the world's rapid social and technological changes. Teaching remains largely a process of imparting knowledge and skills recognizing very little that environment is continually changing. Student growth in knowledge alone is susceptible to obsolescence and soon becomes insufficient. The teaching function needs to be expanded so that it will encourage students to "think."

Students need to be exposed to thinking processes that will enable them to convert what is learned today into usable knowledge for tomorrow's application. Rogers has so aptly stated the goal of education.

We are, in my view, faced with an entirely new situation in education where the goal of education, if we are to survive, is the facilitation of change and learning. The only man who is educated is the man who has learned how to learn; the man who has learned how to adapt and change; the man who has realized that no knowledge is secure. Changingness, a reliance on process rather than upon static knowledge, is the only thing that makes any sense as a goal for education in the modern world. (45, p.2)

Many teaching situations fail to challenge the multi-talented minds of students. Much classroom teaching emphasizes the student's ability to adjust, to memorize and to ascertain how well he understands printed material. Consequently, in too many classrooms, students are not given the time nor the opportunity to think.

Historically, the term intelligence has been used to define the gifted academic student, and the gifted academic student has fared well in our educational system. The reason for this success is that too often our instructional programs are so geared as to enable only the academically talented to succeed.
Guilford (23) has done extensive research on mental abilities and has defined more than 70 separate intellectual talents. Guilford uses the term intellect to define the composite of mental abilities.

Taylor (61, p.364) claims the typical intelligence test measures only six to eight of the more than 70 separate mental abilities. Taylor points out that the term intelligence has been used in a comprehensive sense representing the entire range of the intellect. Those mental talents employed in a good performance on an intelligence test represent a narrow segment of the continuum of the intellect.

The Problem

The objective of this dissertation has been to experiment with a teaching strategy that exposes students to thinking processes which are thought to foster creative thinking. The basic problem is to give students experience in using their multiple talents while also helping them progress in subject matter.

The study was a testing of a teaching situation and technique which emphasized learning by inquiry. Teaching students to learn by inquiry imposes a far different role on the teacher than is usually the case with the traditional, textbook approach. Inquiry teaching is a student-centered approach in which the teacher plays the role of a resource person. The typical textbook approach calls for a teacher-centered, more authoritative and structured classroom setting.

The study compares two teaching strategies by measuring student change in creative thinking abilities and subject-matter achievement.
The fundamental question is: can students progress in subject-matter content and expand their creative thinking abilities simultaneously?

The primary focus of this investigation centered upon the following hypotheses:

1. There is no difference in gain scores between the experimental and control groups on tests of subject-matter achievement.

2. There is no difference in gain scores between the experimental and control groups on tests of creative thinking.

3. There is no difference in attitude toward science classes between the experimental and control students.

4. There is no relationship between scores on measures of creative thinking ability and IQ.

5. There is no relationship between scores on measures of creative thinking ability and marks of academic performance.

6. There is no sex difference on scores of creative thinking ability measures.

Need for the Study

There seems to be a traditional concept that creativity belongs to the author, artist and others in the creative arts area. This diminutive concept of creativity needs to be broadened and better understood. There are creative teachers, architects, business executives, scientists and engineers as well as painters and composers.

Teachers and school administrators must have an understanding of creativity and its implications for education specifically and for society in general. Lowenfield claims:

... you can teach subjects and subject-matter forever; you can "adjust" a child to his environment forever; and, if you are lucky, you may find a way to teach a child subject matter (i.e. the facts of history, math., the
sciences, etc.) and "adjust" him at the same time; but—and this is the big but—if your child cannot apply creatively his knowledge, he cannot make the kinds of contribution to society which "break through barriers."
By that I mean he cannot use his knowledge and his energies to find new ways to live, to work, to play—and to do all these things in a world of peace rather than one of war. (37, p.10)

Through this study an attempt has been made to apply in the classroom some of the findings of the research in creativity. Teachers frequently expose youngsters to mental activities that generate creative thinking, but this kind of teaching is too often done intuitively. There is a real need, on the part of most educators, for a better understanding of the kinds of teaching strategies that are thought to be effective in opening student minds; and on the kinds of administrative and classroom climates which foster teacher and student productive thinking.

Research in psychology has produced a wealth of knowledge about how people's minds function, about the learning and thinking processes, and on the motivational levels of people. This study, in a very small way, is an attempt to help bridge the gap between research and its application. The field of psychology has a major contribution to make to education, and this contribution will have its impact when educators and psychologists begin communicating with each other.

Definition of Terms

In reviewing the literature various definitions have been found to define both creativity in general and the component mental processes which are thought to be important to creative thinking. To avoid ambiguity as well as to establish a framework of constructs, a list of definitions is
Creativity is a mental process involving a set of intellectual talents enabling the mind to recombine known elements into something new.

Productive thinking is the term that will be used interchangeably with creativity. Productive thinking denotes the kind of thinking that is problem solving and/or original, imaginative and constructive.

Ideational fluency is the ability to think of many ideas in a situation free from criticism. The quality of the idea is unimportant.

Flexibility is the ability to produce various ideas in a situation free from criticism. It can be tested by asking a person to list uses for a common object, but the factor is evaluated according to how many classes of uses were suggested. Classes may be thought of as two kinds of uses. A brick used as a paper weight and building material represents two classes. A brick used as building material for a garage and a house represents only one class.

Associational fluency is the ability to produce words from a restricted area of meaning. It can be tested by asking a person to list synonyms for certain words.

Elaboration is the ability to supply details to complete a given outline or skeleton form.

Divergent thinking is the kind of thinking that moves in many directions. Divergent thinking may take place in either a data rich or data poor situation. A situation in which there is no predetermined answer or solution provides an experience in divergent thinking.

Convergent thinking is the kind of thinking that progresses toward a predetermined solution or answer.

Evaluative thinking is the making of value judgments and applying ideas and information appropriately to a given situation.

Academic intelligence is associated with convergent thinking and applies to those mental abilities measured by the IQ test.

Creative talents are primarily those talents associated with divergent thinking, elaboration, evaluation, and, in many instances, convergent thinking.
Intellect is the term that refers to the spectrum of mental abilities. Kincaid (35) concludes that much of the research and literature on creativity has resulted in erroneous, dualistic thinking. For example, intelligence and creativity have come to be viewed as two separate and unrelated mental operations. Definitions, because of their need in scientific inquiry, help to advance this dualistic view and readers ought to be cautioned not to conceptualize a too rigid view of creativity. It is suggested that creativity be thought of as a unified phenomenon composed of overlapping and interacting mental processes which are important to both creativity and intelligence.

Sources of Data

The data required to test the stated hypotheses were obtained primarily from the eighth-grade class attending the Urbandale Junior High School located in Urbandale, Iowa. The records from the central office of the Urbandale Junior High School provided student scores on the Iowa Tests of Basic Skills, student grade point averages (GPA) and marks indicating past school achievement. The eighth-grade students enrolled in physical science classes provided pre- and post-test scores on measures of achievement and creativity as well as scores on a post-experimental measure designed to elicit student interests and attitudes toward the experimental teaching program. Intelligence test scores were obtained from the testing program administered by the Polk County Board of Education office.
Delimitations of the Study

This study was limited to those eighth-grade students attending the Urbandale Junior High School for the 1967-68 school year. The concern of this investigation was the cultivation of creative-thinking abilities among students enrolled in eighth-grade physical science classes. The experiment concentrated on a teaching strategy which emphasized teaching through student inquiry.

Organization of the Study

This study was organized into five chapters. The first chapter includes the problem, need for the study, definition of terms, sources of data, delimitations of the study and organization of the study. The second chapter contains a review of literature which first categorizes creativity into areas in hopes to facilitate the understanding of creativity in an educational setting, and, second, the review ends with a section discussing other related research. The outline for the second chapter includes structure of the intellect, recent developments in measuring creativity, the relationship among creativity, scores on intelligence tests, and achievement, cultivating creativity in the classroom, creative and critical thinking, creativity as an attitude, and other related research. The third chapter includes information pertinent to the experimental design such as the setting, research paradigm, experimental and control groups, experimental teaching program, teacher inservice education, measuring devices used, and statistical analysis of data. The fourth chapter contains the findings relevant to
Each stated hypothesis. The fifth chapter focuses on the summary, conclusions, recommendations and suggestions.

Summary

One of the greatest challenges to educators is the rapidity in which social and technological changes are taking place. The knowledge explosion imposes tremendous problems upon the act of teaching and demands that classroom instruction be more encompassing in order to cultivate student thinking abilities. This study was an investigation of a teaching strategy which would broaden the act of teaching to include an additional instructional dimension: this additional dimension being the cultivation of student creative thinking abilities. If growth in subject-matter content and creative thinking abilities can be effected concurrently, great strides in education in keeping abreast with change are possible.
REVIEW OF RELATED LITERATURE

The review of literature concerning creativity will focus on several aspects of creativity which have important implications for educators. The organization of this chapter will include the following categories: structure of the intellect, measuring creative talent, the relationship between creativity and IQ, cultivating creativity in the classroom, creative and critical thinking, and creativity as an attitude.

Structure of the Intellect

Guilford (24, p.3) has developed a theoretical model (see Figure 1) which enables one to think of intelligence as a multi-dimensional phenomenon. Guilford's model, the Structure-of-the-Intellect, is the genesis of much research regarding the identification and measurement of creative thinking abilities.

The complete Structure-of-the-Intellect Model would contain 120 intellectual factors. In 1955, Guilford had identified some 42 intellectual factors, and, by 1961, identification of 62 intellectual factors had been accomplished.

Guilford's model classifies and organizes mental abilities according to (1) the contents or types of information dealt with, (2) the operations performed on the information, and (3) the products resulting from the processing of the information. The important implication of the Structure-of-the-Intellect Model for educators lies in the operations category.

The operations dimension is further subdivided into evaluative,
Figure 1. Structure-of-the-intellect model
convergent, divergent, memory, and cognition classifications. Each of these classifications represents a type of thinking process or mental operation.

Wilson (76, p.21) contends that the model should serve as a reminder to classroom teachers of the "... great richness and diversity of human thinking abilities and help to keep the teacher from concentrating on too narrow a range of thinking skills in the classroom."

Guilford and Merrifield (25) believe that divergent thinking abilities are uniquely important to creativity and that divergent thinking has been overlooked in both the identification of student talent and in the education of children in general.

Torrance (66, p.29) emphasizes that the fostering of creative thinking ability has rarely been recognized as an objective of secondary education. He does contend there are some promising changes emerging in educational objectives especially in such courses as mathematics, physics, biology, and chemistry. However, Torrance's 1959-60 survey of the instructional objectives of the Minnesota social science teachers points out that creativity is often overlooked by classroom teachers.

Torrance classified the instructional objectives of the Minnesota social science teachers using the operations dimension of the Structure-of-the-Intellect Model as a criterion and reported the following:

Cognitive ...... 70.7 percent
Memory ........ 5.3 percent
Convergent ....... 18.7 percent
Divergent ....... 1.7 percent
Evaluative ...... 3.6 percent
Torrance's survey substantiates to some extent Guilford's notions about education when the latter stated:

... (Education) has emphasized abilities in the areas of convergent thinking and evaluation, often at the expense of development in the area of divergent thinking. We have attempted to teach students how to arrive at correct answers that our civilization has taught us are correct. This is convergent thinking ... Outside the arts we have generally discouraged the development of divergent-thinking abilities unintentionally but effectively. (23, p.19)

If the cultivation of divergent thinking ability is the key variable in the creative process, then Torrance and Guilford may be justified in generalizing that educators are neglecting creative-thinking abilities among students. Torrance classified 70.7 percent of the instructional objectives submitted by the Minnesota social science teachers as cognitive operations. Wilson's (76) interpretation of the Structure-of-the-Intelect Model defines cognitive-thinking abilities as those related to discovery, recognition and comprehension of information. Bloom's taxonomy of the cognitive domain (7) outlines many components which are associated with cognition. Before one could generalize that no creative thinking is cultivated through the development of cognitive-thinking abilities, more research is needed.

Recent Developments in Measuring Creativity

In order to measure creative thinking ability, some consensus has to be derived about what kind of thinking is related to creativity. Guilford and Merrifield have suggested six kinds of thinking ability which are now considered to be involved in creativity:
1. Sensitivity to problems: seeing defects, needs, deficiencies; seeing the odd, the unusual; seeing what must be done.

2. Flexibility: ability to shift from one approach to another, one line of thinking to another, to free oneself from a previous set.

3. Fluency: ability to produce a large number of ideas.

4. Originality: ability to produce remote, unusual, or new ideas or solutions.

5. Elaboration: ability to work out the details of a plan, idea, or outline; to "embroider" or elaborate.

6. Redefinition: ability to define or perceive in a way different from usual, established, or intended way, use, etc. (25, p.4)

These six kinds of thinking ability, with the exception of sensitivity to problems and redefinition, may be thought of as largely sub-classifications of divergent thinking. According to Torrance (66) redefinition abilities must be classified in the convergent-production category of the Structure-of-the-Intellect Model, and sensitivity to problems falls in the evaluation category. Thus, Guilford's present theory regarding the thinking processes involved in creativity still emphasizes the divergent-thinking operation but does include the evaluation and convergent operations.

Primary attention in this section is devoted to Torrance's work with the Bureau of Education Research of the University of Minnesota. Torrance, perhaps more than any other researcher, has attempted to adapt creativity measures for general use in education.

In 1958, the Bureau of Education Research of the University of Minnesota began a study of creative thinking ability. The Bureau's
basic task was to adapt Guilford's experimental materials in assessing creative thinking to suitable forms for measuring creativity in students ranging in ages from kindergarten to graduate school.

The results of Torrance's work with the University of Minnesota have been the development of two tests, both having alternate forms, for the measurement of creative thinking ability. One test is entitled Thinking Creatively with Words and the other is called Thinking Creatively with Pictures. The tests are published by Personnel Press, Inc., Princeton, New Jersey.

Some specific examples of the test exercise will elucidate the kind of student thinking the test attempts to measure. The verbal test, Thinking Creatively with Words, has seven exercises beginning with three Ask-And-Guess activities. In these activities students have a picture to study.

The examinee's first task, Asking, is to write as many questions about the picture as he can. The written questions are to be of such a nature that they are not answered merely by looking at the picture.

The second task is Guessing Causes. Examinees are to list as many causes possible for the action shown in the picture.

The third task is Guessing Consequences. This activity requires the listing of results or consequences of the action shown in the picture.

The fourth task is Product Improvement. In this exercise the examinee is shown a stuffed toy such as an elephant or monkey. The requirement is to list as many ways possible to change the stuffed toy so that children will have more fun playing with it. Cost is not a factor
in suggesting changes or improvement for the toy.

The fifth task is Unusual Uses. Examinees are asked to list as many uses as they can for a cardboard box or perhaps a tin can. The uses are not restricted to any specific dimension or size of cardboard box or tin can.

The sixth task involves the examinees in the listing of Unusual Questions. This exercise is a continuation of task five. If cardboard boxes were the subject of task five, examinees in task six are asked to list as many unusual questions about cardboard boxes as possible. The kinds of questions should lead to a variety of different answers and might arouse interest and curiosity in other people concerning boxes.

The seventh and last task concerns a Just Suppose situation. Examinees are to list consequences or results of a highly improbable condition. Just Suppose clouds had strings attached to them which hang down to earth is an exemplary situation.

Examinees are exposed to all seven tasks under timed conditions. All tasks, with the exception of Product Improvement and Unusual Uses, are allotted five minutes. Ten minutes are allowed for the two excepted tasks.

Torrance's verbal test for creativity was chosen as the measuring instrument in this experiment because it was thought that the experimental teaching strategy in this study emphasizes student verbal skills more than nonverbal skills.

The validity of Torrance's tests of creativity thinking has been the subject of much interest. Torrance has offered evidence of validity
through research projects conducted in cooperation with Wallace (70) and Sommers (47). Wallace's study showed a significant correlation between high performances on selected tasks from Torrance's tests and the sales productivity of saleswomen in a large department store. Sommer's study at Stout State College, Menomonie, Wisconsin, showed a significant relationship between faculty selection of highly-creative students in industrial-design classes and performances on specific tasks on Torrance's tests of creative thinking.

Other validity evidence has been provided by Torrance which is encouraging, but he is the first to admit that much more evidence is needed in order to substantiate that his test battery of creative thinking abilities measures those key variables important in creativity.

Torrance's tests are difficult to score and are time consuming. The scoring factor hinders their wide acceptance and has restricted their usage to experimentation and research. One might criticize the face validity of these tests especially when they are used at the senior-high or college levels. The pictures on which the test exercises focus are slanted toward the interests of elementary children. However, these tests represent a pioneering effort in assessing creative abilities in an educational setting. Also, Torrance's attempts in validating his creative measures have not been surpassed.

The Relationship between Scores on Creativity Tests and Scores on Intelligence and Achievement Tests

Often educators appear to think that tests of scholastic ability, measures of achievement, and school marks identify all gifted students
including those with creative talent. The findings of recent research should give educators some cause for doubting the effectiveness of many current measuring devices in assessing the broad-gamut of mental abilities.

The findings of Getzels and Jackson (19) suggest that intelligence is not a reliable predictor of creativity. Getzels and Jackson worked with a group of 500 adolescents, ranging from sixth-grade to high school seniors. These two psychologists selected from the original 500 students two groups--one made up of students in the top 20 percent as measured by intelligence (IQ) tests but not creativity, and the other group was comprised of students in the top 20 percent in creativity but not IQ. Creativity was measured by using several experimental exercises developed by Guilford in his factor analytical studies of the structure of the intellect. Getzels and Jackson found that high-IQ and creativity correlated only up to a certain point.

The research of Getzels and Jackson was limited in that it concerned only those students in the high-IQ range. This research has led some to believe that intelligence and creativity are mutually exclusive talents.

Torrance (66) replicated the work of Getzels and Jackson studying children at various levels on the IQ continuum. Torrance concludes (1) that by depending solely on IQ tests to measure creativity we miss about 70 percent of our creative youngsters, (2) although a certain level of intelligence is needed to be creative (IQ of 120) beyond that level there is a small relationship between intelligence and creativity, and (3) although outstanding creativity is seldom found among children of
below-average IQ, some type of creativity may be found anywhere along the IQ continuum except perhaps at the bottom.

Jacobson (33), in his study of creative thinking ability as related to school performance and intelligence, found little relationship among high-IQ students (121-142) when comparing scores on the California Achievement Tests and tests of creative thinking ability. An exception to this relationship was in reading vocabulary. Jacobson's sample included 206 sixth-grade boys all with IQ's of 105 or more.

Further conclusions drawn by Jacobson were (1) there is a low correlation between creative thinking ability and measures of school performance, and (2) school marks seem to reflect citizenship and other qualities in addition to achievement rather than creative thinking ability.

Cultivating Creativity in the Classroom

In view of the omission in most educational programs for the orderly consideration of creative talent, the nurturing of this talent in the classroom is one of the most important challenges facing educators today. Educators often look for teaching methods with attached labels and handles which ease their implementation. However no single technique for developing student creative thinking ability has emerged as a sure-fire teaching approach. Perhaps fostering creative thinking ability is more closely related to the teacher's charisma than to any method of teaching, instructional device or materials.

Many of the teaching activities which are thought to develop creative thinking abilities center upon divergent thinking activities. Parnes and
Meadow (43) at the State University of New York at Buffalo have stimulated much interest in the idea that people can be trained for creative thinking. Experiments by Parnes and Meadow have shown that college students enrolled in creative-problem-solving courses excel in performance on creativity measures over students not enrolled in creative-problem-solving courses. The students in the creative-problem-solving courses were encouraged to use their imagination in the solution of problems in all walks of life. Parnes and Meadow placed great emphasis on the brainstorming technique which calls for rapid ideation on the part of students with critical judgment suspended.

Several studies have been conducted whereby experimental teaching has been used in an attempt to foster creativity. Hutchinson (32), in the Granite School District in Salt Lake City, Utah, experimented with eight sections of seventh-grade students involved in a three-week social science unit. The specific subject content focused on transportation. The eight sections of seventh-grade students were matched with each other on the basis of their mental ages and sex. The total number of students in the study was 256, including 128 in the total experimental group and 128 in the total control group.

A three-dimensional model developed by Taylor, et al. (64, p.31) served as a guide for Hutchinson's experimental teaching strategy. The model's first dimension (see Figure 2) concerns the teacher's utilization of teaching methods, instructional materials, and stage setting. The second dimension deals with the subject areas and content, and the third dimension involves the learning and thinking processes that occur while
<table>
<thead>
<tr>
<th>Content Learned by Student</th>
<th>Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology Classwork</td>
<td>Intellectual</td>
</tr>
<tr>
<td>Biology Laboratory</td>
<td>Cognitive</td>
</tr>
<tr>
<td>Biology Research</td>
<td>Memory</td>
</tr>
<tr>
<td>Physics Classwork</td>
<td>Divergent</td>
</tr>
<tr>
<td>Physics Laboratory</td>
<td>Convergent</td>
</tr>
<tr>
<td>Physics Research</td>
<td>Cognitive</td>
</tr>
<tr>
<td>Other Sciences</td>
<td>Convergent</td>
</tr>
<tr>
<td>Mathematics</td>
<td>Cognitive</td>
</tr>
<tr>
<td>English</td>
<td>Memory</td>
</tr>
<tr>
<td>Languages</td>
<td>Divergent</td>
</tr>
<tr>
<td>History</td>
<td>Convergent</td>
</tr>
<tr>
<td>Art</td>
<td>Cognitive</td>
</tr>
<tr>
<td>Music</td>
<td>Memory</td>
</tr>
<tr>
<td>Various Crafts</td>
<td>Divergent</td>
</tr>
<tr>
<td>Health &amp; Physical Education</td>
<td>Convergent</td>
</tr>
<tr>
<td>Etc.</td>
<td>Cognitive</td>
</tr>
</tbody>
</table>

**Third Dimension:**

Teaching Methods & Aids, Teacher, Fellow Students and Other Environmental Factors Affecting Thinking and Learning Processes

*Figure 2. A representation of two main dimensions, content and processes, of the three dimensional model*
the student is learning subject matter.

Taylor has the following comments about the three-dimensional model.

... new insights into intellectual and learning processes as implied in the three-dimensional framework, reveal that students might more appropriately be thought of as "thinkers" rather than just "learners." If educators conceive that students were really thinkers, much greater development of all of the potential abilities of our youth should occur.

(63, p.12)

Hutchinson's experimental teaching strategy involved four teachers each teaching one experimental and one control group. By exposing students to a variety of thinking processes, three of the four teachers experienced greater gains on measures of subject-matter achievement for their experimental groups. However, only in one of these three cases was the difference considered statistically significant. All four teachers showed gains which were statistically significant for their experimental groups on four measures of creative thinking ability.

Hutchinson's study suggests that creative thinking abilities can be cultivated without loss in student growth in subject matter, and in fact, suggests that achievement of subject matter may be greater if students are given opportunities to use a variety of thinking abilities.

A weakness of Hutchinson's research is that nowhere does he define his experimental teaching procedure. How did his teachers expose their students to various thinking processes? This is an important question which concerns teaching methodology and strategy.

Williams's research (74, p.110) in creativity has led to the expansion of Taylor's three-dimensional model (see Figure 3). Williams's model offers numerous teaching approaches in cultivating creative thinking
Figure 3. Model for the teaching of productive-divergent thinking through subject matter content
abilities. The important implication for classroom teachers suggested by Figure 3 is that to expose students to a variety of thinking processes calls for the application of numerous teaching approaches. Frequently the teaching approach will depend on the subject-matter content, but the theory conveyed is that creativity can be cultivated in all subject areas.

Clark (12), in a study involving two groups of ninth-grade mathematic students (40 students in each group), found that gains in subject matter achievement could be obtained while permitting students to use their creative thinking abilities. The subject area for Clark's study was the solving of story problems.

Clark carefully outlined the difference in his teaching programs designed for the experimental and control groups. The control group was given a definite outline to follow in solving story problems while the experimental group was permitted to experiment and to draw upon their mathematic background in the solution of problems.

The major findings of this study showed that the experimental group achieved statistically significant gains at the .05 level on pre- and post-test measures of the student's ability to solve story problems. No significant differences were observed in measures assessing creative thinking ability.

While Clark's sample was extremely small and no effort was made to control for the teacher variable, it does imply that students can experience growth in subject matter in a highly-unstructured teaching situation. This study does provide some evidence that the teacher lecture, student discussion of textbook information, and teacher dominance
of classroom learning exercises are not the only ways to impart subject matter.

Creative and Critical Thinking

Since classroom teachers are essentially products of the system in which they received their education and especially influenced by institutions of higher education, creative and critical thinking need to be separated and analyzed as two kinds of thinking processes.

Not all educators are willing to accept creative and critical thinking as separate mental processes. For example, in a 1954 report by the American Council on Education entitled General Education--Explorations in Evaluation, Harding reports the following:

The issue of creative thinking was regarded as important but outside of the province of the Committee to resolve. The Committee was unwilling to take sides as to any differences which might exist between the creative act and the critical act. Rather the Committee was willing to accept, for purposes of compromise at least, the hunch that creativity and criticalness might be merely differing degrees of the same essential process. (27, p.4)

Harding, in the presentation of a paper at a 1958 Creative Problem-Solving Institute held at the University of Buffalo, expressed an attitude which is in direct opposition to the position espoused by the Committee of the American Council on Education.

... American Higher Education is, I regret to say, oriented more towards Critical Thinking than towards Creative Thinking. We produce critics rather than artists or poets or inventors in the broad sense of those magnificent words. Our graduate students far too often grow up in an atmosphere of skepticism, of indecision and doubt, and of strong negative conditioning. (27, p.4)
Critical thinking seems to convey the idea that there is one best way to solve a problem whereas creative thinking may lead to a variety of possible solutions. An important difference between critical and creative thinking may be in the mental attitude in which a problem is approached.

Critical thinking is frequently accompanied by immediate evaluation. The immediate evaluation often stems from past experience or research findings and may have a stifling effect upon further generation of ideas. Parnes's brainstorming technique purposefully postpones evaluation and permits thinking to occur without immediate judgment. This period of suspended judgment allows students to ideate freely without fear of being criticized. It might be well for teachers, in many classroom discussions, to employ the "suspended judgment principle" which is underlying in the brainstorming technique.

The difference between critical and creative thinking may be an important concept for teachers to understand in order to nurture creative thinking abilities. Perhaps the mental processes used in both critical and creative thinking overlap, but the climate or environment in which the thinking occurs could be the significant difference.

Creativity as an Attitude

Some researchers have attempted to demonstrate that attitude is an important mental phenomenon attributing to one's creative thinking capacity. Since attitude is thought to be a prime factor in motivating a person's outward behavior, personality traits and personal characteristics have been the center of attention for much research dealing with
creativity as an attitude.

If creativity is viewed as a special endowment of aptitude possessed by very few individuals, educators may wonder why all the bother about cultivating creative thinking abilities. However, on the other hand, when creativity is discussed as a multi-dimensional phenomenon which relates to attitude, the implications for teachers, school administrators and parents take on many new aspects. These new aspects focus on cultural, social and educational settings that are deemed important in developing creativity.

An extensive study, developed by Adorno and his associates (1), focusing on the "Authoritarian Personality" was conducted during World War II at the University of California at Berkeley. This investigation was concerned with race prejudice and proposed that any answer about the origin of prejudice would be useful in understanding the roots of anti-semitism and Naziism.

The findings of the study included several theories about personality which went far beyond the mere study of prejudice. It was found that highly prejudiced people held many personality traits in common. This combination of personality traits was labeled as the "Authoritarian Personality." The authoritarian individual was found to be rigid, concrete in his thinking, unable to manage abstractions easily, conventional and conforming. He prefers absolutes—black and white, cannot tolerate ambiguity, and tends to have a rigid conscience.

Steinberg believes that the important implications emerging from Adorno's study are:
The characteristics of the authoritarian personality are the antithesis of the creative attitude we seek. Creative behavior is characterized by variety and richness of perception. Whatever produces narrowness and rigidity becomes an important factor in limiting creativity. Attitudes that characterize authoritarianism seem representative of a range of social beliefs and predispositions that children develop . . . (48, p.130)

Teachers and school administrators are in strategic positions to nurture creative attitudes on the part of students. The research on creativity as an attitude has a direct relationship to the function of administrative rules and regulations governing teacher and student behavior. If rigidity and conformity of behavior is the goal of school administrators and classroom teachers, the advancement of creativity may be seriously hampered.

In developing an open mind or a creative attitude, one might be concerned about the boundaries in such a suggested, permissive climate. Hayakawa's definition of permissiveness may be helpful to the classroom teacher in establishing limits for student behavior.

... permissiveness does not mean, and no one has ever meant it to mean, allowing children to break up the furniture or pour hot soup on their sisters. Permissiveness means permitting children to do what they want, up to the point of not creating disturbances for others, not hurting others. . . an important component of permissiveness is that children should feel free to express their deepest feelings. Whether they do anything about them or not, they should always feel free to express them. (28, p.50)

Another problem in cultivating a creative attitude has to do with values. If a nonauthoritarian attitude is important in developing creative thinking ability, is there any assurance that the thinking will always be constructive? It seems that educators ought to qualify creative thinking as thinking that solves problems. For educators the term
productive thinking may be more meaningful than creative thinking.

Another study conducted by Holland (30) indicates important personality differences between individuals exhibiting creative behavior and high academic performance. Academic performance is believed to be a function of a personal syndrome characterized by: perseverance, self-control, good behavior, rigidity. Creative behavior is exhibited by a conscious conception of being original, actively participating in creative hobbies. Holland's study implies that high academic achievement involves different intrinsic motives than those associated with creative performances.

A misinterpretation which could easily be made from Holland's findings is that perseverance is only a characteristic of high academic achieving students. However, the creative-problem solving process described by Wallas (71) conveys the idea that in order for an individual to be creative he must have extreme patience and be willing to become steeped in the act of solving a problem. Wallas has described the complete act of creative production in terms of four stages--preparation, incubation, illumination, and verification. The preparation stage includes recognition and analysis of the problem. The incubation stage is explained as that period of time where no observable work is being done toward the solution of the problem, but the subconscious mind is continually searching for solutions. The illumination stage is characterized by a sudden flash of genius or the emergence of a possible solution, and verification is testing the possible solution. Wallas's definition of creative problem solving seems to parallel Dewey's steps in scientific problem solving. Any difference between Dewey and Wallas's approach to problem
solving is difficult to determine.

Other Related Research

This section is devoted to doctoral dissertations which have been completed in the area of creativity and education. Few studies, prior to 1962, were undertaken which emphasizes the recency of creativity as a phenomenon for consideration by educators. The creativity research reported in this section, the researcher believes, represents a sample of the kinds of studies educators have completed in their attempts to relate creativity to the arena of education.

Yamamoto (79) investigated teacher creativity and its influence on the scholastic performance of students. The source of data for this study was provided by 19 fifth-grade teachers and their 461 students.

The 19 teachers, on the basis of creative-thinking measures, were dichotomized into a low-creative group (9) and a high-creative group (10). The students were administered pre- and post-tests consisting of a battery of achievement measures. Five months elapsed between the pre- and post-tests. At the time of pre-testing, students were also given a creative-thinking test.

In analyzing the data a 2x3x2 factorial design was employed. Two levels of teacher creativity, three levels of student creativity and sex were the variables in the design. The criterion variable examined was scholastic achievement.

The findings indicated a significant interaction among teacher creativity, student creativity, and achievement in reading comprehension
and mathematlc skills, but no significant main effect between teacher creativity and student scholastic performance was found. Yamamoto's research points out the complexity of creativity and perhaps dispels the common notion held by many educators that creative teachers produce better, academic-performing students. One of the problems in assessing the effects which creative teachers have on their students lies in the testing devices used. There may be important side-benefits accrued by students from creative teachers, but these benefits are not measured by most achievement tests.

A study conducted by Carey (10) involving 196 sixth-grade students in a metropolitan school district in Indiana found that student creativity was not related to student achievement. However, Carey reported significant correlation coefficients existing between IQ and Fluency and IQ and Originality. Fluency and Originality are considered important components of creativity. The implications of this study point to the danger in considering creativity and intelligence as separate mental processes.

Metcalf (41) investigated the relationship between scores on tests of creativity and scores on IQ and school achievement measures. This study included 312 eighth-grade students. Metcalf reported significant correlations between Flexibility and achievement as well as Flexibility and IQ. Significant intercorrelations among Fluency, Originality and Flexibility were also reported. However, Flexibility was found to be more closely related to IQ and achievement than either Fluency or Originality.

Many studies such as Metcalf's look at isolated bits of creativity. This is not a criticism of Metcalf's study but reflects an inadequacy in
creative-measuring devices. Flexibility, Fluency and Originality are considered key components of creativity; but, in addition, variables such as Elaboration, Sensitivity to Problems and Redefinition Ability are deemed important in the creative process. Thus far most of the creative tests employed in research assess only a portion of those variables which Guilford and Merrifield (25) consider germane to creativity.

An experimental investigation which examined the possibilities of teacher inservice education and its impact on developing student creative abilities was conducted by Enoch (17). Four fifth-grade teachers and their 97 pupils were the participants in this study. The teachers and students were divided into two groups, one experimental and one control group. During a ten-week period, sixteen audio-video tapes were made of the activities in the experimental classrooms. At the close of each day in which an audio-video recording was made, Enoch, along with the classroom teacher, discussed the video tape. This discussion focused on the following teaching principles: (1) treat all pupil questions with respect, (2) all unusual ideas from students should be respected, (3) indicate to students that their ideas are valued, (4) encourage student initiative for learning, and (5) allow students to discuss many ideas relating to a problem without immediate evaluation.

On the basis of pre- and post-creativity measures, students of the experimental teachers showed significant gains in Originality. No differences were found with respect to Flexibility.

The evaluation of teacher inservice education programs prove to be an arduous task when creativity is the criterion variable. Student
creativity, or at least some aspect of it, may be enhanced as a result of teacher inservice education; but the key variables to which this growth can be attributed often is never discovered.

Perhaps one of the best instruments available for studying the classroom oral activities is the Aschner and Gallagher analysis scale (5). This scale divides verbal activity within the classroom into five categories: routine, cognitive-memory, convergent thinking, evaluative thinking and divergent thinking. The Aschner-Gallagher System is an adaption of Guilford's operations dimension of the structure-of-the-intellect model to the analysis of the verbal activity in the classroom. Hutchinson (32) used this scale to analyze the verbal activity within the classrooms included in his study. A significant reduction in the cognitive-memory classification of verbal activity was reported by Hutchinson in those experimental classrooms where creativity was successfully developed.

Enoch (17) employed a system of analyzing classroom behavior which was developed by Flanders (18). Flanders's system examines the verbal activity in the classroom by recording the frequency of remarks which reflect teacher-student behavior and attitudes in the following areas: (1) teacher acceptance of student feeling, (2) teacher praise and encouragement of students, (3) teacher acceptance of student ideas, (4) teacher questions, (5) teacher lectures, (6) teacher directions, (7) teacher criticism, (8) student responses, (9) student initiatory remarks, and (10) classroom silence and confusion. Enoch concluded, on the basis of Flanders's system of analyzing classroom verbal activity, that those
classrooms in which student questions and ideas are encouraged and respected; student Originality is enhanced.

Castle (11) investigated the difference in creativity between rural and urban students. The rural group was comprised of 87 students from a rural school system and an equal number of students from Oklahoma City made up the urban group.

These students were matched on the basis of intelligence test results, age, sex and grade classification. Castle found that rural and urban students did not differ on scores of creativity tests. Other comparisons of the creativity measures were made on the basis of sex, socio-economic background and religious preference; no significant differences were found.

Janssen (34) examined the difference in performance on creative tests between student dropouts and nondropouts from lower socio-economic status groups. The dropout group consisted of 48 students and the nondropout group was comprised of 198 students. The tenth-grade classes from two high schools in Knoxville, Tennessee, provided the subjects.

In analyzing the data, Janssen controlled for IQ in comparing scores on creativity tests. The results of this study showed that the dropout students did significantly better on tests of creativity. Janssen inferred from these findings that possibly the middle-class conformity imposed upon lower, socio-economic students reduces student creative-thinking ability.

A study conducted by Pogue (44) investigated the interrelationships of creativity, self-esteem and race. The sample was composed of 263
students in grades four, five and six. The proportion of Negro students in the sample approximated 50 percent.

The findings of this study indicated a significant relationship between creativity scores and self-esteem scores, but no differences were found between white and Negro students in creative ability. Pogue's creativity measures consisted of the Incomplete Figures Tasks and the Circle Tasks which are part of the Minnesota Test of Creative Thinking. These exercises are completely nonverbal and would seem to be limited in measuring the multifaceted complex of creativity.

Trowbridge (67), at Iowa State University, studied the relationship between creativity and technical competence as expressed by students enrolled in art classes. The subjects for this investigation were comprised of 75 children ranging in ages from 3 to 18 years. These children were categorized into five age groups.

From each child two paintings were randomly selected and evaluated by a panel of three judges. Rating scales were employed in assigning creativity and technical competence scores to each painting.

The findings indicated a zero correlation between the two dimensions, creativity and technical competence. The developmental patterns of these two dimensions were also examined. Technical competence was found to increase gradually and steadily with age whereas creativity remained relatively stable from 3 to 15 years and increased sharply from 15 to 18 years.

Wieser (73) investigated creativity among prospective teachers enrolled in the College of Education of the University of Missouri.
Creativity tests were administered to 282 students preparing to obtain a teaching certificate. In addition, scores from each of these students were obtained from the Educational Interest Inventory.

There were no differences found among the mean creativity scores of those students planning on teaching science, mathematics, social studies, fine arts, physical education, special education, commercial education and homemaking. Also, no differences were found when the criterion variable, creativity, was applied to elementary and secondary teachers. The only significant finding was a positive relationship existing between scores on the College Professor Scale of the Educational Interests Inventory and creativity test scores.

To conclude this section, a study involving creativity and educational administrators by Antley (3) is reported. Forty-two Mississippi school administrators participated by taking tests of creative-thinking ability as well as the Administration and Supervision Test and Supplement of the National Teacher Examination.

Antley's purpose was to study the relationships among creativity, job knowledge and decision-making ability of school administrators. Decision making was evaluated in three ways. First, each superintendent solved six problems which were presented in case study, simulated form. These simulated problems related to school systems which varied in terms of the number of students enrolled. Secondly, each superintendent kept daily logs describing the most important decision made each day. The log contained a list of suggested solutions as well as the one selected. In addition the superintendent was to record by position title those
individuals involved in the decision. Thirdly, a randomly selected group of teachers from each school system was asked to complete a questionnaire naming the positions of those persons who made the decisions on various school matters.

The findings revealed that job knowledge and three decision-making variables (decision level, decision fluency and cooperative decision making) related significantly to creativity measures. The decision-making variables as well as job knowledge were used as prediction variables of creativity in a multiple-regression analysis. The analysis indicated that these four variables accounted for .216 of the variance of creativity with job knowledge being the best predictor and decision level ranking second.

Antley concluded that administrators of large schools who are older reflect more creativity in the administration of their school. These administrators appeared to be more fluent in suggesting possible solutions to problems and make more unique decisions. Also those administrators who scored higher on job knowledge tests involved more people in the decision-making process.

Antley's study is one of very few investigations which examines creativity within school administrators. The manner in which the decision-making process was analyzed appeared to be highly susceptible to bias. However, the study represents a pioneering effort into an area of education which may have great potential in fostering creative-thinking ability among students.
Summary

Research in creativity is not of recent origin and has long been a subject of interest in the fine arts. Not until 1950, when Guilford's factor analytical studies began to probe into the structure of the intellect, did creativity become a concern for many psychologists.

The Structure-of-the-Intellect Model, proposed by Guilford, has three dimensions. The operations dimension, which classifies thinking into cognition, convergent, evaluative, divergent and memory processes, is of particular value to educators in understanding students as "thinkers."

Guilford's model has served as the point of departure for many research studies in the areas of measuring and identifying creative behavior. Torrance, perhaps more than any other researcher, has attempted to develop creative thinking measuring devices for broad application in education. Torrance's tests have not been widely used in education because of the difficulty in scoring them. The tests have been basically used in experimental research.

Research concentrating on IQ and creativity has indicated that intelligence (those mental abilities measured by IQ tests) and creativity may involve different mental processes. Creativity and intelligence are not completely mutually exclusive combinations of talent but do differ in degree. Creativity has been found to be related to intelligence when the IQ measures are in the range of 120 and below. For those individuals with IQ's above 120, the relationship between creativity and intelligence declines rapidly.

The diverse results of many doctoral studies point to the difficulty
in making generalizations about the relationships among creativity, IQ and scholastic performance. A basic problem may be in the creativity measures available. Much research is conducted using creativity measures that only assess a portion of the creativity complex.

Developing creative thinking abilities in the classroom, which has been the crux of this study, is the basic challenge to educators. Several research projects, emphasizing a teaching strategy, have demonstrated that students can grow in knowledge while enhancing their creative thinking ability.

The kind of teaching approach thought to foster student creative behavior is far less dominant than what is often found. The classroom activities are student centered, and divergent thinking is stressed by using a variety of teaching techniques.

For some researchers and writers on the subject of creativity, a distinction between creative and critical thinking is important. Critical thinking appears to be negative in the sense that it encourages skepticism. Critical thinking discourages ideation and is more concerned with the judgment of a proposed solution to a problem. Creative thinking encourages flexibility and openness in thinking and recognizes that there may be many good solutions to a proposed problem.

The question as to whether creativity is an aptitude or attitude is of vital concern to educators. The aptitude concept tends to limit creative thinking ability to those few, specially-endowed individuals. However, if attitude is an important variable in creative behavior, then the implications are that creativity may be a talent that all people
possess. This latter concept places important demands on teachers and educational administrators to provide the proper climate for creative thinking ability to flourish.

The Aschner Gallagher analysis scale as well as Flanders's system have been employed to examine classroom verbal activities. These scales assist researchers in quantifying classroom activities and to isolate those teacher-student verbal interactions which are thought to be pertinent to the development of creativity.

Prospective teachers of various disciplines and grade levels, on the basis of limited research, reflect little difference on scores of creativity measures. Experience and job knowledge have been found to enhance the amount of creativity exhibited by educational administrators.

Sex, race and socio-economic status seem to have little influence on creative-thinking ability. However, the results of some research have found that dropouts of low socio-economic status groups performed better on tests of creativity than non-dropouts of the same status levels.
THE EXPERIMENTAL DESIGN

The primary purpose of this chapter is to outline and explain the procedure followed in implementing this study. The description of the approach will elaborate on the setting, control and experimental groups, measuring devices used, teacher inservice education and the teaching program. Hopefully the experiment could be easily replicated after studying this portion of the dissertation.

Setting

The experiment was conducted involving the eighth grade students enrolled in the Urbandale Junior High School for the 1967-68 school year. The Urbandale Community is one of the fastest growing suburban areas of Des Moines. The Urbandale Junior High, which is the only junior high school in the Urbandale School District, is located about six miles northwest of the center of Des Moines. Urbandale's school patrons reflect incomes and educational levels above the average for the State of Iowa, and the school system seems to be a pacesetter in establishing instructional practices leading to a nongraded curriculum.

Urbandale Junior High School is a three-year school comprised of grades seven, eight and nine. The student body is made up of 650 students. This study included the eighth-grade class which has an enrollment of 204 students.

The specific subject area used in this investigation was the eighth-grade physical science class. The physical science classes were organized into seven class sections with one teacher having four sections and
another teacher three sections. The class size for the seven sections ranged from 25 to 32 students.

The administrative practice of the school indicated that the students were, in most cases, randomly assigned to class sections with no attempt at ability grouping. The two physical science teachers were of the opinion that each of the seven sections represented a cross section of student academic ability.

Since it was important that each group be quite similar in levels of achievement and ability, the seven groups were compared using their seventh-grade composite scores on the Iowa Basic Skills Test and marks received in seventh-grade mathematics.

In analyzing the variance for the composite scores on the Iowa Basic Skills Test, an F ratio of 1.659 with 6/188 degrees of freedom was obtained. The F is considered nonsignificant at the .05 level. In analyzing the variance of the marks received in seventh-grade mathematics, an F ratio of 1.662 with 6/190 degrees of freedom was obtained. This F was also found to be nonsignificant at the .05 level.

With this preliminary analysis of academic performance, it was concluded that each group of students represented a cross section of academic ability, and, that no group differed significantly with respect to past school performance and achievement.

The two teachers cooperating in the implementation of this study had master's degrees and five or more years of teaching experience. Hereafter the cooperating teachers shall be identified as teacher A and teacher B.
The Research Paradigm

The research procedure follows the pre-test/post-test control group design. The control group (93 students) was comprised of three sections of eighth-grade students enrolled in physical science classes and is designated as $G_1$. The experimental group (111 students) contained four sections of eighth-grade students enrolled in physical science classes and is designated as $G_2$. The pre- and post-test measures of achievement and creativity are represented by $O_1$ and $O_2$ respectively. The letter X represents the experimental teaching program which was administered to the experimental group for a five-week period. The following paradigm represents the basic research design.

\[
\begin{array}{ccc}
G_1 & O_1 & O_2 \\
G_2 & O_1 & X & O_2 \\
\end{array}
\]

The Experimental and Control Groups

Some difficulty was encountered in selecting which class sections would represent the experimental group. There were seven class sections; four sections taught by teacher A and three sections by teacher B. It was impossible to organize a balanced research design including an equal number of students in both the control and experimental groups.

It was decided to proceed with four classes representing the experimental group and the remaining three classes would make up the control group. Two of the four class sections taught by teacher A, and two of the three classes taught by teacher B were randomly selected to represent
the experimental group.

The total number of students comprising the experimental group was 111 students whereas the control group consisted of 93 students. The average number of students enrolled in the four class sections making up the experimental group was 27.1. For the three class sections in the control group, the average number of students per section was 31.

The rationale for having four class sections in the experimental group was to enable better control for the teaching variable. Both teacher A and B were assigned to classes representing the experimental group.

The Experimental Teaching Program

The experimental teaching strategy was applied to a five-week instructional unit covering specific subject matter content on temperature and heat. The rationale for the experimental teaching program comes from Suchman's (58, p.33) Thinking-Learning-Acting-Model (Figure 4). Suchman's model diagrams the thinking-learning processes students actually experience when permitted to learn by inquiry. Before going further, an explanation of Suchman's terms follow:

Meaning The pursuit of meaning is a fundamental human activity and is probably the chief motivation for most inquiry. Before trying to analyze the complex processes by which people make experience meaningful, we must first consider what meaning is and how it is possible for the meaning to be generated.

Perceiving is the result of an interaction between whatever is "out there" and available to our senses, and what is already internal and available to our thinking. We don't use our senses simply as wide open windows to bring in everything
Figure 4. Thinking-learning-acting model
from outside. The world is too complex—besides, we are not interested in everything. Instead, we are selective.

Encounter  There is a point of contact in time and space between man and his environment. Life is a succession of such contacts. People encounter the real world around them in many ways. They encounter minute objects, large complex events, and people.

The main points about encounters are: (1) the environment may offer a great many or only a few; (2) the individual can generate more encounters for himself by playing an active role and stirring things up; (3) a teacher can increase the numbers of encounters for his pupils by enriching and activating the environment, surrounding the children with more stuff, and giving them more of a chance to get at it.

Organizer  The organizer resides within the person; it is a particular condition of the mind that permits the learner to respond to encounters in selected ways. An organizer helps the person to impose some degree of order upon his encounters. It affords a framework for new encounters and makes the encounters meaningful.

An organizer is available because of what has happened in the past. It is a pattern which guides the selection, grouping, and ordering of encounters. Organizers take many forms. One is produced through the retention and recall of a previous encounter. The second time a person watches a baseball game, the encounter will be more meaningful simply on the basis of the first game that was seen.

Action  This function is the best starting place, because it is most clearly evident in the learner. Obviously, the learner moves about, talks, and manipulates objects. Any teacher or parent knows how much drive a child has to move about and do things. The drive is present at birth and throughout his life, although, as he gets older, other functions begin to replace some of the action. While older persons can sit still for longer periods and watch, read, or think, the school-age child approaches his world mobilized to do things.

Control  It is difficult to imagine what humans would be like without the control function. Even in the case of a newborn baby, certain internal regulations cause crying when he is hungry or in pain; other make him focus on and follow objects in his field of vision. (Gesell identified dozens of patterns of control in newborn infants and showed that the absence of controls usually indicated impairment.)

School-age children have highly sophisticated control systems. All of these are triggered and regulated in a creative or adaptive way in response to (a) the desire of the
child, (b) his knowledge and experience, and (c) what he perceives in his environment.

Intake The human is a perceiving creature. Through his senses he encounters his environment. But at no time is he taking in all that is available. What he sees, hears, and feels is selected and organized by him.

Storage If you stop to think about it, it is fairly clear that what you perceive is a function of what you know. When I listen to music on the radio, I can usually tell when Beethoven is being played. I think I can tell the difference between Bach and Mozart, but I rarely notice mistakes in performance, unless I am very familiar with the selection and the mistake is a bad one. Some persons cannot only identify every composer and opus, but can sense slight deviations in tempo and pitch which I could never detect. Critics and most good musicians have knowledge that enables them to make refined discriminations and to find meaningful patterns in what would seem far less meaningful to a musical layman. This is true in thousands of ways throughout our daily lives. We all develop specialized knowledge which sharpens and organizes our intake as well as our action.

Systems Systems give you a structure for separating certain dimensions from the whole. They are tools for categorizing or characterizing your world, for extracting meaning from any encounter through analysis.

If we could not categorize or analyze, we would have the enormous job of interpreting every encounter as a completely unique experience. Although we might recognize an encounter as having a vague familiarity, we could never know why this was so. Neither would we be able to describe, explain, or relate it to something else. Systems, then, are the instruments by which we organize the similarities and differences of our world and which thus enable us to create the structures of our disciplines.

Data We also provide children with data that has been generated by applying systems to encounters. When we state that Pike's Peak is 14,110 feet high, we rely upon somebody's previous application of the system of linear measure (feet) to the encounter of the mountain itself. The resulting statement is data.

Inference Data represent in effect discrete samplings of the environment. As one accumulates samplings, he begins to construct or abstract beliefs, theories, generalizations, or principles about the nature of the thing he is sampling. This is commonly known as inference or induction.
Visceral level  The physiological needs of a child such as
hunger, thirst, overtired, overconfined conditions.

Social-ego pressures  Psychological needs such as worry
about failure and rejection.

Closure  When a person's knowledge seems incomplete or
inadequate to him, when something puzzles him that he can't
figure out, when he wants an answer, a solution, a final and
satisfying explanation, he is said to be seeking closure.
He is disturbed by the open-endedness of things. Closure
motivation is common among children. Most people enjoy
the satisfaction of finding new meaning where it was absent.
They feel better about the world when all the parts fit together
and they feel they have a handle on it.

Curiosity  This is very different from closure. Some people
want to open the world up--to find new problems rather then
solve old ones. There can be great pleasure and satisfaction
in probing, wondering, and doubting, even when it never leads
to closure.

Power  Knowledge is power, and many people pursue knowledge
for that reason. Being able to predict and control one's
environment gives one a sense of sureness and competence.
Some people feel this more than others, but it cannot be
ignored as a basis for motivation in learning. (49, p.29,78;
51, p.27,66; 53, p.33,92,94)

In implementing the experimental teaching approach, the Inquiry
Development Program (IDP) was used. This program was developed by
Suchman in conjunction with Science Research Associates, Inc., of Chicago,
Illinois.

Since the IDP is designed for teaching physical science for the
entire school year, some adaption of the program had to be made for theive-week teaching experiment. The IDP in physical science includes 66
problems, 25 presented in film, 29 with the teacher demonstration kit,
and 12 in the student idea book. In adapting the IDP to the experimental
teaching unit covering temperature and heat, only those problems pertinent
to the subject-matter content of the unit were used.
An IDP problem consists of a discrepant event presented to the class either through an eight millimeter, silent film loop, teacher laboratory demonstration or by a written problem in the student idea book. A discrepant event is a scientific phenomenon which has been explained by the operation of scientific principles but is not readily explained or understood by mere observation. For example, a problem or discrepant event is presented to the class using a silent, eight millimeter film loop. The film shows that a specific kind of knife blade (when heat is applied to the blade) bends only one way. No attempt, either by the teacher or through the film, is made to give students any data for understanding the behavior of the knife blade.

After seeing the discrepant event, the students attempt to construct a reasonable theory to account for it. The inquiry session involves teacher-student interaction as well as student-student verbal interaction. A major part of the inquiry session is often devoted to data-gathering questions raised by the students and answered by the teacher.

The rules for conducting the inquiry session follow:

1. Student questions should be phrased in such a way that they can be answered yes or no.

2. Once called upon, a student may ask as many questions as he or she wishes before yielding the floor.

3. The teacher does not answer yes or no to statements of theories, or to questions that attempt to obtain the teacher's approval of a theory.

4. Any student can test any theory at any time.

5. Any time the students feel a need to confer with one another without the teacher's presence, they should be free to call a conference.
6. Inquirers should be able to work with experimental kits, idea books or resource books at any time they feel the need. (52, pp.152-153)

The experimental teaching program concentrated on the inquiry session. As the rules for the inquiry session imply, a permissive classroom climate prevailed. The teacher served more as a learning consultant than a director of student learning activities.

The role of the teacher was to elicit theories from the students which explained the observed discrepant events. Students were encouraged to test their theories by having the freedom to use the classroom laboratory facilities and their student IDP experimental kits. Frequently brain storming sessions emerged from class discussion concerning how a theory could be tested.

Evaluation of subject-matter achievement was minimized. One testing period was devoted to the experimental group. However, during this one testing period, the students were not asked to answer questions about scientific principle in heat and temperature; but, on the contrary, students were asked to write test questions.

Nearly 100 percent of the class time was devoted to the inquiry session. The teacher's role was not one which permitted students to receive closure regarding their attempts at theorizing. The closure-seeking students had to find security by reading resource books and supplementary reading materials.
Teacher Inservice Education

Teachers A and B were exposed to a short period of inservice education designed to prepare them for carrying out the experimental teaching program. Both teachers were free from teaching assignments daily from 8:00 A.M. to 9:30 A.M. The inservice education period consisted of ten one-and-one-half hour sessions.

The inservice education program stressed student thinking as a process which leads to creativity, and, in addition, concentrated on the behavior of the teacher in stimulating student productive thinking. The two teachers were familiarized with the IDP and its accompanying instructional materials. Various eight-millimeter films were shown that were appropriate for the content unit on temperature and heat. A phonograph record was obtained recording an inquiry session conducted by Suchman.

Another source of material, which was found to be most helpful during the inservice education program, was an instructional unit on creativity (29). The unit had been prepared by Science Research and Associates, Inc. for teacher inservice education. This material contained several suggested teaching techniques which were proposed to stimulate student creative thinking. In addition to the inquiry session, other teaching strategies such as brainstorming, group processes, and independent study were discussed as being applicable to the teaching program.

The Teaching Program for the Control Group

The teaching program for the control group consisted of a standard textbook supplemented by various reading materials. The teacher's func-
tion was basically to lecture and to lead a teacher-directed class discussion. The primary objective was to cover the unit subject-matter content thoroughly. The teachers held laboratory experiments with no attempt to involve students as doers but only as observers.

The control group was exposed to short quizzes designed to evaluate subject-matter achievement. Teacher centeredness and domination of all learning experiences were the outstanding characteristics of the teaching program administered to the control group.

Measuring Devices Used

Achievement test

To establish the levels of student achievement for the seven class sections, a pre-test was administered to all students one week before the experimental teaching period commenced. The pre-test was composed of 60 multiple-choice type questions.

In constructing the achievement test a variety of instructional materials was used from which to select test items. Teacher A, teacher B, and the researcher each submitted 50 test items for consideration in developing the achievement test. The test items were purposefully constructed to test for understanding and application of knowledge rather than testing for memory of facts.

A pilot achievement test including 120 multiple-choice items was developed for the purpose of establishing test reliability. This test was administered to 110 ninth-grade students enrolled in the Callanan Junior High School located in Des Moines. The results of this test were
examined by doing an item analysis. Each of the 120 test items was analyzed as to difficulty and discrimination according to a set of criteria recommended by the Iowa State University Testing Center. The reliability coefficient for the pilot test of 120 multiple-choice items was 90.1 percent.

After the pilot test was administered and the 120 test items analyzed, 60 of the 120 test items were selected to be included in the final instrument for testing achievement. This 60-item test was also administered to the same 110 ninth-grade students enrolled at the Callanan Junior High School. A reliability coefficient of 88.6 percent was computed from the results.

As a pre- and post-achievement measure the same 60-item, multiple-choice test was used. However for the post measure the 60 test items were administered in a different order. The post-test was given to all students on the day following the end of the teaching period.

**Testing for creative thinking ability**

To measure the change in creative thinking ability a pre- and post-test were administered to all students. The pre-test was entitled Creative Thinking With Words, Form A, and the post-test was Form B of the same test.

This test was developed by Torrance and attempts to measure creative thinking ability. The results of the test are reported as a composite score which is comprised of three sub-scores. The sub-scores indicate ideational flexibility, fluency in thinking and originality. For a detailed description of this test see the review of literature.
The arduous task in working with Torrance's test is the scoring. To assure consistency in scoring, all tests were scored by a team of employees working for the Personnel Press Publishing Company in New York city. This team has been trained to evaluate such tests.

Statistical Analysis of Data

Complete data on pre- and post-tests of achievement and creativity were collected from 185 of the 204 eighth-grade students. Of these 185 students, four class sections with a total number of 96 students represented the experimental group, and three class sections with a total of 89 students represented the control group.

Mean-gain comparisons were made between the combined experimental and control (E and C) groups as well as between the class sections (e₁, e₂, e₃ and e₄) which were in the experimental teaching program and the class sections (c₁, c₂ and c₃) which were in the control teaching program. The statistical procedures employed in examining the data were analysis of variance and multiple comparisons using the least significant difference (l.s.d.) method. (77, p.350)

A correlation matrix was developed to study the relationship existing between creativity and seventh-grade grade point average (GPA), IQ, marks in seventh-grade mathematics, scores on the physical science test which was constructed for the teaching experiment and seventh-grade composite scores on the Iowa Basic Skills Test. Wert (72, p.424) was used in determining the significance of the r values reported in the matrix.

At the end of the experimental teaching period, all students were
asked to complete an attitude scale designed to elicit their interest in science. The answers to the questions on the attitude scale were constructed in a bi-polar fashion enabling the students to select a number from one to seven to indicate the degree of their interest. The attitude scales were analyzed by comparing the mean scores between the experimental and control groups using analysis of variance.

Assumptions Applicable to Tests of Significance

1. Teachers A and B are equally competent in applying the experimental teaching program.

2. Teachers A and B are equally interested in applying the experimental teaching program.

3. Differences in class sizes ranging from 25-33 will not affect the application and results of the experimental teaching program.

4. Any attitudinal differences between students in the experimental and control groups toward science at the end of the experiment may be attributed to the experimental teaching program.
RESULTS

Findings

In presenting the findings of the teaching experiment, the mean-gain scores on measures of subject-matter achievement and creativity were compared by combining the class sections into one control and one experimental group. All statistical tests reported in the findings chapter were based on the combined groups. Complete data were collected on 185 of the 204 students participating in the study; 89 control students and 96 experimental students. These combined groups are designated as E for the experimental students and C for the control students.

The experimental group is composed of four class sections identified as e1, e2, e3 and e4. The combined control group is composed of three class sections labeled as c1, c2 and c3. Since the null hypotheses were tested by examining differences between the combined experimental and control groups, the multiple comparisons of the individual class sections were not reported in the findings chapter. The Appendix contains tables in which subgroup comparisons on mean-gain scores are shown.

Mean-gain scores on creative thinking measures were examined by analyzing subscores for fluency, flexibility and originality. A total creativity score was computed by adding the T-scores of the three subtests.

Test of hypothesis 1

Hypothesis 1 was stated as follows: There is no difference in gain scores between the experimental and control groups on tests of subject-
matter achievement.

The performance of the students in the experimental and control groups on a pre- and post-test of achievement measuring growth in physical science subject matter is presented in Table 1.

Table 1. Subject-matter achievement means on pre- and post-tests in physical science

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-tests</th>
<th>Post-tests</th>
<th>Mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>31.32</td>
<td>37.87</td>
<td>6.55</td>
</tr>
<tr>
<td>C</td>
<td>32.35</td>
<td>41.00</td>
<td>8.64</td>
</tr>
</tbody>
</table>

A comparison of the mean-gain scores on subject-matter achievement for the experimental and control groups is presented in Table 2.

Table 2. Difference in mean-gain scores on subject-matter achievement

<table>
<thead>
<tr>
<th>Mean-gain scores</th>
<th>Mean difference</th>
<th>Standard error of mean difference</th>
<th>df</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>6.05</td>
<td>2.59</td>
<td>171</td>
<td>3.23**</td>
</tr>
<tr>
<td>C</td>
<td>8.64</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Significant at the 1 percent level.

As can be observed in Table 2, students in the control teaching program gained significantly more in subject-matter achievement than did the students in the experimental program. Therefore, hypothesis 1 was refuted in favor of the control teaching program.
Test of hypothesis 2

Hypothesis 2 was stated as follows: There is no difference in jain scores between the experimental and control groups on tests of creative thinking ability.

In testing the aforementioned hypothesis, differences between the experimental and control groups in mean-gain scores for fluency, flexibility, originality and total creativity were examined.

The performance of the students in the experimental and control groups on pre- and post-tests measuring the fluency dimension of creativity are reported in Table 3.

Table 3. Fluency means on pre- and post-tests of creative thinking

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-tests</th>
<th>Post-tests</th>
<th>Mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>52.60</td>
<td>52.76</td>
<td>0.16</td>
</tr>
<tr>
<td>C</td>
<td>49.21</td>
<td>52.97</td>
<td>3.76</td>
</tr>
</tbody>
</table>

A comparison of the mean-gain scores on fluency for the experimental and control groups is presented in Table 4.

Table 4. Difference in mean-gain score on fluency

<table>
<thead>
<tr>
<th>Mean-gain scores in gain scores</th>
<th>Mean difference</th>
<th>Standard error of mean difference</th>
<th>df</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>0.16</td>
<td>3.60</td>
<td>1.15</td>
<td>171</td>
</tr>
<tr>
<td>C</td>
<td>3.76</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Significant at the 1 percent level.
The data in Table 4 show that the control students gained significantly more on fluency measures than did the experimental students. Hypothesis 2 was rejected in favor of the control teaching program when considering the fluency dimension of creativity.

Table 5 contains the mean scores on pre- and post-tests of creativity measuring the flexibility component of creativity.

Table 5. Flexibility means on pre- and post-tests of creative thinking

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>61.40</td>
<td>62.55</td>
<td>1.15</td>
</tr>
<tr>
<td>C</td>
<td>59.04</td>
<td>60.67</td>
<td>1.63</td>
</tr>
</tbody>
</table>

A comparison of the mean-gain scores on flexibility for the experimental and control groups is presented in Table 6.

Table 6. Difference in mean-gain scores on flexibility

<table>
<thead>
<tr>
<th>Mean-gain scores</th>
<th>Mean difference in mean scores</th>
<th>Standard error of mean difference</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>1.15</td>
<td>0.48</td>
<td>171</td>
<td>0.10</td>
</tr>
<tr>
<td>C</td>
<td>1.63</td>
<td>1.46</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In examining Table 6, one finds that the mean-gain scores of the two groups do not differ significantly. When considering the flexibility dimension of creativity, hypothesis 2 was retained.

Table 7 contains the means on pre- and post-tests of creativity scored for originality.
Table 7. Originality means on pre- and post-tests of creative thinking

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-tests</th>
<th>Post-tests</th>
<th>Mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>47.70</td>
<td>50.15</td>
<td>2.45</td>
</tr>
<tr>
<td>C</td>
<td>43.65</td>
<td>51.00</td>
<td>7.35</td>
</tr>
</tbody>
</table>

The comparison of the mean-gain scores for originality is presented in Table 8.

Table 8. Difference in mean-gain scores on originality

<table>
<thead>
<tr>
<th>Mean-gain scores</th>
<th>Mean difference</th>
<th>Standard error of mean difference</th>
<th>df</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>2.45</td>
<td>4.90</td>
<td>1.35</td>
<td>171</td>
</tr>
<tr>
<td>C</td>
<td>7.35</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Significant at the 1 percent level.

As can be observed in Table 8, students taught by the control teaching program gained significantly more on post-tests of originality than did the experimental students. Hypothesis 2 was refuted in favor of the control teaching program when considering the originality dimension of creativity.

The performance of the two groups of students on pre- and post-tests of creativity scored for total creativity is presented in Table 9.

Table 9. Total creativity means on pre- and post-tests of creative thinking

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-tests</th>
<th>Post-tests</th>
<th>Mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>161.71</td>
<td>165.46</td>
<td>3.75</td>
</tr>
<tr>
<td>C</td>
<td>151.91</td>
<td>164.65</td>
<td>12.74</td>
</tr>
</tbody>
</table>
The comparison of the mean-gain scores on total creativity is reported in Table 10.

Table 10. Difference in mean-gain scores on total creativity

<table>
<thead>
<tr>
<th>Mean-gain scores</th>
<th>Mean difference in gain scores</th>
<th>Standard error of mean difference</th>
<th>df</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>E 3.75</td>
<td>C 12.74</td>
<td>8.99</td>
<td>3.13</td>
<td>171</td>
</tr>
</tbody>
</table>

**Significant at the 1 percent level.

The statistical analysis reported in Table 10 shows that the students in the control teaching program gained significantly more on post-tests measuring total creativity than did the experimental students. Hypothesis 2 was rejected in favor of the control students.

Test of hypothesis 3

Hypothesis 3 was stated as follows: There is no difference in attitude toward science classes between the experimental and control groups.

To test hypothesis 3, an attitude scale was constructed which yielded a numerical rating indicating a liking or disliking for science classes. A high numerical rating indicated a liking for science classes and a low numerical rating indicated little interest or a disliking for science classes. A copy of the attitude scale can be found in the Appendix.

The mean numerical ratings for the experimental and control groups on the attitude scale as well as the results of the F test are presented in Table 11.
Table 11. A comparison of the mean numerical ratings on the attitude scale for the experimental and control groups

<table>
<thead>
<tr>
<th>Mean rating score</th>
<th>Mean difference in rating scores</th>
<th>df</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.7</td>
<td>20.5</td>
<td>4.2</td>
<td>183</td>
</tr>
</tbody>
</table>

*Significant at the 1 percent level.

The results of the statistical test reported in Table 11 show that the experimental students scored higher on the attitude scale and consequently indicated more interest in and liked science more than the control students. An assumption was made in Chapter 3 which was stated as follows: Any difference found in attitude between the experimental and control students toward science classes will be attributed to the teaching approach used. Therefore, hypothesis 3 was rejected in favor of the experimental teaching program.

Test of hypothesis 4

Hypothesis 4 was stated as follows: There is no relationship between scores on measures of creative thinking ability and IQ.

To test hypothesis 4, a correlation matrix was developed using creativity scores, marks of academic performance and IQ scores obtained from the 185 students involved in the study. Table 12 contains r values which indicate the degree of relationship between scores on creativity measures and the Otis Quick-Scoring IQ test.

In examining Table 12 one finds r values ranging from .189 to .236
Table 12. Correlations showing the relationship between scores on creativity, IQ and academic performance measures for 185 eighth-grade students

<table>
<thead>
<tr>
<th>Creative Thinking Measures</th>
<th>IQ, Otis Quick Scoring</th>
<th>Grade Point Average 7th Grade</th>
<th>Iowa Basic Skills Tests 7th Grade Comp.</th>
<th>7th Gr. Math Marks</th>
<th>Pre-Ach. Test in Physical Science</th>
<th>Post-Ach. Test in Physical Science</th>
<th>Pre-Fluency</th>
<th>Pre-Flexibility</th>
<th>Pre-Originality</th>
<th>Post-Fluency</th>
<th>Post-Flexibility</th>
<th>Post-Originality</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ, Otis Quick Scoring</td>
<td>1.00</td>
<td>1.00</td>
<td>.725</td>
<td>.531</td>
<td>.526</td>
<td>.769</td>
<td>1.00</td>
<td>.063</td>
<td>.065</td>
<td>1.00</td>
<td>.063</td>
<td>.065</td>
</tr>
<tr>
<td>Grade Point Average 7th Grade</td>
<td>2.616</td>
<td>1.00</td>
<td>.777</td>
<td>.714</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iowa Basic Skills Tests 7th Grade Comp.</td>
<td>3.795</td>
<td>.777</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7th Grade Math Marks</td>
<td>4.561</td>
<td>.803</td>
<td>.648</td>
<td>.626</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Ach. Test in Physical Science</td>
<td>5.561</td>
<td>.503</td>
<td>.651</td>
<td>.526</td>
<td>.769</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Ach. Test in Physical Science</td>
<td>6.553</td>
<td>.531</td>
<td>.651</td>
<td>.526</td>
<td>.769</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Fluency</td>
<td>7.189</td>
<td>.181</td>
<td>.200</td>
<td>.166</td>
<td>.114</td>
<td>.065</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Flexibility</td>
<td>8.286</td>
<td>.269</td>
<td>.314</td>
<td>.239</td>
<td>.169</td>
<td>.168</td>
<td>.778</td>
<td>.100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Originality</td>
<td>9.214</td>
<td>.336</td>
<td>.306</td>
<td>.370</td>
<td>.203</td>
<td>.148</td>
<td>.631</td>
<td>.552</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Fluency</td>
<td>10.190</td>
<td>.280</td>
<td>.261</td>
<td>.284</td>
<td>.193</td>
<td>.213</td>
<td>.726</td>
<td>.652</td>
<td>.556</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Flexibility</td>
<td>11.276</td>
<td>.392</td>
<td>.332</td>
<td>.357</td>
<td>.262</td>
<td>.268</td>
<td>.646</td>
<td>.660</td>
<td>.587</td>
<td>.861</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Post-Originality</td>
<td>12.216</td>
<td>.288</td>
<td>.253</td>
<td>.313</td>
<td>.262</td>
<td>.319</td>
<td>.533</td>
<td>.511</td>
<td>.469</td>
<td>.783</td>
<td>.712</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*These two values are nonsignificant, all other r values are significant at the 1 percent level; r values enclosed in the box indicate the relationship between scores on measures of creative thinking ability and scores on IQ and academic performance measures.*
which indicate a positive relationship between the three dimensions of creativity—fluency, flexibility and originality—and IQ scores. Although these r values are low, all are significant at the 1 percent level. Hypothesis 4 was rejected.

Test of hypothesis 5

Hypothesis 5 was stated as follows: There is no relationship between scores on measures of creative thinking ability and marks of academic performance.

The correlation matrix contained in Table 12 was used in testing Hypothesis 5. The r values indicating the relationship between creativity scores and marks of academic performance range from .065 to .392. Although these r values are low only two of them fail to be significant. The two r values, .114 and .065, indicate no relationship between pre-fluency scores and scores on pre- and post-tests in physical science. Since 28 of the 30 r values are significant at the 1 percent level, a positive relationship between creativity scores and marks of academic performance exists. Hypothesis 5 is rejected.

Test of hypothesis 6

Hypothesis 6 was stated as follows: There is no sex difference on scores of creative thinking ability measures.

To test hypothesis 6 the mean scores according to sex were compared for the various measures of creativity. Of the 185 students involved in the study, 34 were girls and 101 were boys.

Comparisons of the performances of boys and girls on measures of
creativity are presented in Table 13.

In examining the data in Table 13, one finds the girls scoring significantly higher than the boys on post-flexibility, pre- and post-originality, and post-total creativity measures. The girls also scored higher than the boys on post-fluency, pre-flexibility and pre-total creativity measures but not significantly higher. The boys scored higher than the girls on only one measure; this was pre-fluency. Hypothesis 6 is rejected on four of the creativity measures, and on four of the creativity measures, hypothesis 6 was retained. However, higher

Table 13. Mean scores on creativity measures according to six measures

<table>
<thead>
<tr>
<th>Creativity measures</th>
<th>Mean scores</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>Mean</td>
<td>S. E.</td>
<td>df</td>
<td>F</td>
</tr>
<tr>
<td>Pre-fluency</td>
<td>50.77</td>
<td>51.14</td>
<td>0.36</td>
<td>1.56</td>
<td>171</td>
<td>0.05</td>
</tr>
<tr>
<td>Post-fluency</td>
<td>54.64</td>
<td>51.38</td>
<td>3.25</td>
<td>1.68</td>
<td>171</td>
<td>3.72</td>
</tr>
<tr>
<td>Pre-flexibility</td>
<td>60.65</td>
<td>59.95</td>
<td>0.70</td>
<td>1.72</td>
<td>171</td>
<td>0.16</td>
</tr>
<tr>
<td>Post-flexibility</td>
<td>63.69</td>
<td>59.95</td>
<td>3.73</td>
<td>1.93</td>
<td>171</td>
<td>3.95*</td>
</tr>
<tr>
<td>Pre-originality</td>
<td>47.14</td>
<td>44.60</td>
<td>2.53</td>
<td>0.97</td>
<td>171</td>
<td>6.77**</td>
</tr>
<tr>
<td>Post-originality</td>
<td>52.20</td>
<td>49.20</td>
<td>3.00</td>
<td>1.51</td>
<td>171</td>
<td>3.95*</td>
</tr>
<tr>
<td>Pre-total creativity</td>
<td>158.57</td>
<td>155.69</td>
<td>2.87</td>
<td>3.82</td>
<td>171</td>
<td>0.56</td>
</tr>
<tr>
<td>Post-total creativity</td>
<td>172.53</td>
<td>160.53</td>
<td>10.00</td>
<td>4.73</td>
<td>171</td>
<td>4.46*</td>
</tr>
</tbody>
</table>

* Significant at the 5 percent level.
** Significant at the 1 percent level.
performances on measures of creativity were in the direction of the girls.

An interesting finding in this experiment, although not presented as a testable hypothesis, concerned the teachers' ability to identify highly-creative students. Teachers A and 3, who were involved in the teaching experiment, were requested to name from the 204 students enrolled in the eighth-grade class 35 students who were thought to be the most creative. These 35 students were then compared to the 35 top-performing students on post-measures of total creativity. Fourteen of the students selected by the teachers were included in the 35 top-performing group. The teachers involved in this study were able to identify 40 percent of the 35 top-performing students on post-measures of creative thinking ability.

Summary

The performances of the students in the control and experimental teaching programs were compared by analyzing mean-gain scores on pre- and post-tests of subject-matter achievement and creativity. The statistical tests applied to mean-gain differences between the experimental and control students favored the control teaching program on nearly all variables investigated. The control teaching program yielded significantly higher gains in subject-matter achievement than did the experimental teaching program. On measures of creativity, the control teaching program surpassed the experimental program by yielding significantly higher gains on fluency, originality and total creativity measures. Only on the flexibility dimension of creativity there was no significant difference found between the control and experimental program.
A significant positive relationship was found to exist between creativity scores and performance on IQ and academic achievement measures. The r values indicating positive relationships were low but nevertheless significant.

Students in the experimental teaching program indicated more interest in and a liking for science classes than did the students in the control teaching program. This was evident by a statistical analysis of the mean-numerical rating on the attitude scale.

Sex differences in favor of the girls were found when examining the performances on creativity measures. The girls scored significantly higher than boys on four of the eight creativity measures used in the experiment.

The teachers who cooperated in this teaching experiment were able to identify 40 percent of the 35 top-performing students on measures of creative thinking ability.
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

This study was a teaching experiment in which the inquiry method of teaching was employed. The experiment focused on a physical science instructional unit covering course content on heat and temperature. The experimental teaching program was tested for its effectiveness in cultivating student creative thinking ability as well as providing for student growth in subject-matter content. The experimental teaching strategy was adapted from the Physical Science Inquiry Development Program (IDP) which is produced and marketed by Science Research Associates, Inc.

Purpose

The purpose of the study was to obtain evidence in an attempt to answer the following general questions:

1. Can student creative thinking abilities be cultivated in the classroom?
2. Can students progress in subject-matter content and creative thinking abilities simultaneously?
3. How does the inquiry teaching approach compare with the teacher-centered, more traditional teaching method in yielding student growth in creativity and subject-matter content?
4. What is the relationship between scores on tests of creativity and measures of academic performance and IQ?
5. Are there any sex differences on scores of creativity measures?
Experimental Procedure

To investigate the general problem areas before mentioned, a teaching experiment was conducted which involved 204 eighth-grade students. These students were distributed over seven class sections.

A preliminary investigation indicated that the seven groups of students were homogeneous with respect to past academic performance.

Two teachers participated in the teaching experiment. Teacher A taught four class sections while Teacher B was responsible for three classes. Two of the four classes taught by Teacher A and two of the three classes taught by Teacher B were randomly selected as experimental classes. The remaining three classes represented the control group.

At the outset of the experiment, all students were given a pre-test in subject-matter over heat and temperature as well as Torrance’s tests of creative thinking. For five weeks following the pre-tests, the experimental classes were taught employing the Inquiry Development Program, and the control classes were taught by teacher lectures, demonstrations and teacher-centered discussions. The experimental students were exposed daily to inquiry, student-theorizing sessions. These sessions emerged from a problem that had been introduced to the class either through a filmstrip or teacher demonstration. The inquiry problems exposed the students to scientific behavior of heat and temperature but left for the students to theorize about the cause of the observed event or scientific behavior. The teacher made few attempts to give the students the scientific principles explaining the observed event. Students had available instructional materials explaining the scientific
phenomena presented in the inquiry problems. The control students followed closely a textbook and concentrated on subject-matter coverage and understanding.

Immediately following the five-week period, all students were exposed to post-tests of creativity and subject-matter achievement. Complete data were collected on 96 of the 111 students in the experimental group and on 39 of the 93 students enrolled in the control classes.

To examine the effectiveness of the experimental teaching program as well as to investigate specific variable relationships to creative thinking ability, the following hypotheses were formulated:

1. There is no difference in gain scores between the experimental and control groups on tests of subject-matter achievement.
2. There is no difference in gain scores between the experimental and control groups on tests of creative thinking ability.
3. There is no difference in attitude toward science classes between the experimental and control students.
4. There is no relationship between scores on measures of creative thinking ability and $W$. 
5. There is no relationship between scores on measures of creative thinking ability and marks of academic performance.
6. There is no sex difference on scores of creative thinking ability measures.

Results

In evaluating the effectiveness of the experimental teaching program, differences in mean-gain scores on pre- and post-tests of subject-matter
achievement and creativity were analyzed. The results of the statistical
tests were:

1. Hypothesis 1 was rejected. The control students made signifi-
cantly greater gains in subject-matter achievement.

2. Hypothesis 2 was rejected on three of the four creativity
measures. The control students made significantly higher gains
on the fluency and originality dimensions of creativity as well
as on total creativity scores. There was no difference in mean-
gain scores between the experimental and control students on the
flexibility dimension of creativity.

3. Hypothesis 3 was rejected. The experimental students indicated
a significant difference in attitude toward science classes.
The experimental students showed more interest in and liked
science classes more than the control students.

To test the following two hypotheses, scores for the 185 students on
pre- and post-creativity measures, the Otis Quick-Scoring Intelligence
Test, seventh-grade GPA, composite scores for the seventh-grade Iowa Basic
Skills Tests, marks in seventh-grade mathematics, and the pre- and post-
experimental achievement test were correlated and presented in a matrix.

4. Hypothesis 4 was rejected. A significant positive relationship
existed between scores on creativity measures and performances
on the Otis Quick-Scoring Intelligence Test.

5. Hypothesis 5 was rejected. A significant positive relationship
existed between scores on creativity measures and marks
indicating academic performance. Only two of the 30 r values
showing the relationship between creativity scores and academic achievement were nonsignificant. The pre-fluency score on the test of creative thinking ability did not relate significantly to scores on the pre- and post-experimental achievement test in physical science.

In testing the following hypothesis, mean-score performance on pre- and post-tests of creativity were analyzed according to sex. Mean differences by sex were statistically tested.

6. Hypothesis 6 was rejected on four of the creativity measures in favor of the girls. Also, on four of the creativity measures, hypothesis 6 was accepted. The girls scored significantly higher than the boys on post-flexibility, pre- and post-originality, and post-total creativity measures. The girls also scored higher than the boys on post-fluency, pre-flexibility and pre-total creativity measures but not significantly higher. The boys only scored higher than the girls on one measure but not significantly higher; this was pre-fluency.

An additional finding, not presented as a testable hypothesis, concerned the ability of teachers to identify creative talent. Both teachers involved in the experiment were requested to collaborate and identify the 35 most creative students in the eighth-grade class of 204 students. The 35 students selected by the teachers were compared to the 35 top-performing students on the post-test of creative thinking ability. Of the 35 top-performing students on tests of creativity, 14 were identified by the teachers. The teachers involved in the experiment were
able to identify 40 percent of the 35 most creative students.

Limitations of the Study

There are certain limitations in an experiment of this nature, and some of these limitations are believed to center upon the following issues:

1. The teacher inservice education period was relatively short to expect teachers to completely change their method of teaching. Although the teachers in the experiment appeared to be implementing the inquiry teaching approach satisfactorily, some question could arise as to whether the philosophy behind inquiry teaching was completely understood.

2. The experimental teaching strategy, the Inquiry Development Program, was designed to be implemented for a full school year. The experiment adapted the program to a five-week instructional program. A teaching experiment lasting only five weeks may not be long enough to adequately evaluate the teaching program.

3. The teachers involved in the experiment as well as the researcher questioned the testing instruments used. If there were student benefits derived from the inquiry teaching approach, perhaps tests have yet to be developed in order to properly assess these benefits.

Discussion

The inquiry teaching approach shifts the responsibility for student learning from the teacher to the students. The researcher believes that most students have not been accustomed to assuming responsibility for
learning. For students to assume a huge portion of the responsibility for learning requires much motivation on the part of the teacher and may take years to develop.

The researcher as well as the teachers involved in the experiment were surprised by the findings of the experiment. It was anticipated that the experimental teaching program would be superior to the control program in cultivating student growth in creative thinking abilities.

The basic criticism of the experimental teaching program expressed by the teachers involved concerned the lack of subject-matter coverage. Students were permitted to ponder, think and test their individual theories in an effort to explain scientific phenomena; this procedure took time.

However, the reason why the control teaching program exceeded the experimental teaching program in yielding student growth in creative thinking abilities is difficult to establish. One possible explanation may be that science, more than any other subject-matter discipline, is fostering creative thinking ability among students. Science textbooks, instructional materials, and science teachers have improved in quality immensely since the National Defense Education Act of 1958. Many science textbooks contain material which is presented in a most interesting fashion. Also, many science textbooks emphasize the why's and how's of scientific principles more than straight presentations of factual material.

The inquiry teaching approach used in this experiment appeared to neglect the need for students to have a basic foundation of scientific
knowledge. Without a basic reservoir of knowledge, it is difficult to surmise that productive and creative thinking will occur.

Conclusions

On the basis of the findings in this investigation, the following conclusions were drawn:

1. Inquiry teaching in physical science is not as effective as teacher lectures, demonstrations, and teacher-centered class discussions in obtaining student growth in subject-matter achievement.

2. Inquiry teaching in physical science is not as effective as teacher lectures, demonstrations, and teacher-centered class discussions in obtaining student growth in creative thinking abilities.

3. Student growth in creative thinking ability and subject-matter achievement can be cultivated simultaneously by teacher-centered instructional activities.

4. Student growth in creative thinking ability and subject-matter achievement are being fostered by science teachers who employ teacher-centered, instructional activities.

5. Inquiry teaching in science should be used as a periodic, supplemental teaching approach which will tend to activate student interest in science.

6. Girls show a tendency to score higher on verbal measures of creative thinking ability than do boys.
7. If teachers were to attempt an identification of their most creative students, chances are that over half of the most creative students would not be recognized.

8. There is a relationship between creative ability and academic aptitude and achievement. However, this relationship is slight.

Recommendation for Additional Research

The exploratory nature of this study offers only a tentative evaluation of the inquiry teaching approach. To substantiate the findings of this investigation, the following activities may prove valuable.

1. The study should be replicated with the experiment continuing for an entire school year.

2. The students involved in this study should be categorized as either high, average or low in academic aptitude. Then, the test results could be analyzed in an effort to determine whether the inquiry teaching approach was more suitable for high, average or low ability students.

3. The reliability of Torrance's test, Thinking Creatively with Words, should be examined by administering the tests again to the students who participated in this study. This would not only help to check the reliability of the test but would help determine whether the gains in creative thinking ability experienced by the control students were maintained.
4. A teaching experiment employing inquiry teaching should be conducted in another discipline, that is, language arts or social studies.
BIBLIOGRAPHY


82


APPENDIX

Post-Experimental Attitude Scale

HOW MUCH DO YOU LIKE

1. science class?
   LIKE A LITTLE  1 2 3 4 5 6 7  LIKE A LOT

2. to participate in discussion in science class?
   LIKE A LITTLE  1 2 3 4 5 6 7  LIKE A LOT

3. to participate in science class experiments and demonstrations?
   LIKE A LITTLE  1 2 3 4 5 6 7  LIKE A LOT

4. reading magazines and books about science?
   LIKE A LITTLE  1 2 3 4 5 6 7  LIKE A LOT

5. to do extra for science class?
   LIKE A LITTLE  1 2 3 4 5 6 7  LIKE A LOT
Experimental Achievement Test

PHYSICAL SCIENCE TEST OVER
HEAT AND TEMPERATURE

1. The term "adhesion" refers to
   a. the force that holds molecules of the same material together.
   b. the force that forces molecules of the same material apart.
   c. the force that holds molecules of different materials together.
   d. the force that forces molecules of different materials apart.

2. Which of the following represents the best reason why water is rarely used in a thermometer.
   a. Water is difficult to see.
   b. Water would evaporate too easily.
   c. Water, when frozen, expands greatly and would break the glass.
   d. Water, when frozen, contracts greatly and would be difficult to see.

3. Which of the following would make the best insulator?
   a. copper
   b. water
   c. air
   d. a vacuum

4. Heat waves from the sun reach us by means of
   a. radiation.
   b. insulation.
   c. convection currents.
   d. conduction.

5. Two houses are sitting side by side, one with snow on the roof and one with no snow on the roof. What conclusion could you draw?
   a. Both are well insulated.
   b. Both are poorly insulated.
   c. The house with no snow on the roof is well insulated, while the other is not.
   d. The house with snow on the roof is well insulated, while the other is not.

6. The wind in our atmosphere is an example of
   a. radiation.
   b. insulation.
   c. convection currents.
   d. conduction.
7. On a very hot day, you touch the black fender of a car with one hand and some chromium of the car with the other hand. What should be the results?
   a. The chromium is cooler than the fender.
   b. The fender is cooler than the chromium.
   c. They feel the same, as far as the heat is concerned.
   d. None of the above.

8. A thermometer with some cloth saturated in alcohol and wrapped around the bulb will cause the following results.
   a. The temperature of the thermometer will remain the same.
   b. The temperature of the thermometer will go up.
   c. The temperature of the thermometer will go down.
   d. The temperature of the cloth will go up.

9. On a warm day, and with the air almost saturated with moisture, which of the following conditions exist?
   a. The moisture in the air makes you feel cool.
   b. You feel hot because the moisture cannot evaporate from your skin.
   c. You feel no different than any other time.
   d. Your skin feels extremely dry.

10. In ice, molecules
    a. move the same speed as molecules in water.
    b. move much faster than the molecules in water.
    c. move much slower than the molecules in water.
    d. are in suspension and do not move at all.

11. Radiant heat is most closely associated with
    a. cosmic rays.
    b. ultra-violet rays.
    c. infrared rays.
    d. gamma rays.

12. Why are not air coolers such as are found in Arizona, Nevada, New Mexico, etc. found in Iowa?
    a. Our humidity is too low, and the evaporation would be too rapid.
    b. They are much more expensive than air conditioning.
    c. Our humidity is so high the evaporation within the air cooler cannot take place.

13. What happens to the freon chemicals after they have been evaporated in the refrigerator?
    a. They are condensed and used again.
    b. They are released to the outside and new freon used.
    c. They coat the freezing tray.
    d. They are used as a lubricate for the electric motor.
14. As temperature of a substance increases, the substance  
a. forms a liquid.  
b. expands.  
c. contracts.  
d. forms a gas.

15. Heat is believed to be  
a. an invisible substance that enters and leaves a material.  
b. an energy produced by molecular action.  
c. a substance produced only by a chemical change.  
d. none of these.

16. Which of the following objects will most readily absorb heat?  
a. highly polished aluminum foil  
b. a rough black surface  
c. a smooth black surface  
d. a rough white surface

17. The blower in a furnace may be controlled by a  
a. thermometer.  
b. thermocouple.  
c. thermostat.  
d. thermograph.

18. 20° centigrade is equal to  
a. 78°F  
b. 104°F  
c. 68°F  
d. 18°C

19. If a piece of copper is placed in water, heat must go from the  
a. water to the copper.  
b. copper to the water.  
c. water and copper to the air.  
d. warmer substance to the colder.

20. The uneven expansion of metal is the basis for the operation of the  
a. alcohol thermometer.  
b. mercury thermometer.  
c. vacuum bottle.  
d. thermostat.

21. Cases are good insulators because  
a. they prevent convection current.  
b. their molecules are far apart.  
c. their molecules move slowly.  
d. they cannot be compressed.
22. Hammering a nail or rubbing two pieces of metal together produces heat by causing
   a. molecules to move faster.
   b. molecules to move slower.
   c. contraction.
   d. expansion.

23. Shiny aluminum foil sometimes is used in the walls and ceilings of buildings because
   a. it is fire resistant.
   b. it is a good conductor of heat energy.
   c. it reflects radiant energy.
   d. none of these.

24. When you touch a cold doorknob, your hand feels cold. This is due to
   a. poor circulation in your hand.
   b. heat being transferred away from your hand.
   c. cold being transferred away from your hand.
   d. none of these.

25. -273° centigrade equals
   a. 0° Kelvin.
   b. 50° Fahrenheit.
   c. 273° Kelvin.
   d. none of these

26. The movement of smoke particles in an airtight chamber is due to
   a. the attraction of molecules.
   b. air current within the chamber.
   c. the movement of molecules.
   d. none of these.

27. The spinning of a pinwheel above a flame illustrates that
   a. air is in motion.
   b. warm air rises.
   c. a pinwheel is easy to turn.
   d. none of these.

28. Heat is transferred through solids mainly by
   a. convection.
   b. radiation.
   c. conduction.
   d. none of these.

29. Wind is a good example of
   a. radiation.
   b. conduction.
   c. infrared rays.
   d. convection.
30. Air at the highest temperature in a room can be found
   a. along the side of the walls.
   b. along the floor.
   c. along the ceiling.
   d. in the center of the room.

31. Temperature decreases with an increase in the
   a. density of the air.
   b. humidity.
   c. elevation.

32. Heat energy causes matter to
   a. expand.
   b. contract.
   c. keep the same volume.
   d. have a squeezing molecular action.

33. A cubic foot of warm air contains
   a. fewer molecules than a cubic foot of cold air.
   b. more molecules than a cubic foot of air.
   c. no way of determining.
   d. the same number of molecules as a cubic foot of cold air.

34. When it comes to absorbing and losing heat
   a. water takes longer than the earth.
   b. the earth takes longer than water.
   c. air takes longer than either.
   d. earth loses faster but water absorbs faster.

35. Convection is described by
   a. the transfer of heat by conduction.
   b. the transfer of heat by the circulation of air and water.
   c. the transfer of heat by radiation.
   d. the transfer of heat through a solid.

36. A tub of cold water placed in an unheated basement on a cold, mid­winter night would
   a. cool the basement as it freezes.
   b. warm the basement slightly as it freezes.
   c. have no effect on the temperature of the basement as it freezes.
   d. radiate kinetic energy.

37. Air expands and contracts because the
   a. molecules move all the time.
   b. molecules move fast when heated and slow when cooled.
   c. atoms take up more room.
   d. air is a compound.
38. In a hot air heating system, transfer of heat from the furnace to the rooms takes place chiefly by
   a. convection.
   b. radiation.
   c. conduction.

39. Combustion is another name for
   a. decaying.
   b. burning.
   c. boiling.
   d. melting.

40. Heat is best described by the word
   a. matter.
   b. substance.
   c. gas.
   d. energy.

41. The thermometer which has fixed points of 32 and 212 degrees is called the
   a. Fahrenheit thermometer.
   b. Centigrade thermometer.
   c. BTU thermometer.
   d. Coil thermometer.

42. Steam and water pipes are often wrapped in asbestos because of its
   a. conduction qualities.
   b. insulating qualities.
   c. radiating qualities.
   d. convection qualities.

43. The symbol (°) indicates
   a. degrees.
   b. atoms.
   c. molecules.
   d. electrons.

44. To change Fahrenheit temperatures to Centigrade temperatures
   a. subtract 32° and divide by 1.8.
   b. add 32° and divide by 1.8.
   c. divide by 1.8.
   d. subtract 32°.

45. To change Centigrade temperatures to Fahrenheit
   a. multiply by 1.8 and add 32°.
   b. add 32° divide by 1.8.
   c. subtract 32° and divide by 1.8.
   d. add 32°.
46. Heat travels from the sun to the earth by
   a. changing to light.
   b. radiation.
   c. conduction.
   d. convection.

47. The top may pop off the milk bottle brought from the refrigerator into a warm room because
   a. heat expands the milk and air in the bottle.
   b. fermentation gives off gases.
   c. dissolved oxygen escapes.

48. In general, the boiling point of water can be lowered by
   a. reducing air pressure.
   b. applying heat faster.
   c. covering the container.

49. The fixed points on a thermometer are determined by finding the temperature of melting ice and of boiling water at
   a. ground level.
   b. surface level.
   c. sea level.

50. Man has scarcely begun to tap the limited heat resources of
   a. coal.
   b. natural gas.
   c. the sun.
   d. electricity.

51. The quantity of heat needed to raise the temperature of one pound of water through one degree Fahrenheit is called a
   a. British Thermal Unit.
   b. calorie.
   c. alpha ray.
   d. kilowatt.

52. When steam is condensed, heat is
   a. absorbed.
   b. stored.
   c. released.
   d. evaporated.

53. Cooking problems arise in the high altitude regions of the mountains. These problems could be overcome by using a
   a. pressure cooker.
   b. blast furnace.
   c. household heaters.
   d. generators.
54. The boiling point for liquids differ depending on the
   a. atmospheric pressure.
   b. weather.
   c. season.
   d. dew point.

55. The degree of hotness or coldness is represented by the word
   a. humidity.
   b. circulation.
   c. temperature.
   d. radiation.

56. The average speed of molecules increases as matter
   a. absorbs heat.
   b. releases heat.
   c. contracts.

57. The temperature of a body is a measure of
   a. the size of its molecules.
   b. The average speed of its molecules.
   c. the rate of expansion of the molecules.
   d. the rate of contraction of the molecules.

58. The dew point is the temperature at which the water vapor in the
   air begins to
   a. evaporate.
   b. circulate.
   c. expand.
   d. condense.

59. Absolute zero is the lowest possible temperature and reads
   a. -320 degrees Fahrenheit.
   b. -279 degrees Fahrenheit.
   c. -800 degrees Fahrenheit.
   d. -459 degrees Fahrenheit.

60. Which of the following is an example of light energy being changed
    to chemical energy?
   a. a growing plant
   b. a rapidly flowing stream
   c. a ringing doorbell
   d. a burning log
Experimental and Control Subgroup Comparisons

Table 14. Subject-matter achievement means on pre- and post-tests for the seven groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-tests</th>
<th>Post-tests</th>
<th>Mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>e₁</td>
<td>27.83</td>
<td>33.75</td>
<td>5.91</td>
</tr>
<tr>
<td>e₂</td>
<td>35.82</td>
<td>42.67</td>
<td>6.85</td>
</tr>
<tr>
<td>e₃</td>
<td>31.39</td>
<td>39.34</td>
<td>7.95</td>
</tr>
<tr>
<td>e₄</td>
<td>31.50</td>
<td>35.16</td>
<td>3.66</td>
</tr>
<tr>
<td>c₁</td>
<td>30.83</td>
<td>39.83</td>
<td>9.00</td>
</tr>
<tr>
<td>c₂</td>
<td>32.74</td>
<td>40.96</td>
<td>8.22</td>
</tr>
<tr>
<td>c₃</td>
<td>33.46</td>
<td>42.12</td>
<td>8.65</td>
</tr>
</tbody>
</table>

Table 15. Differences in mean-gain scores on subject-matter achievement between the experimental and control subgroups

<table>
<thead>
<tr>
<th>Groups compared</th>
<th>Mean difference in gain scores</th>
<th>Standard error of mean difference</th>
<th>df</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>e₁ - e₁</td>
<td>-3.02</td>
<td>1.67</td>
<td>171</td>
<td>3.39</td>
</tr>
<tr>
<td>e₁ - e₂</td>
<td>-2.30</td>
<td>1.71</td>
<td>171</td>
<td>1.80</td>
</tr>
<tr>
<td>e₁ - e₃</td>
<td>-2.73</td>
<td>1.64</td>
<td>171</td>
<td>2.73</td>
</tr>
<tr>
<td>e₂ - c₁</td>
<td>-2.14</td>
<td>1.60</td>
<td>171</td>
<td>1.78</td>
</tr>
<tr>
<td>e₂ - e₂</td>
<td>-1.36</td>
<td>1.64</td>
<td>171</td>
<td>0.68</td>
</tr>
<tr>
<td>e₂ - e₃</td>
<td>-1.79</td>
<td>1.58</td>
<td>171</td>
<td>1.29</td>
</tr>
<tr>
<td>e₃ - c₁</td>
<td>-1.05</td>
<td>1.76</td>
<td>171</td>
<td>0.35</td>
</tr>
<tr>
<td>e₃ - e₂</td>
<td>-0.27</td>
<td>1.80</td>
<td>171</td>
<td>0.02</td>
</tr>
<tr>
<td>e₃ - e₃</td>
<td>-0.70</td>
<td>1.74</td>
<td>171</td>
<td>0.16</td>
</tr>
<tr>
<td>e₄ - c₁</td>
<td>-5.33</td>
<td>1.67</td>
<td>171</td>
<td>10.15**</td>
</tr>
<tr>
<td>e₄ - e₂</td>
<td>-4.55</td>
<td>1.71</td>
<td>171</td>
<td>7.06**</td>
</tr>
<tr>
<td>e₄ - e₃</td>
<td>-4.98</td>
<td>1.64</td>
<td>171</td>
<td>9.14**</td>
</tr>
</tbody>
</table>

**Significant at the .01 level.
Table 16. Fluency means on pre- and post-tests of creative thinking for the seven groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-tests</th>
<th>Post-tests</th>
<th>Mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>e₁</td>
<td>56.45</td>
<td>52.03</td>
<td>-4.37</td>
</tr>
<tr>
<td>e₂</td>
<td>50.35</td>
<td>54.82</td>
<td>4.46</td>
</tr>
<tr>
<td>e₃</td>
<td>56.25</td>
<td>57.00</td>
<td>0.75</td>
</tr>
<tr>
<td>e₄</td>
<td>48.33</td>
<td>47.50</td>
<td>-0.83</td>
</tr>
<tr>
<td>c₁</td>
<td>52.00</td>
<td>54.16</td>
<td>2.16</td>
</tr>
<tr>
<td>c₂</td>
<td>49.25</td>
<td>54.07</td>
<td>4.81</td>
</tr>
<tr>
<td>c₃</td>
<td>46.65</td>
<td>50.93</td>
<td>4.37</td>
</tr>
</tbody>
</table>

Table 17. Differences in mean-gain scores on fluency between the experimental and control subgroups

<table>
<thead>
<tr>
<th>Groups compared</th>
<th>Mean difference</th>
<th>Standard error of mean difference</th>
<th>df</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>e₁ - c₁</td>
<td>-6.54</td>
<td>2.14</td>
<td>171</td>
<td>9.32**</td>
</tr>
<tr>
<td>e₁ - c₂</td>
<td>-9.18</td>
<td>2.19</td>
<td>171</td>
<td>17.53**</td>
</tr>
<tr>
<td>e₁ - c₃</td>
<td>-9.75</td>
<td>2.11</td>
<td>171</td>
<td>17.15**</td>
</tr>
<tr>
<td>e₂ - c₁</td>
<td>2.29</td>
<td>2.05</td>
<td>171</td>
<td>1.24</td>
</tr>
<tr>
<td>e₂ - c₂</td>
<td>-0.35</td>
<td>2.11</td>
<td>171</td>
<td>0.02</td>
</tr>
<tr>
<td>e₂ - c₃</td>
<td>0.08</td>
<td>2.02</td>
<td>171</td>
<td>0.00</td>
</tr>
<tr>
<td>e₃ - c₁</td>
<td>-1.41</td>
<td>2.25</td>
<td>171</td>
<td>0.39</td>
</tr>
<tr>
<td>e₃ - c₂</td>
<td>-4.06</td>
<td>2.30</td>
<td>171</td>
<td>3.10</td>
</tr>
<tr>
<td>e₃ - c₃</td>
<td>-3.65</td>
<td>2.22</td>
<td>171</td>
<td>2.64</td>
</tr>
<tr>
<td>e₄ - c₁</td>
<td>-2.99</td>
<td>2.14</td>
<td>171</td>
<td>1.96</td>
</tr>
<tr>
<td>e₄ - c₂</td>
<td>-5.64</td>
<td>2.19</td>
<td>171</td>
<td>6.62*</td>
</tr>
<tr>
<td>e₄ - c₃</td>
<td>-5.20</td>
<td>2.11</td>
<td>171</td>
<td>6.07*</td>
</tr>
</tbody>
</table>

* Significant at the 5 percent level.

** Significant at the 1 percent level.
Table 18. Flexibility means on pre- and post-tests of creative thinking for the seven groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-tests</th>
<th>Post-tests</th>
<th>Mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>e1</td>
<td>62.70</td>
<td>62.50</td>
<td>0.20</td>
</tr>
<tr>
<td>e2</td>
<td>62.50</td>
<td>68.92</td>
<td>6.42</td>
</tr>
<tr>
<td>e3</td>
<td>64.25</td>
<td>59.25</td>
<td>-5.00</td>
</tr>
<tr>
<td>e4</td>
<td>56.45</td>
<td>57.91</td>
<td>1.45</td>
</tr>
<tr>
<td>e5</td>
<td>65.83</td>
<td>62.00</td>
<td>-3.83</td>
</tr>
<tr>
<td>e6</td>
<td>56.66</td>
<td>62.22</td>
<td>5.55</td>
</tr>
<tr>
<td>e7</td>
<td>54.68</td>
<td>58.12</td>
<td>3.44</td>
</tr>
</tbody>
</table>

Table 19. Differences in mean-gain scores on flexibility between the experimental and control subgroups

<table>
<thead>
<tr>
<th>Groups compared</th>
<th>Mean difference</th>
<th>Standard error of mean difference</th>
<th>df</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>e1 - c1</td>
<td>3.62</td>
<td>2.72</td>
<td>171</td>
<td>1.76</td>
</tr>
<tr>
<td>e1 - c2</td>
<td>-5.76</td>
<td>2.79</td>
<td>171</td>
<td>4.25*</td>
</tr>
<tr>
<td>e1 - c3</td>
<td>-3.64</td>
<td>2.68</td>
<td>171</td>
<td>1.33</td>
</tr>
<tr>
<td>e2 - c1</td>
<td>10.26</td>
<td>2.61</td>
<td>171</td>
<td>15.37**</td>
</tr>
<tr>
<td>e2 - c2</td>
<td>0.87</td>
<td>2.68</td>
<td>171</td>
<td>0.10**</td>
</tr>
<tr>
<td>e2 - c3</td>
<td>2.99</td>
<td>2.57</td>
<td>171</td>
<td>1.34</td>
</tr>
<tr>
<td>e3 - c1</td>
<td>-1.16</td>
<td>2.87</td>
<td>171</td>
<td>0.16</td>
</tr>
<tr>
<td>e3 - c2</td>
<td>-10.55</td>
<td>2.93</td>
<td>171</td>
<td>12.90**</td>
</tr>
<tr>
<td>e3 - c3</td>
<td>-8.43</td>
<td>2.83</td>
<td>171</td>
<td>8.83**</td>
</tr>
<tr>
<td>e4 - e1</td>
<td>5.29</td>
<td>2.72</td>
<td>171</td>
<td>3.76</td>
</tr>
<tr>
<td>e4 - e2</td>
<td>-4.09</td>
<td>2.79</td>
<td>171</td>
<td>2.15</td>
</tr>
<tr>
<td>e4 - e3</td>
<td>-1.97</td>
<td>2.68</td>
<td>171</td>
<td>0.54</td>
</tr>
</tbody>
</table>

* Significant at the 5 percent level.

** Significant at the 1 percent level.
Table 20. Originality means on pre- and post-tests of creative thinking for the seven groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-tests</th>
<th>Post-tests</th>
<th>Mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>e1</td>
<td>49.16</td>
<td>43.12</td>
<td>-1.04</td>
</tr>
<tr>
<td>e2</td>
<td>48.75</td>
<td>55.53</td>
<td>6.78</td>
</tr>
<tr>
<td>e3</td>
<td>49.50</td>
<td>52.50</td>
<td>3.00</td>
</tr>
<tr>
<td>e4</td>
<td>43.54</td>
<td>43.95</td>
<td>0.41</td>
</tr>
<tr>
<td>c1</td>
<td>42.56</td>
<td>50.83</td>
<td>8.16</td>
</tr>
<tr>
<td>c2</td>
<td>45.18</td>
<td>49.25</td>
<td>4.07</td>
</tr>
<tr>
<td>c3</td>
<td>43.28</td>
<td>52.62</td>
<td>9.34</td>
</tr>
</tbody>
</table>

Table 21. Differences in mean-gain scores on originality between the experimental and control subgroups

<table>
<thead>
<tr>
<th>Groups compared</th>
<th>Mean difference in gain scores</th>
<th>Standard error of mean difference</th>
<th>df</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>e1 - c1</td>
<td>-9.20</td>
<td>2.51</td>
<td>171</td>
<td>13.40**</td>
</tr>
<tr>
<td>e1 - c2</td>
<td>-5.11</td>
<td>2.57</td>
<td>171</td>
<td>3.94*</td>
</tr>
<tr>
<td>e1 - c3</td>
<td>-10.33</td>
<td>2.47</td>
<td>171</td>
<td>17.54**</td>
</tr>
<tr>
<td>e2 - c1</td>
<td>-1.38</td>
<td>2.41</td>
<td>171</td>
<td>0.32</td>
</tr>
<tr>
<td>e2 - c2</td>
<td>2.71</td>
<td>2.47</td>
<td>171</td>
<td>1.19</td>
</tr>
<tr>
<td>e2 - c3</td>
<td>-2.55</td>
<td>2.37</td>
<td>171</td>
<td>1.15</td>
</tr>
<tr>
<td>e3 - c1</td>
<td>-5.16</td>
<td>2.65</td>
<td>171</td>
<td>3.79</td>
</tr>
<tr>
<td>e3 - c2</td>
<td>-1.07</td>
<td>2.70</td>
<td>171</td>
<td>0.15</td>
</tr>
<tr>
<td>e3 - c3</td>
<td>-6.34</td>
<td>2.61</td>
<td>171</td>
<td>5.87*</td>
</tr>
<tr>
<td>e4 - c1</td>
<td>-7.74</td>
<td>2.51</td>
<td>171</td>
<td>9.49**</td>
</tr>
<tr>
<td>e4 - c2</td>
<td>-3.65</td>
<td>2.57</td>
<td>171</td>
<td>2.01</td>
</tr>
<tr>
<td>e4 - c3</td>
<td>-8.92</td>
<td>2.47</td>
<td>171</td>
<td>12.96**</td>
</tr>
</tbody>
</table>

* Significant at the 5 percent level.

** Significant at the 1 percent level.
Table 22. Total creativity means on pre- and post-tests of creative thinking for the seven groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-tests</th>
<th>Post-tests</th>
<th>Mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>e1</td>
<td>168.33</td>
<td>162.70</td>
<td>-5.62</td>
</tr>
<tr>
<td>e2</td>
<td>161.60</td>
<td>179.25</td>
<td>17.67</td>
</tr>
<tr>
<td>e3</td>
<td>170.00</td>
<td>168.75</td>
<td>-1.25</td>
</tr>
<tr>
<td>e4</td>
<td>148.33</td>
<td>169.37</td>
<td>1.04</td>
</tr>
<tr>
<td>e5</td>
<td>160.50</td>
<td>167.00</td>
<td>6.50</td>
</tr>
<tr>
<td>e2</td>
<td>151.11</td>
<td>165.55</td>
<td>14.44</td>
</tr>
<tr>
<td>e3</td>
<td>144.53</td>
<td>161.68</td>
<td>17.15</td>
</tr>
</tbody>
</table>

Table 23. Differences in mean-gain scores on total creativity between the experimental and control subgroups

<table>
<thead>
<tr>
<th>Groups compared</th>
<th>Mean difference</th>
<th>Standard error of mean difference</th>
<th>df</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>c1 - c1</td>
<td>-12.12</td>
<td>5.82</td>
<td>171</td>
<td>4.31*</td>
</tr>
<tr>
<td>e1 - c2</td>
<td>-20.06</td>
<td>5.98</td>
<td>171</td>
<td>11.26**</td>
</tr>
<tr>
<td>e1 - e3</td>
<td>-22.78</td>
<td>5.75</td>
<td>171</td>
<td>15.66**</td>
</tr>
<tr>
<td>e2 - c1</td>
<td>11.17</td>
<td>5.60</td>
<td>171</td>
<td>3.99*</td>
</tr>
<tr>
<td>e2 - c2</td>
<td>3.23</td>
<td>5.75</td>
<td>171</td>
<td>0.21</td>
</tr>
<tr>
<td>e2 - e3</td>
<td>0.52</td>
<td>5.51</td>
<td>171</td>
<td>0.00</td>
</tr>
<tr>
<td>c3 - c1</td>
<td>-7.75</td>
<td>6.15</td>
<td>171</td>
<td>1.56</td>
</tr>
<tr>
<td>e3 - c2</td>
<td>-15.69</td>
<td>6.28</td>
<td>171</td>
<td>6.22*</td>
</tr>
<tr>
<td>e3 - e3</td>
<td>-18.40</td>
<td>6.07</td>
<td>171</td>
<td>9.17**</td>
</tr>
<tr>
<td>e4 - c1</td>
<td>-5.45</td>
<td>5.83</td>
<td>171</td>
<td>0.87</td>
</tr>
<tr>
<td>e4 - c2</td>
<td>-13.40</td>
<td>5.98</td>
<td>171</td>
<td>5.02*</td>
</tr>
<tr>
<td>e4 - c3</td>
<td>-16.11</td>
<td>5.75</td>
<td>171</td>
<td>7.83**</td>
</tr>
</tbody>
</table>

* Significant at the 5 percent level.

** Significant at the 1 percent level.