Verifying the Teaching of Analogies to Fourth Grade Students

Terese A. Byrne

University of Massachusetts Boston

Follow this and additional works at: http://scholarworks.umb.edu/cct_capstone

Part of the Elementary Education and Teaching Commons

Recommended Citation

http://scholarworks.umb.edu/cct_capstone/40

This is brought to you for free and open access by the Critical and Creative Thinking Program at ScholarWorks at UMass Boston. It has been accepted for inclusion in Critical and Creative Thinking Capstones Collection by an authorized administrator of ScholarWorks at UMass Boston. For more information, please contact library.uasc@umb.edu.
VERIFYING THE FEASIBILITY OF TEACHING ANALOGIES TO FOURTH GRADE STUDENTS

A Synthesis Project Presented
by
TERESE A. BYRNE

Submitted to the Office of Graduate Studies, University of Massachusetts
Boston, in partial fulfillment of the requirements for the degree of

MASTER OF ARTS
June 1999

Critical and Creative Thinking Program
© 1999 by Terese A. Byrne
All rights reserved.
VERIFYING THE TEACHING OF ANALOGIES
TO FOURTH GRADE STUDENTS

A Synthesis Project Presented

by

TERESE A. BYRNE

Approved as to style and content by:

Delores Gallo, Associate Professor
Chairperson of Committee

Steve Schwartz, Associate Professor
Member

Delores Gallo, Program Director
Critical and Creative Thinking Program
The proliferation of technology and the information it makes available to all has forced education to realign itself to meet the changing needs of today's students. A shift away from amassing information, toward the development of critical thinking skills, presents teachers with new questions. What skills are appropriate to teach at a given age or level, and how can those skills be developed? This project takes one of those skills, analogies, and investigates the degree of success a teacher might expect in teaching them to fourth grade students.

The project was designed as a data generating study. Fifty-seven fourth grade students from a suburban Boston community participated in the study. There were 28 students in the study group and 29 students in the control group. As there are no commercially available tests that would measure growth in the necessary manner, an instrument was devised for the study. The test contained four subtests at increasing...
levels of proficiency: recognition, completion, analysis, and generation of analogies. Within each subtest five types of relationships were included: descriptive, comparative, categorical, serial, and causal. All participants were given a pretest and a posttest on designated dates. The study group received 16 instructional sessions of 15-20 minutes each between the pre- and posttests. The results were then compared.

The overall analysis showed significant gains for the study group compared to the control group. The greatest gains were made in the fourth subtest, generating analogies. This is particularly encouraging since it requires the greatest facility with the integrated reasoning process of analogical thinking. The findings of the study support the hypothesis that it is feasible to teach analogical skills to fourth grade students, and they suggest that critical thinking can be successfully included in the curriculum of elementary schools.
ACKNOWLEDGMENTS

The author wishes to thank the following people for their invaluable assistance in completing this project: Delores Gallo, Ph. D., Chairperson of the Critical and Creative Thinking Program at UMass, for her inspiration and guidance; Steve Schwartz, Ph. D., Chairperson of the Psychology Department at UMass, for coaching throughout the project and assistance with statistical analysis; Peter Kurzburg, Superintendent, and Ann Keenan, Director of English/ Director of Testing, both of the Braintree Public Schools, who made it possible to conduct the study within the excellent school system; Bruno Zoltowski, principal of the school in which the research was conducted; the fifty-seven wonderful fourth-graders who participated enthusiastically in the study; my colleagues on whom I imposed for time and flexibility in scheduling; Ellen Fogarty, who spent hours helping with reliability scoring; my daughter, Lee, for technical advice; and my husband Jim, who put up with me throughout the process. Without these wonderful people, this research could not have taken place.
## CONTENTS

Abstract................................................................................................................................. iv  
Acknowledgments.................................................................................................................... vi  
List of Tables and Figures........................................................................................................ ix  

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>2. WHAT IS ANALOGICAL THINKING?</td>
<td>5</td>
</tr>
<tr>
<td>3. PURPOSE OF THE STUDY</td>
<td>9</td>
</tr>
<tr>
<td>4. METHOD</td>
<td>11</td>
</tr>
<tr>
<td>5. DESIGN AND MATERIALS</td>
<td>12</td>
</tr>
<tr>
<td>6. RELIABILITY AND PARITY</td>
<td>18</td>
</tr>
<tr>
<td>7. PROCEDURE</td>
<td>19</td>
</tr>
<tr>
<td>8. RESULTS</td>
<td>27</td>
</tr>
<tr>
<td>9. DISCUSSION</td>
<td>31</td>
</tr>
<tr>
<td>APPENDIX</td>
<td>35</td>
</tr>
<tr>
<td>A. Byrne’s Analogy Test, Level D, Forms A and B</td>
<td>35</td>
</tr>
<tr>
<td>B. Scoring Rubric</td>
<td>51</td>
</tr>
<tr>
<td>C. Sample Lesson: Recognizing Analogies</td>
<td>55</td>
</tr>
<tr>
<td>D. Sample Lesson: Completing Analogies</td>
<td>57</td>
</tr>
</tbody>
</table>
CONTENTS, cont.

E. Sample Practice: Generating Analogies..........................58

F. Individual Student Results: Raw Data..........................60

G. Graphic Organizer: Reasoning by Analogy......................62

BIBLIOGRAPHY...................................................................63
LIST OF TABLES AND FIGURES

TABLE

Table 1. Comparison of Mean Scores by Subtest and Total, With Significance....28

FIGURE

Figure 1. Comparison of Mean Scores by Subtest .............................................29
Figure 2. Test Results by Percentage of Gain .......................................................29
INTRODUCTION

The essence of teaching is to enable the student - to enable him/her both to learn and to apply appropriately, independently of the teacher, what (s)he has learned.

The ongoing challenges for teachers are anticipating the kinds of knowledge and skills students will need as they move from the constructed school environment to the workplace and the world, and finding ways of teaching them so that what is learned will transfer effectively. As we enter the new millennium, we find ourselves standing at a very compelling juncture. In the same way that the Industrial Revolution created a demand for a new kind of worker and changed the face of much of the world's economy and society itself two hundred years ago, the Information Revolution today is exerting demands for a different kind of worker and citizen.

The Bureau of Labor Statistics, cited in Newsweek (Feb. 1, 1999), projects that by the year 2006 manufacturing jobs will account for only about 12 percent of jobs in this country. Where a generation ago expertise in a single discipline, craft or profession, was enough to ensure career stability through retirement, today's young worker faces an estimated ten job changes in three careers. Hunt (1995) analyzed the kinds of skills that will be needed in the early decades of the next century in this country. As America moves away from manufacturing, there is an increasing demand for what is called the "knowledge worker." The knowledge worker is one who can carry out multistep operations, manipulate abstract and complex symbols and ideas.
efficiently acquire new information, and be flexible enough to recognize the need for 
continuing change.

In addition to the skills needed in the workplace, the sheer magnitude of the 
information explosion is another reason to demand a new paradigm in education, one 
that stresses critical thinking skills. With the deluge of information available at one’s 
fingertips via the Internet and other remote sources, and with much of that information 
of questionable value, there is a corresponding need for the skillful selection, analysis, 
evaluation, and application of that information (Halpern, 1998). To lack these skills 
renders the information useless, no matter how convenient.

Critical thinking skills are often referred to as higher order skills. Beyond the 
recall of facts, they require judgment, analysis, and synthesis. They are context 
sensitive, reflective, and self-monitored. Deciding on source credibility and finding 
causal relationships which may be counterintuitive, are examples of critical thinking 
applications. By contrast, using mathematical algorithms repetitiously is not 
considered to be higher order thinking (Halpern, 1998). Computational Mathematics 
and other fact based knowledge tends to be easier to teach and to assess because their 
mastery is gauged by direct recall or formula use. The effective application of 
Mathematics and information in novel situations is much more complex, and requires 
critical and/or creative thinking skills in addition to recall and computation.

The complexity of higher order skills has made them more difficult to test, and 
skeptics have questioned their transferability to the real world. However, tests 
recently have been developed that can measure critical thinking fairly well (Halpern
Many states, such as Texas, Virginia, and Massachusetts are testing curriculum and learning, measured against critical thinking, by including open-ended responses scored with a rubric that gives more credit for answers that include making judgments and inferences, drawing conclusions, and using analogies. Transferability has been studied by Lehman and Nisbett (1990), Kosonen and Winne (1995), and Perkins and Grotzner (1997) and others. Their studies provide evidence that critical thinking can be learned with appropriate instruction and that it can transfer successfully to novel domains. (Halpern 1998).

Halpern suggests a four-part model for teaching thinking skills so they will transfer across domains of knowledge. They are: a) an attitude or disposition to think critically, b) instruction and practice with critical thinking skills, c) structure-training activities designed to facilitate transfer, and d) a metacognitive component to direct and assist thinking. While recognizing the importance of all four components of this model, this study will be concerned primarily with the second, the instruction and practice with thinking skills.

There are two major assumptions upon which instruction in critical thinking must be based. First, there must be identifiable skills that students can be taught to recognize and to apply appropriately; second, if these skills are recognized and applied, the students will be more effective thinkers. Halpern’s (1998) list of thinking skills, which should be transferable because they are not dependent upon a particular instructional discipline, include: understanding how cause is determined, recognizing and criticizing assumptions, analyzing means-goal relationships, giving
reasons to support a conclusion, assessing degrees of likelihood and uncertainty, 
incorporating isolated data into a wider framework, and using analogies to solve 
problems.

This study will take a closer look at the last of these, analogies. In 
particular it will define analogy and examine analogical thinking, as reported in 
recent literature. It will also present an original study demonstrating the feasibility 
of teaching fourth grade students to recognize, complete, analyze, and generate 
analogies.

The interest of this study is focused on the elementary classroom for two 
reasons. First, it is the environment in which structured learning begins. Reason 
would dictate that if there is an identified goal, in this case of functional critical 
thinking, that it should be taught as the child is developing and practiced as a habit 
of thinking throughout his/her education. In the same way that a child who learns 
to read early and continues to read regularly develops greater facility than the child 
who starts later and practices less, the child who learns to think critically and 
practices it regularly ought to develop greater facility than the child who learns later 
and uses it less. Habits of mind that have developed over time require multiple 
learning experiences, distributed over time and settings, to be changed (Halpern, 
1998). Recognition of this can be put to advantageous use by developing those 
habits of mind and the skills of reasoning, throughout the time students are in 
school.
The second reason the elementary school is the most appropriate place to commence instruction with analogical reasoning, is that the full range of curricula is most often taught by only one or two teachers in a given year. This presents an optimum environment for modeling transfer across disciplines. Examples can be drawn from a variety of situations so that the flexibility of analogical thinking can be practiced from the start. In Halpern’s structure training model, she explains that thinking skills not only need to be explicitly and consciously taught, they need to be used with many types of examples.

The research aspect of the project will be designed as a study comparing two groups of students - those receiving instruction on the target skill and those receiving the existing instruction in their classes. In all, 57 students were involved, 28 in the study group and 29 in the control group. All students were given a pretest and a posttest. Between tests, the study group received 15 lessons focused on the skills of identifying, completing, analyzing, and generating analogies. The results of both groups’ performance will be compared and analyzed. Finally, the study will make suggestions on the use of the information gained to guide interdisciplinary instruction of analogical thinking, toward the goal of transfer.

What is Analogical Thinking?

In its simplest definition analogical thinking refers to the transfer of knowledge previously learned in one context or domain to another (Chen, 1996). It is the process of understanding a novel situation in terms of one that is already
familiar (Gentner & Holyoak, 1997). Although recent theories vary in their analyses of analogical thinking, they do tend to share some aspects of a basic model. A familiar situation, stored in memory, serves as a kind of model for making inferences about a novel situation. Between these exists a mapping stage in which the individual traces the similarities between the familiar and the novel. The defining characteristic of analogy is that it involves an alignment of relational structure (Gentner & Markman, 1997).

A four stage componential analysis is proposed by Sternberg (1982), which is appropriate for this study. The stages are: encoding, inferring, mapping, and applying. Given an analogy to comprehend, an individual, in this case the student, first needs to be able to encode each item used in the analogy. If a teacher explains the flow of electricity through copper wire by comparing it to water flowing through a pipe, it is first necessary that the student understand all the terms being used in order for it to qualify as familiar and proceed with the reasoning. If the elements are not familiar, the student is incapable of retrieving appropriate information from memory for mapping. Next, (s)he has to infer a relationship between the elements of the analogy. How does water flow through a pipe? If the student does not understand this source of comparison, (s)he cannot extend it to the target comparison. Having encoded the elements and retrieved information from memory, the student can begin the mapping phase.

At this early phase of mapping, one initially receives a barrage of potential “matches” that need to be sorted out. Most anything associated with parts of the
analogy flood the active mind. It is somewhat like the lists of “matches” offered by an Internet search engine. In the mid-mapping phase parallels are sought between the source and the target. The goal is to achieve a 1 : 1 correspondence. But a thing cannot be analogous to itself, so while it may seem obvious to consider similarities, differences are also important in order to arrive at an understanding of the analogy. Electricity is not water, and the wire is not pipe. Which similarities are important and which differences are important? Those that are not important get discarded, while those that are salient advance toward an alignment until one or a few possibilities remain. When the individual is satisfied with the solution, the mapping is complete.

The final stage in the reasoning process is to apply the inferred relationship to the complete analogy. If the elements are understood and the mapping is accurate, comprehension results. If not, misunderstanding is likely to be the result. In the same way that the pipe is the vehicle for the distribution for water, copper wire can be a vehicle for the distribution of electricity. Water flows; electrons flow. But a wire is not hollow as the pipe is, and the pipe need not be copper, and there are many other differences that do not figure into the successful completion of the reasoning process.

Analogical thinking is a natural process (Gentner, 1997; Holyoak, Jenn, & Billman, 1984). We live in a world in which no experience can ever be exactly duplicated. While most elements of a situation may remain the same, enough vary that a person has to be alert in order to adjust appropriately. Commuting to work
provides one example. A person may develop a routine that is tightly scheduled. Leaving the house at the same time everyday, (s)he may follow the same route. Conditions may seem to be the same everyday, but traffic varies. A tie-up on an artery across town may throw additional traffic onto your route. Frustrated drivers may not react in the usual way. Thoughtful awareness of the differences is necessary to avoid an accident.

In order to understand our day to day events, as well as to solve perplexing problems, we depend on the power of the mind to find or even create similarities between past experiences and present situations. When you anticipate landing at an unfamiliar airport on vacation, mentally you rehearse what you know about other airports you have experienced. You know that this airport will not be exactly like any you have experienced, yet you know it should have some things in common. You try to visualize the layout or the route to baggage or rent-a-car so you can find your way even though cues may be minimal.

As often as we employ this kind of reasoning, it is easy to observe adults having difficulty perceiving analogous relationships between common problems of their own practical experience, and therefore having difficulty applying learned solutions (Chen, 1996). One problem may be that experiences are not placed into memory in a sufficiently flexible way to be recognized when a similar but non-identical situation arises. Another could be inaccuracy in the mapping of the two situations. Both of these are addressed in the directed instruction of analogy. Learning how to reason analogically as well as practice in applying it should lead to
an improved transfer of the skill in novel situations (Chen, 1996; Fogarty, Perkins, & Barell, 1992).

Purpose of the Study

This study is designed to offer data supporting the appropriateness of beginning the specific instruction of analogical thinking in the elementary school. Prior to the Information Revolution, when education stressed the accumulation of facts, analogies were rarely if ever taught in the elementary grades. Part of the reason may have been oversight regarding the ways people need the skill in their everyday lives. Analogies were perceived as an "intellectual" skill not essential for everyone. Not commonly developed in regular programs of study, they became indicator items on tests of cognitive skills (Gentner & Markman, 1997). Through the use of the familiar frame a : b : : c : d, analogies also became associated with formal logic and syllogisms. To some this would cause analogies to be considered burdensomely abstract, when in actuality the effective use of analogies brings the familiar or concrete to the novel. This misconception has made their introduction into the elementary curriculum difficult. Many of the skills identified as pre-analogical, such as synonyms, classification by characteristic, comparing using Venn diagrams, cause and effect, and ordering from the general to the specific, are being taught. Yet there is a failure to bring the skills together and complete the reasoning process as analogical thinking and then to apply it across the curriculum.
Another assumption that may have inhibited the introduction of analogies is that younger students lack a significantly broad base of knowledge upon which to draw when reasoning. As Sternberg (1999) emphasizes, it is essential that the student understand all the parts of the analogy. Encoding is the first step in the process of analogical reasoning. If a student cannot encode the elements of the relationship, (s)he cannot proceed to the other steps. But this is not to say that young students cannot perform the reasoning; what it does say is that teachers need to choose appropriately the comparisons they present so that students will be able to map the relationship successfully. Studies by Chen, (1996) and Gentner and Thagard (1997) show sound evidence of reasoning by analogy in children 8, 6, & 5 years old, and even younger in their observations of preschool children.

In this study, the model of pretest, focused instruction, and posttest will be used to show significant improvement in the ability of fourth grade students to recognize, complete, analyze, and generate analogies. This degree of understanding would provide a foundation upon which future instruction in various curriculum areas could be structured. The accomplishment of the skills on the test are not viewed as the final goal of instruction, but rather the means of establishing a common language and schema upon which instruction in the fuller process of analogical reasoning can later be based. If students can master this foundation in a relatively short term of instruction, it would provide substantial support for the appropriateness of including analogical reasoning in the instructional framework of the elementary school.
Method

A total of 57 fourth-graders participated in the study. Fourth-graders were selected because of the experimenter's interest in the age of student and because of her familiarity with students' ability and the curriculum as it is most commonly presented at fourth grade as well as the recommendations of the new Massachusetts Curriculum Frameworks. All the students in the study attend a public school in a middle-class community south of Boston. The students range in age from 9 years 2 months to 10 years 4 months. Students were divided into two groups. The study group consisted of 28 students and the control group 29 students. The division was based upon placement in Language Arts class as part of the agreement upon which permission to conduct the study was granted. The classes are homogeneously grouped according to reading performance. Since the study group began with a higher performance base, it was determined that statistical analysis would need to consider this, and a greater gain in posttest score would be necessary to indicate success. The Language Arts block is the longest of the day, and the most broadly based in terms of content and skills. The inclusion of instruction in analogical thinking therefore would fit most appropriately within its curriculum as currently written.
Of the 57 participating students, five have been identified as having a mild to moderate special need for which an Educational Plan has been developed. One of the five was a member of the study group; the other four were in the control group. In all there are 66 students enrolled in the grade. Three were absent on the day of pretesting; three others were absent on the day of the posttest; and three students had schedule conflicts that made them unavailable at the time of the pretest. Since the tests required more than an hour to administer, considerable disruption to the schedules of a number of people would have been necessary to make them up. All nine absent students were members of the control group, and since the number of students in the study and control groups remained almost equal, it was felt that the results would not be significantly affected.

Design and Materials

The study was designed to answer the question of whether fourth grade students could improve their facility with analogies as a result of focused instruction. With a pretest and a posttest administered to the whole group on the same dates, only the study group would receive instruction between. Comparing the results, the amount of growth, if any, could guide a determination of the feasibility of pursuing instruction with analogical reasoning.

Burns, Mental Measurement Yearbooks, 1998, lists no commercially available test which specifically measures a child's proficiency with analogies. While the Otis Lenon and the CMP III tests of cognitive skills do contain subtests
that include solving analogies, there are fewer than ten items on either test and they do not subdivide by levels of competency. Some tests administered in Middle Schools and Secondary Schools use the analogy frame, but a substantial part of the goal of the tests is not so much the reasoning as the understanding of the vocabulary terms employed or the sophistication of verbal skills. None of the commercially available tests use an open ended format, which can evaluate critical thinking development. The lack of an appropriate test made it necessary to develop an instrument specifically for this study.

Adhering to the first component of Sternberg's analysis of analogical reasoning, that the subject must be able to encode the information in order to continue the process, careful attention was given to selecting vocabulary and concepts which could be assumed to be within the range of all fourth-graders participating in the study. The point was to carefully limit the scope of the test only to the skills of analogy.

Four levels of performance with analogies were included: recognition, completion, analysis, and generation. Since some lessons from Ridgewood Analogies (Libonate et al, 1996), one of few focused instructional materials available, would be included in the teaching phase of the study, some format similarity was adopted for the test as well. The complete test is available in Appendix A. At the recognition level, students were asked to find in a limited array, two other items that went together in the same way as two items that had been connected by a line.
For completion, three elements of a standard four-part analogy were presented. From a limited bank, students were asked to find and write the missing element. Included in all word banks were distracter words - words that children might commonly associate with the prompt, but which do not meet the requirement of sharing the relationship indicated in solving the analogy.

<table>
<thead>
<tr>
<th>brain</th>
<th>strong</th>
<th>skull</th>
<th>smart</th>
</tr>
</thead>
<tbody>
<tr>
<td>thought</td>
<td>statue</td>
<td>painting</td>
<td></td>
</tr>
</tbody>
</table>

muscle / movement mind / _________

In both of the first two subtests, there was only one correct response available for each prompt. Scoring of the first two subtests was therefore objective.

To demonstrate skill with analysis, a shift was made to the open response format. A completed four-part analogy was given. Students were asked to write a statement telling why the elements go together as they do.

field / soccer court / basketball

A field is the place to play soccer, just like the court is the place to play basketball.

Since the student response is written in the student's own words, there is a greater variety in the quality of response. For this reason, and because the tested skill level
is increasing, a variable score rubric was necessary to properly assess the students’ proficiency. Partial credit could be awarded for answers that indicate a very general grasp of the relationship, while full credit could be given to answers that show clear and specific understanding. The complete scoring rubric is available in Appendix B.

Finally, to generate analogies, students were given a bank of words from which they could either draw directly or develop ideas of their own to write original analogies. After completing all four frames of the standard form, students were asked to write a statement of the relationship. This is the most open-ended subtest, and the one requiring the most careful application of a scoring rubric. The analogy is scored separately from its explanation in order to avoid an all-or-nothing judgment.

Five kinds of analogies were included in the study because of their similarity to the relationships Piaget describes as appropriate for this age, and because of their functionality for younger students. The relationships are: descriptive, comparative, categorical, serial, and causal. Descriptive analogies show a relationship in which one element describes a characteristic, property, function, structure, or use of the other. An example might be that a screwdriver is used to turn a screw, just as a wrench is used to turn a nut or bolt. Another is that walking is the expected mobility of the dog, just as swimming is the expected mobility of the fish. A park is a place to play, just as a pool is a place to swim. As
with most analogy statements, order is important in descriptive analogies. “A park is a place to play” does not have the same meaning as “a play is a place to park.”

Comparative analogies pair objects in each relationship in which both the similarity and the difference are a necessary part of the relationship. Vocabulary pairs such as synonyms, antonyms, homonyms, anagrams and reverses belong to this category. These analogies are rather unique in that the order in which the elements of each pair are listed is not important because their relationship is mutual. “Shout is a synonym of yell,” does have the same meaning as “yell is a synonym of shout.” In both, the meaning is the same, but the sound and spelling are different. That is what makes them synonyms. Shout and whisper, or whisper and shout are antonyms. Their meanings are opposite of one another’s regardless of the order in which they are written.

Categorical analogies show a relationship in which one element is a part of the other, or one belongs to the category named by the other. A second is a part of a minute; a minute is part of an hour. A frog is a species of amphibian; an elephant is a species of mammal. As expected, order matters here. An hour is not part of a minute; an amphibian is not a species of frog. Errors in listing elements in parallel order indicate mapping errors in the thinking process, so they are significant in assessing proficiency.

Serial analogies show relationships between elements in which order by time, sequence, process, quantity, value, or intensity is established. Summer follows Spring; adolescence follows childhood. Third comes before fourth;
comes before tenth. Whisper is a quiet form of speaking; humming is a quiet form
of vocal music.

Causal analogies show relationships in which one element effects a change
on the other. Heat causes ice to melt just as cold causes water to freeze. The angle
of the sun’s rays affects the intensity of sunlight in the same way that the angle at
which a flashlight is held affects the intensity of its beam. Mathematical functions,
such as 50 is ten times 5 just as 60 is ten times 6, fit this category.

With the limited instruction time available, scoring by type of analogy is not
included as part this study. Nevertheless in order to fairly introduce the students to
the spectrum included on the test, and to avoid loading the test with one type or
another which could unfairly favor or penalize one student over another, or one
group over another, a formula was used in devising test items. In each of the first
three subtests there are three examples of each of the five types of relationships, or
a total of fifteen items in each subtest. The order is scrambled so that students
shouldn’t be able to appreciate any pattern and make inferences about subsequent
items. For example, if three descriptive relationships are listed in a row, some
students might assume the same strategy for attempting to solve the next, even
though it might be a comparative or serial relationship. By randomizing the order it
was felt that the maximum objectivity could be achieved. The fourth subtest could
not be controlled in this manner because of the generation variability. However, in
applying the scoring rubric, students could not achieve full credit for repetitive
examples since they do not indicate full generative facility.
To accommodate the pretest, posttest feature of this study, two forms of the test had to be developed. Then a practice test of both forms was administered to fifth graders to verify the appropriateness of the test items. Twenty students participated in this phase of development. The goal was that every student ought to be able to correctly answer some but not all items in each of the first three subtests, and that some students ought to be able to give correct answers in the fourth subtest as well. Since the fourth subtest measures the highest level of proficiency, it would be reasonable for most students to have difficulty with this area since they had not received any previous instruction, as would be the case with students participating in the actual study.

Reliability and Parity

The fifth grade practice test was used to provide the samples needed to determine test's reliability, and to assure parity between forms A and B of the test. Interrater reliability was the method used. In this, two scorers were trained in the use of the rubrics. Three tests were randomly taken from the batch to be used in training. After an item by item discussion of the student response on one of the tests, in terms of the rubric, two other tests, one of each form, were blindly scored by both scorers without discussion. Their scores were compared, and since they were nearly identical, the scorers were considered "trained." All remaining tests in the practice batch were then scored by both raters. The analysis of the results by subtest and total, using standard statistical correlations, are as follows for interrater
reliability: Subtest I = 0.986; Subtest II = 0.928; Subtest III = 0.921; Subtest IV = 0.988; Total test = 0.976. The analysis of results by subtest comparing forms, using total correct responses and mean scores are as follows: Subtest I - Form A (n = 8) 134 / mean = 16.75; Form B (n = 7) 114 / mean = 16.29; Subtest II - Form A (n = 8) 187 / mean = 23.38; Form B (n = 7) 165 / mean = 23.57; Subtest III - Form A (n = 8) 246 / mean = 30.75; Form B (n = 7) 235 / mean = 33.57. Total mean score for three subtests Form A = 70.88; Form B = 73.43. Since the only appreciable difference occurred in Subtest III, and since students were allowed an open response format on the subtest, which accommodates a broader base of individual proficiency, the two forms of the test were considered to be equal in level of difficulty. In addition, using the pretest/posttest design, every student would use both forms in the study, so they were considered to be fair.

Procedure

The pretest was administered to all participants on February 5, 1999, a Friday. The cafeteria was used as the site because of ample room. Students were not assigned seats although generally they remained with their Language Arts groups. Forms A and B of the test were distributed alternately to students. Directions were read orally as well as being printed in the booklet. The subtests were not timed. Three teachers were available throughout the testing to read any words or identify any problematic pictures for students. An aide scribed the test for one hearing-impaired student who also has a written language difficulty. After the
pretest, students returned to their Language Arts classes for the remainder of regular class instruction.

Focused instruction with the study group began on the Monday after the pretest was administered. Instruction included sixteen class periods of 15-20 minutes each followed by a 5-10 minute homework follow-through. The first lesson was a general introduction to the course of study, the nature of analogy, familiar relationships, and the applicability of analogies to intercurricular learning. Since the month of February contains a vacation week in the public schools, a review lesson the day of return from vacation was also built into the schedule. Two days of school during the instruction period were canceled because of snow. The fourteen remaining lessons were specifically focused to a particular type of relationship at a particular proficiency level. The relationships taught were in order: descriptive, comparative, categorical, serial, and causal. The proficiency levels in order were: recognition, completion, analysis, and generation. Within a relationship type, all four proficiency levels were covered before moving to the next type of relationship.

At the introductory level of each relationship, the materials provided in Ridgewood Analogies, 4th grade level, by George Libonate, et al (1994) were used. See Appendix C. With its very simple vocabulary, the relationship alone can be considered by the students. Within a limited word array, two items are connected by an arrow. The student finds two other words in the array that share the relationship and connects them. After discussing the relationship, the arrow is
added to indicate the correct directional order of elements. Each introductory lesson contained 15 items, about half of which were worked out together in class with the remainder to be done independently as homework.

The second lesson with each relationship utilized a Word Bank made up words usually from Reading vocabulary taught and mastered in the Language Arts class. Assured of uniform familiarity because the words were generated from previous work in the same class, it allowed the first extension of the analogy format into a curriculum area. The format presented 15 analogies with a missing element. Students selected a word from the Bank to complete it. Under the analogy a line was provided on which a general phrase stating the relationship was written. Using an overhead transparency for work-along support and modeling of language, students worked at their seats with a Xerox of the lesson. The extension into the Reading vocabulary allowed for a review of multi-meaning words as well as noting relationships, sometimes novel relationships, between items.

For the first lesson on completing analogies, the completion frame was placed in the fourth position. It is easier to solve analogies that proceed from left to right, or in sequential order. It is also easier when the frame is in the final position. The reason left to right is advantageous, is that the student has been taught to read left to right, and encodes three elements of the analogy in order before needing to find the final element. Sequential order also provides a natural direction for the student’s thinking. It is reasonable to expect that if three elements are presented in a row, in order, that the opportunity for error is minimized.
example: sweet : candy :: sour :
fast : cheetah :: slow :
Placing the frame in the fourth position repeatedly, however, can bring the student to complete the frame intuitively with a word (s)he associates with the element even though it does not share the analogous relationship. Item #8 of Form B Subtest II on completion was the most frequently missed item on either test.

scales / fish / fur /
By far, the most common response to this analogy was “coat.” The correct answer was “mammal.” Scales are the outer covering of a fish, in the same way that fur is the outer covering of a mammal. But “fur coat” is such a common association for the children that even though they were working with a limited word bank having only a few possible choices, “coat” satisfied them, and most did not go back to analyze the relationship of the analogy.

To require active thinking in completing analogies, it is necessary to vary the positioning of the frame so that students have to put some effort into perceiving the relationship. Placing the frame in the second position is the smallest increment of difficulty.

example: train : _______ : car : road
Solving this form requires the student only to realize that the first pair of elements can be transposed intact with the second pair, effectively making the above example

car : road : : train : _______.
This is a worthwhile lesson in helping to understand the format of analogies to simplify solving, as well as to review the unit structure before and after the double colon. It reinforces the balance between pairs of elements. The double colon is similar to the equal sign in a simple Math equation:

\[
77 - 28 = 87 - 38
\]

\[
87 - 38 = 77 - 28.
\]

This is employing an analogy to explain an analogy. The double colon is certainly not the same thing as the equal sign and children should not be taught that it is. But in both cases it requires balance on either side. Since equality is a familiar concept to the children, it may be carefully employed in this case. Another analogy that can help to explain the necessary balance between element pairs in analogies is the balance scale. Both the equal sign and the balance scale have appeal in the teaching of analogy because they employ familiar scenarios from other domains, Math and Science. The goal of analogical reasoning is to draw upon familiar information or processes learned in one context or domain in order to understand or solve the novel.

Placing the frame in the first or third position of a completion frame considerably increases the level of difficulty. It requires the student to mentally hold open a position to be filled. (S)he has to pause, however briefly, in the mapping process.

example: _______ : fabulous :: repair : fix
This is not as easy to remedy as the second position frame. As with a standard sentence completion activity, the student has to read the rest of the statement and perceive the relationship based on the final position elements. Because (s)he then has to go back and fit a probable answer into the frame, there is an increased opportunity for error. It takes an extra step in mapping to solve such a statement, just as it does for a child to solve open frame Math statements like $25 + \_ = 47$.

Transposing intact element pairs across the double colon doesn't resolve the difficulty completely, although it may reveal the relationship a bit more easily than leaving the frame in the first position.

\[
\text{repair} : \text{fix} : : \underline{\text{_____}} : \text{fabulous}
\]

Since repair and fix mean about the same thing, the student knows that (s)he is looking for a word that means about the same thing as fabulous. When the relationship is descriptive, categorical, serial, or causal, it may be more difficult than when the relationship is comparative.

\[
\underline{\text{_____}} : \text{amphibian} : : \text{lizard} : \text{reptile}
\]
\[
\text{nickel} : \text{penny} : : \underline{\text{_____}} : \text{nickel}
\]

After step by step guided lessons with recognizing and completing analogies of two types, descriptive and comparative, the children demonstrated ease in working with the formats after which these two steps were able to be combined into a single lesson for the remaining three relationship types. In this way it was possible to keep to the agreed schedule despite two “snow days” on which school was canceled due to heavy snow.
Instruction at the third proficiency level, analysis, centered around writing a complete and precise relational sentence for a provided analogy. In this area it was possible to provide examples from across the curriculum. Since all the examples were provided to the students, the teacher had control over the accuracy of elements and their relationship. Here are some examples from Science and Social Studies that reviewed previously taught material:

- egg : larva :: seed : sprout
- skin : pulp :: crust : mantel
- Florida : peninsula :: Hawaii : island
- oil : fossil fuel :: water : flow energy

At the same time the analogical relationships were being discussed, concepts from other curriculum areas were being applied. The breaking down of artificial boundaries between academic disciplines is a key factor in convincing students that analogical thinking is not subject specific; it is a higher order skill that can be applied in many instances, and being open to this idea and being flexible in thinking is important.

Two levels of proficiency presented themselves in the children’s relationship sentences. Some students could appreciate only a general relationship Florida is a peninsula, just like Hawaii is an island. “...is a ...” only hints at understanding, compared with The major landform of Florida is a peninsula, while the major landform of Hawaii is an island. “... major landform of ...” cements the relationship. The second example shows more accurate encoding, mapping, and matching.
In this analysis phase, the students were also taught a system for realigning elements in the analogy to help them discover the relationship. The original analogy - Florida : peninsula : : Hawaii : island - can be realigned in this way -
Florida : Hawaii : : peninsula : island - followed by the working questions, what do Florida and Hawaii have in common? and what do peninsula and island have in common? This generates the answer sentence The state of Florida's major landform is peninsula, while the state of Hawaii's major landform is an island. The realigning makes the parallel mapping more clear to the students. It also makes the generation, the fourth proficiency level, more successful.

Student perceptions and creativity also took a place in writing relationship sentences. Given the pair faint : dim, presented by the teacher to be synonyms, a precocious student wrote...faint is an even lighter value of dim... The "game" at times, became one of seeking the most unusual correct answer.

The fourth and final proficiency level is that of generating analogies. In this phase students were provided with a word bank and blank analogy frames. Generating analogies was the final lesson in each of the five relationship lessons. Searching the bank, students needed to find all four elements that fit a relationship under study, categorical relationships for example. However it was also encouraged strongly for students to use ideas in the word bank to launch original analogies. To recognize applications in their own interest areas or experience extends the value of the lesson and personalizes it to the student. To start the process, the word bank included special words that had aroused lively discussion in
class, or that had sparked reaction from some students. This, too, provided a sense of ownership of the elements in the bank and sparked very creative responses.

**Nessie "lives" in Loch Ness, just as the Boggart "lives" in Castle Keep.**

This analogy is specific to a book recently read in class. The subtle relationship "lives" is quite sophisticated for ten year old children, given that Nessie and the Boggart are considered to be fictional to some, but not all. Since the generation of analogies is a much more complex process than any of the other proficiency levels, a complete lesson usually consisted of only three examples. See Appendix E. A great deal of high quality discussion occurred in a class when students offered particularly creative examples they had written.

After fourteen daily instructional sessions, the posttest was administered to all students, again in the cafeteria. The same conditions were provided for the posttest as for the pretest.

**Results**

A comparison of pretest and posttest scores on the overall analogies test revealed significant progress by the study group compared to the control group (P < .01). The average total score improved by 16.1 points for the study group, compared to an average gain of 5.4 points for the control group. An analysis of the subtests, (Table 1), indicates that the greatest gain in the study group was on the fourth subtest, generating analogies.
Table 1. Comparison of Mean Scores by Subtest and Total, with Significance

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Pretest</td>
<td>6.48</td>
<td>11.52</td>
<td>11.52</td>
<td>8.59</td>
<td>38.10</td>
</tr>
<tr>
<td>Control Posttest</td>
<td>8.10</td>
<td>11.17</td>
<td>13.90</td>
<td>10.97</td>
<td>44.14</td>
</tr>
<tr>
<td>Control Gain/Loss</td>
<td>1.62</td>
<td>-0.35</td>
<td>2.38</td>
<td>2.38</td>
<td>6.04</td>
</tr>
<tr>
<td>Study Pretest</td>
<td>9.14</td>
<td>12.79</td>
<td>14.79</td>
<td>12.21</td>
<td>48.93</td>
</tr>
<tr>
<td>Study Posttest</td>
<td>12.14</td>
<td>13.75</td>
<td>20.90</td>
<td>18.25</td>
<td>65.04</td>
</tr>
<tr>
<td>Study Gain/Loss</td>
<td>3.00</td>
<td>0.96</td>
<td>6.11</td>
<td>6.04</td>
<td>16.11</td>
</tr>
<tr>
<td>Sig. (t-test)</td>
<td>.054</td>
<td>.107</td>
<td>.165</td>
<td>.061</td>
<td>.001</td>
</tr>
</tbody>
</table>

In the first subtest, recognizing analogies, the mean gain by the test group was 2.96 points compared to 1.48 for the control group. The t-test for statistical significance indicates that the gain of the study group does not quite reach greater statistical significance (P = .054). On the second subtest, completing analogies, the mean study group score showed a gain of .96 compared to a loss, -.34, for the control group (P = .107). In the third subtest, analyzing analogies, the study group showed an average gain compared to the control group of 6.1 compared to 2.5 with (P = .165). The greatest gain for the study group occurred in the fourth subtest, generating analogies. In this subtest the mean gain for the study group was 6.0, compared to 2.5 for the control group, (p = .061). This is a sound gain for the study group. This strong gain, together with the lesser but consistent gains made in each of the other subtests combine to create a highly significant analysis favoring the
study group. The total gain of 16.0 points compared to 5.4 (P < .001) Figure 1 shows the comparison of mean raw scores as a graph.

Figure 1. Comparison of Mean Scores by Subtest

![Figure 1](image_url)

Figure 2 shows a comparison of the gain or loss by subtest and total mean, using percentage of gain. A complete listing of the raw data is available in Appendix F.

Figure 2. Test Results by Percentage of Gain

![Figure 2](image_url)
The overall test results indicate strongly that fourth grade students can, indeed, benefit from focused instruction with analogy skills. All four subtests showed gains by the study group greater than those made by the control group, with the combined gains of the study group significantly stronger than their counterparts. This indicates that it was the instruction that effected the improvement. While the gains on subtests II and III, completion and analysis, did not quite reach statistical significance, the trends are in the expected direction. There is evidence that our second subtest was in fact too easy, and should be reconstructed. Calling for students to choose a word from the bank to complete an analogy, it was likely the consistent placement of the blank in the fourth position that gave students more cues that desirable. In the initial screening with the fifth grade trial group, the students achieved a mean score of 10.35, compared to the fourth grade mean score of 12.3 on the pretest. Additionally, 18 of 57 students scored either a perfect score or within one point of perfect on the pretest, indicating that the ceiling was too low to accurately report growth.

The third subtest, analyzing analogies, showed quite a different circumstance. Its t-test result just lower than that hoped, was more likely due to the effect of widely varying student scores on the statistical analysis than with the test design. In this instance a larger test population ought to correct this irregularity.

It is encouraging, nonetheless, that even those students who did not receive instruction showed modest gains on the posttest compared to their pretests. It seems indicative of the readiness of fourth graders to understand analogies and a
general comprehensibility of the format, that for some might be enough to lead them into a higher level of performance even without formal instruction.

**Discussion**

The fourth subtest, generating analogies, presented the most significant gains for the study group compared to the control group. Generating analogies brings together all the features of encoding, mapping and inferring. Since this is the most comprehensive and difficult proficiency level, the gains are very encouraging. To accomplish this with a minimum of cues represents a significant gain in terms of our goal. Having acquired this schema for recognizing parallel relationships, students are well poised to begin structure training activities to facilitate transfer, as suggested in Halpern’s model. Teachers should be mindful of the need to analyze, model and practice transfer skills by providing interdisciplinary opportunities for their students.

The skills demonstrated in the generation of analogies is also one of the essential creative thinking skills. Analogy is a close relative of metaphor in structure (Gentner & Holyoak, 1997). Having established the four-item frame, teaching metaphor and simile become the extension into creative expression. The same principles of encoding, mapping, and inferring apply equally well to understanding similes and metaphors and to generating them.

Once understood, the basic frame can be put to use in a variety of simple but effective ways in the classroom, some of which I will briefly illustrate below.
A) Since comparative analogies, as defined in this study, deal with synonyms, antonyms, homonyms, and the like, it is poised for implementation in vocabulary lessons.

ask : inquire : : answer : respond

construction : destruction : : build : destroy

I'll : aisle : : you'll : yule

B) Descriptive analogies can be easily used in other aspects of literature, such as comparing heroes, villains, settings or genre.

Castle Keep : Boggart : : Castle Coffin : Duke

paragraph : story : : stanza : poem

C) An analogy can be employed to clarify the common Math confusion between Area and Perimeter. Area can be analogized to the lawn, covered with grass, and Perimeter to the fence that encloses it. Visual models can support the reinforcement of the analogy.

D) While the specific intent if this study was to discover whether fourth graders could demonstrate improved understanding of analogies, the indications for the data reach beyond the four-frame a : b : : c : d analogy. The larger goal is to lay a foundation upon which instruction and practice with analogical reasoning can proceed, and explanations based on analogical reasoning can be employed to clarify new ideas to the students. For example, the conflict in Yugoslavia is a very complex topic that is likely to come into discussion in many Social Studies or Current Events classes. In discussing the primary cause of NATO intervention,
ethnic cleansing, students may need help to understand. Some news reporters draw
an analogy between the Albanian condition and the Jewish Holocaust. This would
be one opportunity to extend the basic analogy into the application of analogical
reasoning. A graphic organizer such as the one suggested by Swartz and Parks
(1994), see Appendix G, can guide the development of the lesson. Listing the
similarities and differences is a mapping procedure:

<table>
<thead>
<tr>
<th>Germany</th>
<th>Yugoslavia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hitler</td>
<td>Milosavic</td>
</tr>
<tr>
<td>Nazis</td>
<td>Serbs</td>
</tr>
<tr>
<td>Jews:</td>
<td>Albanians:</td>
</tr>
<tr>
<td>- passive citizens</td>
<td>- resistance army</td>
</tr>
<tr>
<td>- no homeland</td>
<td>- neighboring homeland</td>
</tr>
</tbody>
</table>

As the discussion progresses, students may infer that if Adolph Hitler’s
genocide of the Jews in Germany was cause for intervention, then Milosavic’s
genocide of the Albanians warrants intervention. Of course this may not be the
conclusion of all groups since there are some significant differences. One might
anticipate lively discussion in which a variety of similarities and differences may
surface and be judged more or less salient by the group. Regardless of the outcome
of the group’s judgment, the discussion affords an opportunity to take students
through the entire process of reasoning by analogy.

E) The study of biography, whether as part of a literature study or a
historical one in any subject area including Science or Math, affords one of the
most poignant opportunities to apply analogical reasoning. Maya Angelou stated on her summer speaking tour (Dubuque, IA, 1998), that “...we live our lives in direct relation to our heroes and our (s)heroes...” If she is right, this presents itself as a very compelling reason to delve into analogical reasoning at an early age. Besides the many literal accomplishments the subjects of biography present for study, their strength of character, personal resolve, overcoming of adversity, vision, and much more, are there for students to discover for comparison to themselves. If students are asked such questions as what they admire most about a person and why, or in what ways they might see themselves as similar to the subject, and what contribution they might make themselves someday, our students might accomplish one of the greatest positive transfers of learning into any novel situation - their lives.

In conclusion, what this study has undertaken to do is to provide support for the idea that elementary school students can learn and apply critical thinking skills such as reasoning by analogy. By demonstrating the ability, students show that they should be provided with instruction in, and a broadly based application of the process of reasoning by analogy. Recent studies indicate that this is one way in which we may achieve transfer from the constructed environment of the classroom to the often seemingly random environment outside of the school.
SUBTEST I
RECOGNIZING ANALOGIES

DIRECTIONS: In each box the two items connected by the line go together in a certain way. Think about the way they are related, then find two more items that go together in the same way. Draw a line connecting the two items you choose.

Example:

Student name _______________________
Grade ___________ Teacher ___________
Date ________________

© Copyright 1998 All rights reserved.
1. Glass, bowl, spoon, teapot, milkbox, saucer

2. Envelopes, stamps, bills, letter, mailbox

3. Beef, vegetable, carrot, fruit, meat, milk

4. Ice, water, steam, liquid, solid, cloud

5. Pan, head, heel, peel, fan, pig, pit, bead

6. Statue, sing, composer, carve, music, sculptor

7. Whisper, scream, hum, sing, talk, laugh

8. Bare, cub, bear, sub, fuss, meat, bus, meet
SUBTEST II
COMPLETING ANALOGIES

DIRECTIONS: The first two words in each group go together in a certain way. Think about the way the second word goes with the first. Then read the third word. Choose a word from the bank that goes with the third word in the same way the second word goes with the first. Write the word on the line.

EXAMPLE:

fish / swim    bird / ________
drive          fly
              ocean
              sky

1. hand / pocket foot / ________
2. owl / hoot pig / ________
3. nose / scent tongue / ________
4. hoof / foot paw / ________
5. pal / pail pan / ________
6. dime / 10 quarter / ________
SUBTEST III
ANALYZING ANALOGIES

DIRECTIONS: Below are some analogies that have been completed. The first item is related to the second in the same way that the third is related to the fourth. In this part of the test you are to write a sentence under the analogy that explains the way both parts are related. Be sure to include all four items in your explanation.

EXAMPLES:

ant / insect  
parrot / bird

7. tusk / elephant    horn / ________

8. bark / tree        shell / ________

9. banana / fruit     carrot / ________

10. giant / large      dwarf / ________

11. whisper / talk    hum / ________

12. quarter / nickel   half dollar / ________

13. fracture / cast    sickness / ________

14. pain / cry         joy / ________

15. burn / smoke      boil / ________
1. screwdriver / wrench / nut

2. horse / car / hot air balloon / airplane

3. fish / bird / cage

4. spot / stop / blot / bolt

5. burger / meat / fries / vegetable

6. snow / avalanche / mud / landslide

7. court / tennis / field / baseball

8. 4 / fourth / 7 / seventh

9. Sahara / desert / Erie / lake

10. pink / red / grey / black
SUBTEST IV
GENERATING ANALOGIES

DIRECTIONS: In this part of the test you will be asked to do two things. First you must find items that have the same relationship to one another. Then you need to write a sentence explaining what the relationship is. Be sure that the first item goes with the second in the same way that the third item goes with the fourth. You may use words from the word bank provided, or you may use words you think of yourself. You may use some words twice.

EXAMPLE:
WORD BANK
adult bay car child doll
fur glove grasshopper hand nymph

child / adult  nymph / grasshopper
A child is a young human and the adult is grown-up. Nymph is the name for a young grasshopper, which is an insect, not a mammal.
WORD BANK

bee  boot  boy  den  dog  dollar
evil  fast  foot  fox  girl  glove
good  hand  hero  hive  horse  huge
large  length  man  minute  penny  ruler
run  scale  second  slow  small  time
villain  walk  weight  wolf  woman  zebra
RECOGNIZING ANALOGIES

DIRECTIONS: In each box the two items connected by the line go together in a certain way. Think about the way they are related, then find two more items that go together in the same way. Draw a line connecting the two items you choose.

Example:
1. bird cage dog house
2. leaf grass line
3. stove train refrigerator
4. boat frog goat
5. elbow ankle toe
   thumb knee wrist
6. key bug bee goat
   boat
7. nickel fifth triplets third
SUBTEST II
COMPLETING ANALOGIES

DIRECTIONS: The first two words in each group go together in a certain way. Think about the way the second word goes with the first. Then read the third word. Choose a word from the bank that goes with the third word in the same way the second word goes with the first. Write the word on the line.

EXAMPLE:
fish / swim bird / ______ drive
fly ocean sky

WORD BANK
howl pat 5 toe
dime mitten fingers 10
see dog color hoof

1. head / hat hand / ______
2. bird / chirp wolf / ______
3. ear / music eye / ______
4. pan / nap tap / ______
5. penny / 1 nickel / ______
6. nose / snout foot / ______
WORD BANK
paw seal taste boulder
mammal dollar coat thought
pizza statue tail painting
devour work nickel tornado

7. wing / bird
8. scale / fish
9. pbj / sandwich
10. pebble / stone
11. sip / gulp
12. nickel / penny
13. rain / flood
14. muscle / movement
15. author / story

DIRECTIONS: Below are some analogies that have been completed. The first item is related to the second in the same way that the third is related to the fourth. In this part of the test you are to write a sentence under the analogy that explains the way both parts are related. Be sure to include all four items in your explanation.

EXAMPLES:
ant / insect
parrot / bird
DIRECTIONS: In this part of the test you will be asked to do two things. First you must find items that have the same relationship to one another. Then you need to write a sentence explaining what the relationship is. Be sure that the first item goes with the second in the same way that the third item goes with the fourth. You may use words from the word bank provided, or you may use words you think of yourself. You may use some words twice.

EXAMPLE:

WORD BANK
adult bay car child doll
fur glove grasshopper hand nymph

child / adult nymph grasshopper
A child is a young human and the adult is grown up. Nymph is the name for a young grasshopper, which is an insect, not a mammal.
**WORD BANK**

<table>
<thead>
<tr>
<th>ball</th>
<th>bat</th>
<th>bay</th>
<th>boat</th>
<th>cabinet</th>
</tr>
</thead>
<tbody>
<tr>
<td>car</td>
<td>cattle</td>
<td>clock</td>
<td>closet</td>
<td>clothes</td>
</tr>
<tr>
<td>cut</td>
<td>dishes</td>
<td>England</td>
<td>fasten</td>
<td>flock</td>
</tr>
<tr>
<td>glue</td>
<td>herd</td>
<td>Italy</td>
<td>Japan</td>
<td>lake</td>
</tr>
<tr>
<td>London</td>
<td>Mississippi</td>
<td>puck</td>
<td>river</td>
<td></td>
</tr>
<tr>
<td>scissors</td>
<td>sheep</td>
<td>stick</td>
<td>street</td>
<td></td>
</tr>
<tr>
<td>temperature</td>
<td>thermometer</td>
<td>time</td>
<td>Tokyo</td>
<td></td>
</tr>
<tr>
<td>U.S.A.</td>
<td>Utah</td>
<td>VCR</td>
<td>Washington, D.C.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B
Rubrics for Scoring Byrne’s Analogy Test
Level D
Forms A and B

**Subtest I  Recognizing Analogies**

There is only one correct response for each item. Other items may show some relationship to one another, but only one pair is analogous to the prompt.

<table>
<thead>
<tr>
<th>0 point</th>
<th>1 point</th>
</tr>
</thead>
<tbody>
<tr>
<td>incorrect response</td>
<td>one correct connection</td>
</tr>
<tr>
<td>no response</td>
<td></td>
</tr>
<tr>
<td>more than one response</td>
<td></td>
</tr>
</tbody>
</table>

**Form A**

1. glass, (milk) carton
2. money, wallet
3. beef, meat
4. ice, solid
5. pan, fan
6. statue, sculptor
7. sing, hum
8. bare, bear
9. bread, wheat
10. strawberry, fruit
11. 2, second
12. snake, slither
13. colt, horse
14. leg, hip
15. violin, string bass

**Form B**

1. bird, cage
2. needles, pine tree
3. stove, boiling water
4. pear, bear
5. elbow, wrist
6. boat, goat
7. 5, fifth
8. bird, fly
9. flute,
10. tree, oak
11. kid, goat
12. author, story
13. pigeon, bird
14. lava, liquid
15. gobble, nibble
Rubrics for Scoring Byrne’s Analogy Test, cont.

**Subtest II  Completing Analogies**

There is only one correct response for each item. Other items may show some relationship, but only the indicated answer completes the analogous relationship to the prompt. Answers may be either printed or handwritten.

<table>
<thead>
<tr>
<th>0 point</th>
<th>1 point</th>
</tr>
</thead>
<tbody>
<tr>
<td>incorrect response</td>
<td>correct response</td>
</tr>
<tr>
<td>no response</td>
<td>misspelled answer, but not to the point that indicates confusion with any other possible answer choice</td>
</tr>
<tr>
<td>illegible to the point that correctness cannot be determined</td>
<td></td>
</tr>
<tr>
<td>misspelled to the point that the answer could be one of the other available answer choices</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Form A</th>
<th>Form B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. sock</td>
<td>1. mitten</td>
</tr>
<tr>
<td>2. oink</td>
<td>2. howl</td>
</tr>
<tr>
<td>3. flavor</td>
<td>3. color</td>
</tr>
<tr>
<td>4. hand</td>
<td>4. pat</td>
</tr>
<tr>
<td>5. pain</td>
<td>5. hoof</td>
</tr>
<tr>
<td>6. 25</td>
<td>6. hoof</td>
</tr>
<tr>
<td>7. rhino</td>
<td>7. seal</td>
</tr>
<tr>
<td>8. turtle</td>
<td>8. mammal</td>
</tr>
<tr>
<td>9. vegetable</td>
<td>9. pizza</td>
</tr>
<tr>
<td>10. small</td>
<td>10. boulder</td>
</tr>
<tr>
<td>11. sing</td>
<td>11. devour</td>
</tr>
<tr>
<td>12. dime</td>
<td>12. nickel</td>
</tr>
<tr>
<td>13. medicine</td>
<td>13. tornado</td>
</tr>
<tr>
<td>14. laugh</td>
<td>14. thought</td>
</tr>
<tr>
<td>15. steam</td>
<td>15. statue</td>
</tr>
</tbody>
</table>
Rubrics for Scoring Byrne’s Analogy Test, cont.

Subtest III Analyzing Analogies
Since these answers are generated by the student in his/her own words, the answers may vary.

0 point  no answer
incorrect answer

Form A
The screwdriver is a tool and the nail holds a picture on the wall and the other pictures go with the car.
You can paddle a boat with the oar and the rest of the things are tools.
Screwdriver goes with the screw just like the wrench goes with the bolt.

Form B
The carriage and the car both have wheels and the balloon and the plane both fly.
They are all ways to travel.
The horse pulls the carriage and you need gas for the car; and the balloon and the airplane both go in the sky.
Carriage goes with car just like balloon goes with plane.

1 point  basic level of correctness, but may be imprecise or not the germane relationship

Form A
The nail is the same because the screwdriver turns it in the wall and the rachet and the bolt is the same.
The screwdriver screws the nail in. The wrench turns the nut to get it off.

Form B
They go together because it’s like it used to be then.
Old and new.

2 points  higher level of relationship, expressed clearly; parallel structure evident (do not deduct for errors in capital letters, spelling, etc. as long as they do not alter the meaning.)

Form A
The screwdriver is the tool for turning the screw put it in or out. The wrench is the tool for turning the nut (bolt) to put it on or take it off.
Both of the tools turn the other piece to put it in or take it out.

Form B
They used to have horses and carriages to get around but now we have cars. They used to have hot air balloons but now we have airplanes.
The first picture in each one is the old fashioned way to travel and the second picture in each one is modern.
Rubrics for Scoring Byrne’s analogy Test, cont.

Subtest IV  Generating Analogies

Each of the items on this subtest is comprised of two parts - setting up an analogy, and stating the relationship. Each part can be scored 0 - 2 points according to these criteria:

Setting up the analogy:

0 point  incomplete answer / no answer

- boy / man  girl /

- items in first pair do not relate to items in second

- bat / ball  boy / man

- copies analogies from previous subtests, unaltered

- screwdriver / screw  wrench / nut

1 point  selects four items that may be analogous, but writes them in non-parallel sequence

- villain / evil  good / hero

- selects items from previous subtest with minimal change

- pbj / sandwich  cheese / pizza

- minute / hour  day / week

- writes subsequent analogies that are just a series of imitations based on a repeated pattern

- penny / 1 nickel / 5  puppy / dog  kitten / cat

- dime / 10 quarter / 25  colt / horse  lamb / sheep

- half dollar / 50 dollar / 100  calf / cow  tadpole / frog

2 points  two pairs of items sharing the same relationship and listed in correct sequence; non-repetitive; may extend beyond the presented list

- Nintendo / cartridge  Play Station / CD

- up / float  down / sink

- car / motor  bike / pedals

- boy / man  girl / woman

Explaining the relationship

The same rubric conditions can be applied as was used in Subtest III.

0 point  no answer

- incorrect answer

1 point  basic level of correctness; may be imprecise or superficial

2 points  higher level relationship, clearly expressed; parallel structure evident 54
A descriptive analogy shows a relationship between two sets of elements, in which one element of each set describes a characteristic, property, part, function, structure, use, position, or location of the other.

For example, in the sample "Walking is to dog as swimming is to fish," walking describes what a dog does—the movement or function of a dog—and swimming describes what a fish does—the movement or function of a fish.

**SAMPLE:**

<table>
<thead>
<tr>
<th>dog</th>
<th>walking</th>
<th>fish</th>
</tr>
</thead>
<tbody>
<tr>
<td>park</td>
<td></td>
<td>eating</td>
</tr>
<tr>
<td>swimming</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The relationship phrase is: is the movement of. Walking is the movement of a dog, just as swimming is the movement of a fish.

**DIRECTIONS:** In the boxes below, two words that go together in a particular way are connected by an arrow. Find two other words in the box that go together in the same way.

1.  

<table>
<thead>
<tr>
<th>hard</th>
<th>soup</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td></td>
</tr>
<tr>
<td>bowl</td>
<td>bake</td>
</tr>
<tr>
<td>glass</td>
<td></td>
</tr>
</tbody>
</table>

Write the relationship phrase you used to complete this analogy.

2.  

<table>
<thead>
<tr>
<th>person</th>
<th>tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>park</td>
<td>swim</td>
</tr>
<tr>
<td>walk</td>
<td>lake</td>
</tr>
</tbody>
</table>


3. plate : bird :: meat : fly
   person : walk

Write the relationship phrase you used to complete this analogy.

4. person : tree :: grass : plant
   skin : bark

Write the relationship phrase you used to complete this analogy.

5. water : soft :: hard : fish
   glass : grass

Write the relationship phrase you used to complete this analogy.

6. small : father :: big : mother
   pond : lake

Write the relationship phrase you used to complete this analogy.
Comparative Analogies

Directions: Look at the words in each incomplete analogy. Choose words from the Word Bank that make the two pairs of words go together in the same way. If you wish, you can also use your own word choices to complete the analogies, where possible. On the line under your completed analogy, write a complete sentence that states the relationship.

Word Bank

ability aisle crew curry fault flee
furry fuzzy gape gem hall halt
haul hoof jewel magnificent mar mate
omit page ram ruby ship skill
swarm team trample vast whisper zeal

1. fabulous: _________ : : fix : repair

2. _______ : flea : : peek : peak

3. include : _________ : : urban : rural
APPENDIX E

Generating Analogies

<table>
<thead>
<tr>
<th>pyramid</th>
<th>Boar</th>
<th>Montpelier</th>
<th>ball</th>
<th>cube</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>Boston</td>
<td>box</td>
<td>Cape Cod</td>
<td></td>
</tr>
<tr>
<td>Nessie</td>
<td>Sasquatch</td>
<td>Vermont</td>
<td>Borythorn</td>
<td></td>
</tr>
<tr>
<td>Maine</td>
<td>Boggart</td>
<td>Massachusetts</td>
<td>Loch Ness</td>
<td></td>
</tr>
<tr>
<td>sphere</td>
<td>triangle</td>
<td>cube</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Look at the words in the box above. Some of them can be grouped to form analogies. Some of them may give you ideas for other analogies you can make up yourself. Words in the box can be used in more than one example, if necessary.

On each set of lines, write pairs of words you think form complete analogies. Remember that the first item has to be related to the second item in the same way that the third item is related to the fourth.

Under each analogy that you make, write a complete sentence that clearly explains the relationship between items of the analogy.

1. 

____________ / ___________ ___________ / ___________

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________
Generating Serial Analogies

Serial analogies have a relationship based on an order of time, position, degree (of intensity, for example), value, etc. Use the idea bank below to help you think of some serial analogies. Remember to pay attention to the order you use in the first pair of elements so that you keep the same order in the second pair. After you create your analogy, write the relationship sentence below it.

<table>
<thead>
<tr>
<th>IDEA BANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Boggart</td>
</tr>
<tr>
<td>colony</td>
</tr>
<tr>
<td>Earth</td>
</tr>
<tr>
<td>Indian in the</td>
</tr>
<tr>
<td>Cupboard</td>
</tr>
<tr>
<td>Mars</td>
</tr>
<tr>
<td>penny</td>
</tr>
<tr>
<td>Richard Nixon</td>
</tr>
<tr>
<td>square-rigger</td>
</tr>
<tr>
<td>Venus</td>
</tr>
</tbody>
</table>

1. ______________ : ______________ : ______________ : ______________
### Individual Student Results: Raw Data

#### Study Group

| I Pre | I Post | II Pre | II Post | III Pre | III Post | IV Pre | IV Post | Total Pre | Total Post | I Post-Pre | II Post-Pre | III Post-Pre | IV Post-Pre | Total Post-Pre | TPost-Pre |
|-------|--------|--------|---------|---------|----------|--------|---------|------------|------------|------------|-------------|-------------|-------------|-------------|----------------|----------|
| 1     | 14     | 13     | 15      | 14      | 15       | 21     | 18      | 22         | 62         | -1         | 6           | 4           | 8           |              |          |
| 2     | 6      | 11     | 8       | 14      | 6        | 21     | 0       | 14         | 20         | 5          | 6           | 15          | 14          | 40          |        |
| 3     | 9      | 11     | 14      | 12      | 16       | 22     | 17      | 17         | 56         | 62         | 2           | -2          | 6           | 0           | 6             |         |
| 4     | 10     | 14     | 12      | 11      | 16       | 23     | 5       | 12         | 43         | 60         | 4           | -1          | 7           | 7           | 17            |         |
| 5     | 10     | 9      | 14      | 16      | 18       | 12     | 12      | 52         | 53         | -1         | 0           | 2           | 0           | 1           |                |         |
| 6     | 7      | 12     | 13      | 18      | 9        | 14     | 11      | 55         | 56         | 5          | 1           | -5          | 0           | 1           |                |         |
| 7     | 9      | 14     | 13      | 14      | 14       | 14     | 5       | 23         | 41         | 74         | 5           | 1           | 9           | 18          | 33            |         |
| 8     | 10     | 13     | 14      | 12      | 7        | 23     | 21      | 18         | 52         | 66         | 3           | -2          | 16          | -3          | 14            |         |
| 9     | 10     | 13     | 14      | 12      | 7        | 23     | 21      | 18         | 52         | 66         | 3           | -2          | 16          | -3          | 14            |         |
| 10    | 8      | 14     | 14      | 15      | 22       | 19     | 14      | 19         | 58         | 67         | 6           | 1           | -3          | 5           | 9             |         |
| 11    | 9      | 14     | 15      | 13      | 5        | 18     | 16      | 10         | 45         | 55         | 5           | -2          | 13          | -6          | 10            |         |
| 12    | 10     | 12     | 15      | 9       | 20       | 18     | 6       | 13         | 51         | 52         | 2           | -6          | -2          | 7           | 1             |         |
| 13    | 13     | 14     | 15      | 11      | 23       | 20     | 8       | 21         | 59         | 66         | 1           | -4          | -3          | 13          | 7             |         |
| 14    | 6      | 9      | 12      | 13      | 3        | 25     | 0       | 18         | 21         | 65         | 3           | 1           | 22          | 18          | 44            |         |
| 15    | 14     | 9      | 14      | 14      | 7        | 13     | 20      | 18         | 55         | 54         | -5          | 0           | 6           | -2          | -1            |         |
| 16    | 8      | 11     | 10      | 15      | 16       | 18     | 16      | 19         | 50         | 63         | 3           | 5           | 2           | 3           | 13            |         |
| 17    | 10     | 10     | 12      | 14      | 15       | 15     | 5       | 17         | 42         | 56         | 0           | 2           | 0           | 12          | 14            |         |
| 18    | 10     | 13     | 13      | 15      | 13       | 20     | 10      | 17         | 46         | 65         | 3           | 2           | 7           | 7           | 19            |         |
| 19    | 7      | 13     | 9       | 15      | 17       | 23     | 4       | 20         | 37         | 71         | 6           | 6           | 6           | 16          | 34            |         |
| 20    | 6      | 12     | 12      | 15      | 15       | 24     | 0       | 15         | 33         | 73         | 6           | 3           | 9           | 22          | 40            |         |
| 21    | 11     | 11     | 13      | 15      | 18       | 23     | 6       | 14         | 48         | 63         | 0           | 2           | 5           | 8           | 15            |         |
| 22    | 6      | 11     | 13      | 14      | 18       | 25     | 20      | 22         | 56         | 72         | 5           | 1           | 7           | 2           | 15            |         |
| 23    | 11     | 12     | 15      | 15      | 23       | 27     | 17      | 21         | 66         | 75         | 1           | 0           | 4           | 4           | 9             |         |
| 24    | 11     | 14     | 11      | 15      | 13       | 20     | 13      | 16         | 48         | 65         | 3           | 4           | 7           | 3           | 17            |         |
| 25    | 10     | 12     | 12      | 14      | 4        | 22     | 10      | 17         | 36         | 65         | 2           | 2           | 18          | 7           | 29            |         |
| 26    | 12     | 14     | 11      | 15      | 25       | 27     | 22      | 24         | 70         | 80         | 2           | 4           | 2           | 2           | 10            |         |
| 27    | 7      | 13     | 13      | 15      | 16       | 20     | 14      | 21         | 50         | 69         | 6           | 2           | 4           | 7           | 19            |         |
| 28    | 4      | 12     | 14      | 15      | 15       | 23     | 23      | 23         | 56         | 73         | 8           | 1           | 8           | 0           | 17            |         |
## Individual Student Results: Raw Data
### Control Group

<table>
<thead>
<tr>
<th></th>
<th>I Pre</th>
<th>I Post</th>
<th>II Pre</th>
<th>II Post</th>
<th>III Pre</th>
<th>III Post</th>
<th>IV Pre</th>
<th>IV Post</th>
<th>Total Pre</th>
<th>TotalPost</th>
<th>IPost-Pre</th>
<th>IIPost-Pre</th>
<th>IIIPost-Pre</th>
<th>IVPost-Pre</th>
<th>TPost-Pre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>10</td>
<td>14</td>
<td>11</td>
<td>11</td>
<td>15</td>
<td>15</td>
<td>17</td>
<td>48</td>
<td>53</td>
<td>2</td>
<td>-3</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>14</td>
<td>8</td>
<td>5</td>
<td>8</td>
<td>0</td>
<td>3</td>
<td>26</td>
<td>25</td>
<td>-1</td>
<td>-6</td>
<td>3</td>
<td>-1</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>10</td>
<td>4</td>
<td>15</td>
<td>12</td>
<td>18</td>
<td>14</td>
<td>7</td>
<td>3</td>
<td>50</td>
<td>33</td>
<td>-6</td>
<td>-3</td>
<td>-4</td>
<td>-17</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>8</td>
<td>15</td>
<td>11</td>
<td>11</td>
<td>12</td>
<td>16</td>
<td>17</td>
<td>47</td>
<td>48</td>
<td>3</td>
<td>-4</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>15</td>
<td>12</td>
<td>18</td>
<td>2</td>
<td>0</td>
<td>33</td>
<td>34</td>
<td>-1</td>
<td>-2</td>
<td>6</td>
<td>-2</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>10</td>
<td>11</td>
<td>8</td>
<td>12</td>
<td>12</td>
<td>19</td>
<td>23</td>
<td>50</td>
<td>53</td>
<td>2</td>
<td>-3</td>
<td>0</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>12</td>
<td>13</td>
<td>12</td>
<td>13</td>
<td>15</td>
<td>18</td>
<td>21</td>
<td>51</td>
<td>60</td>
<td>5</td>
<td>-1</td>
<td>2</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>7</td>
<td>11</td>
<td>12</td>
<td>6</td>
<td>0</td>
<td>27</td>
<td>27</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>-6</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>5</td>
<td>8</td>
<td>12</td>
<td>11</td>
<td>15</td>
<td>12</td>
<td>14</td>
<td>12</td>
<td>46</td>
<td>43</td>
<td>-1</td>
<td>-3</td>
<td>-2</td>
<td>-3</td>
<td>-3</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>8</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>20</td>
<td>11</td>
<td>18</td>
<td>52</td>
<td>57</td>
<td>-3</td>
<td>-4</td>
<td>5</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
<td>6</td>
<td>13</td>
<td>9</td>
<td>17</td>
<td>12</td>
<td>6</td>
<td>0</td>
<td>46</td>
<td>27</td>
<td>-4</td>
<td>-4</td>
<td>-5</td>
<td>-6</td>
<td>-19</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>6</td>
<td>10</td>
<td>4</td>
<td>8</td>
<td>11</td>
<td>5</td>
<td>4</td>
<td>25</td>
<td>29</td>
<td>4</td>
<td>-6</td>
<td>3</td>
<td>-1</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>8</td>
<td>7</td>
<td>14</td>
<td>9</td>
<td>11</td>
<td>14</td>
<td>8</td>
<td>8</td>
<td>41</td>
<td>38</td>
<td>-1</td>
<td>-5</td>
<td>3</td>
<td>0</td>
<td>-3</td>
</tr>
<tr>
<td>14</td>
<td>10</td>
<td>14</td>
<td>15</td>
<td>14</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>14</td>
<td>47</td>
<td>51</td>
<td>-1</td>
<td>-2</td>
<td>-2</td>
<td>3</td>
<td>-4</td>
</tr>
<tr>
<td>15</td>
<td>5</td>
<td>7</td>
<td>11</td>
<td>12</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>16</td>
<td>29</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>11</td>
<td>10</td>
<td>12</td>
<td>12</td>
<td>10</td>
<td>22</td>
<td>16</td>
<td>23</td>
<td>40</td>
<td>67</td>
<td>-1</td>
<td>0</td>
<td>12</td>
<td>7</td>
<td>27</td>
</tr>
<tr>
<td>17</td>
<td>4</td>
<td>1</td>
<td>9</td>
<td>13</td>
<td>2</td>
<td>9</td>
<td>6</td>
<td>0</td>
<td>21</td>
<td>23</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>-6</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>9</td>
<td>11</td>
<td>11</td>
<td>13</td>
<td>15</td>
<td>20</td>
<td>17</td>
<td>18</td>
<td>52</td>
<td>62</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>19</td>
<td>7</td>
<td>8</td>
<td>12</td>
<td>12</td>
<td>3</td>
<td>15</td>
<td>14</td>
<td>17</td>
<td>36</td>
<td>52</td>
<td>1</td>
<td>0</td>
<td>12</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>20</td>
<td>9</td>
<td>13</td>
<td>10</td>
<td>15</td>
<td>13</td>
<td>15</td>
<td>13</td>
<td>7</td>
<td>45</td>
<td>50</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>-6</td>
<td>5</td>
</tr>
<tr>
<td>21</td>
<td>4</td>
<td>7</td>
<td>13</td>
<td>14</td>
<td>10</td>
<td>17</td>
<td>0</td>
<td>21</td>
<td>27</td>
<td>59</td>
<td>3</td>
<td>1</td>
<td>7</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>22</td>
<td>6</td>
<td>10</td>
<td>14</td>
<td>15</td>
<td>19</td>
<td>21</td>
<td>18</td>
<td>14</td>
<td>57</td>
<td>60</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>-4</td>
<td>3</td>
</tr>
<tr>
<td>23</td>
<td>2</td>
<td>5</td>
<td>12</td>
<td>15</td>
<td>9</td>
<td>11</td>
<td>2</td>
<td>0</td>
<td>25</td>
<td>31</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>-2</td>
<td>6</td>
</tr>
<tr>
<td>24</td>
<td>7</td>
<td>12</td>
<td>9</td>
<td>13</td>
<td>14</td>
<td>16</td>
<td>5</td>
<td>12</td>
<td>35</td>
<td>53</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>25</td>
<td>8</td>
<td>11</td>
<td>14</td>
<td>25</td>
<td>19</td>
<td>13</td>
<td>20</td>
<td>57</td>
<td>64</td>
<td>3</td>
<td>3</td>
<td>-6</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>26</td>
<td>4</td>
<td>8</td>
<td>11</td>
<td>12</td>
<td>15</td>
<td>13</td>
<td>0</td>
<td>6</td>
<td>30</td>
<td>39</td>
<td>4</td>
<td>1</td>
<td>13</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>27</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>14</td>
<td>22</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>28</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>11</td>
<td>10</td>
<td>8</td>
<td>0</td>
<td>11</td>
<td>21</td>
<td>37</td>
<td>1</td>
<td>6</td>
<td>8</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>29</td>
<td>7</td>
<td>11</td>
<td>10</td>
<td>14</td>
<td>16</td>
<td>4</td>
<td>21</td>
<td>35</td>
<td>58</td>
<td>4</td>
<td>0</td>
<td>16</td>
<td>21</td>
<td>23</td>
<td></td>
</tr>
</tbody>
</table>
REASONING BY ANALOGY

A: IS LIKE B:

HOW ALIKE?

ATTRIBUTE

SIMILARITY

WHY SIGNIFICANT?

THINGS KNOWN ABOUT B ( ) THAT MIGHT ALSO BE TRUE OF A ( ) :

SIGNIFICANT DIFFERENCES?

WITH REGARD TO

CONCLUSION ABOUT A ( ) :

APPENDIX G
INFUSING THINKING INTO INSTRUCTION—ELEMENTARY

REASONING BY ANALOGY

465
BIBLIOGRAPHY

Bradley, K. Sue; and Bradley, Jack; “Modifying Curriculum through Divergent Learning Across Disciplines,” Paper presented at the annual Conference and Exhibit of the Association for Supervision and Curriculum Development.

Branderhorst, Mark; Huizenga, Terry; and Kruzich, Kristin. “Developing Transfer in Middle Students’ Learning.” Dissertation; Saint Xavier University.


Fogarty, Robin; Perkins, David; and Barell, John; “How to Teach for Transfer,” The Mindful School, Skylight Publications, Palatine, IL. pp. 79-89.


63


Mental Measurements Yearbooks, Buros Institute of Mental Measurements, University of Nebraska Press, Lincoln, NE. 1998.


