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A COMPARISON OF TWO DIFFERENT FORMULAS FOR MEASURING GAINS IN READING PROFICIENCY

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BY

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Norman, Oklahoma

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A COMPARISON OF TWO DIFFERENT FORMULAS FOR MEASURING GAINS IN READING PROFICIENCY

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CHAPTER I

THE PROBLEM: ITS BACKGROUND AND SCOPE

Introduction

Measurements of change in the proficiency of learned responses are essential aspects of research in education. Without these measurements, determining the degree to which educational objectives are realized would be difficult, if not impossible. Measurements of change in a learned response provide the educator with knowledge of the general status of the learner; with knowledge of the variables that contribute to changes in learning behavior; and with knowledge about the degree to which these changes take place between two moments of observation.

Much of the research in reading education which is devoted to measuring changes in reading proficiency concerns itself with three major problems: measuring gains that occur as a result of improvement in reading proficiency, determining the relationship these gains have to selected characteristics of the learner, and assessing the influence the learning environment has on the proficiency level of the learner. A survey of studies investigating these problems

reveals that two conclusions are derived by researchers with consistent regularity. First, changes in reading proficiency yield gains that are positive and significant.[1] Second, correlates of gains in reading proficiency with measures of aptitude and achievement and correlates of gains with measures of environmental influences yield information that is inconsistent.[2] These conclusions are largely based on statistical designs employing the crude gain formula, a criteria widely used in reading research and one whose reliability has been subject to question.

Thorndike (1924) cautioned against the use of crude measurements, pointing out the spurious results which would inhere in data due to the sharing of common errors between initial and final measurements.[3] Until 1958, when Manning and DuBois published findings based on a new formula, measuring gains in reading and other learned responses were generally limited to crude gain measures. The new formula was called residual gain and was defined

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[1]H. A. Robinson, "A Note on the Evaluation of College Remedial Reading Courses," Journal of Educational Psychology, XLI (January, 1950), 83-96.

[2]Earl F. Rankin, Jr., and R. J. Tracy, "Residual Gain as a Measure of Individual Differences in Reading Improvement," Journal of Reading, VII (March, 1965), 225.

[3]E. L. Thorndike, "The Influence of Chance Imperfections of Measures Upon the Relationship of Initial Score to Gain or Loss," Journal of Experimental Psychology, VII (June, 1924), 225-232.

as "that portion of the final status which is not correlated with initial status."[4]

This study represents an attempt to clarify the problem of determining the differences in the measuring characteristics of two formulas for measuring gains in the reading proficiency of the learner. It will investigate the effects alternate applications of two different gain formulas have on the final measures of reading proficiency. The extensiveness of the problem makes it necessary to limit the study to an investigation of gains in the reading proficiencies of a selected group of college students enrolled in a reading improvement program. In order to understand the problem under investigation, an examination into the characteristics of the gain formulas of the study will be first proffered.

Characteristics of the Crude and Residual Gain Formulas

Crude gain is defined as the arithmetic difference between pre- and post-test measurements. The raw score formula for crude gain is as follows:

$$CG = Y - X$$

Where Y equals the post-test score, X equals the pre-test

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[4]W. H. Manning and P. H. DuBois, "Gain in Proficiency as a Criterion in Test Validation," Journal of Applied Psychology, XLII (June, 1958), 190-194.

score, and Y-X represents the arithmetic difference of the two scores.[5]

Residual gain is defined as the difference between the observed post-test and the predicted post-test score. The predicted score is based on the correlation of the pre- and post-test measurements. Residual gain is also defined as that portion of the final measure which is uncorrelated with the initial measure.[6] The raw score formula for residual gain is written as follows:

$$Y \cdot X = Y - [bX + C]$$

Where Y represents the post-test score, X represents the pre-test score, and bX + C is the predicted score. In order to determine the predicted score, it is necessary to compute b, the correlation, and C, the constant.

where $b = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{N\Sigma X2 - (\Sigma X)2}$

$C = \bar{Y} - b\bar{X}$

$\bar{Y}$ = post-test mean

$\bar{X}$ = pre-test mean

Research findings in reading education reveal two consistent characteristics in the crude gain formula. First,results are spurious where crude measures are used to measure gains in reading proficiency--yielding consistently significant differences favoring improvement in

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[5]Rankin, and Tracy, 224.

[6]Manning, and DuBois, 191.

reading gains. Second, data measuring change in reading proficiency which are obtained by a crude formula do not conform to logical expectations.[7] And what are logical expectations? Since correlates of intelligence with reading proficiency vary from .50 to .80,[8] it would seem logical to expect gains in reading skills to correlate with this particular measure of aptitude. Research findings do not confirm this expectation. Almost all studies investigating the relationship between crude gains in reading and selected characteristics of the learner show that crude measures are uncorrelated with these learner variables.[9] The one study to date employing the residual gain formula obtained a positive and significant correlation (.55) between a gain in reading proficiency and a selected measure of aptitude.[10] The spurious results that are consistently obtained in correlation studies can be explained in terms of the peculiar characteristics of the crude gain formula itself.

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[7]Rankin, and Tracy, 230.

[8]Ruth Strang, C. M. McCullough, and A. E. Thraxler, The Improvement of Reading, (3d ed.; New York: McGraw-Hill Book Company, 1955), p. 25.

[9]W. H. Manning and P. H. DuBois, "Correlational Methods in Research on Human Learning," Perceptual and Motor Skills, XV, 1962, 296.

[10]J. M. Lasater, "Correlates of Change in Reading Skills," Unpublished M.A. thesis, Texas Christian University, 1963.

A major argument against the use of crude measurements is the failure of the test instruments themselves to meet the basic assumptions necessary as conditions for their use when the crude gain formula is to be employed in determining gain scores. The assumptions necessary for such a condition are that pre- and post-test measurements are expressed in identical interval scales; that the two tests have the same zero point; and that these tests are valid and reliable at all levels of proficiency. Rankin points out that these conditions can rarely be met.[11]

Need for the Study

In studies devoted to measuring gains in reading proficiency and to determining the correlates of these gains with other learner characteristics, conclusions have been based on the universally-used crude gain formula. There is reason to suspect these findings are unreliable due to the peculiar characteristics of the crude gain formula when it is employed in research designs for the purpose of measuring changes in a learned performance. There is a need, therefore, to expand knowledge about the characteristics of the recently-developed residual gain formula with a view to determining if it contributes measures that conform more to logical expectations than does the crude gain formula.

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[11]Rankin and Tracy, 230.

Statement of the Problem

The problem of this study is determining the effects two different gain formulas have on measuring changes in the reading proficiency of the learner. It will be necessary to determine if there is a significant difference between the final measures reflecting changes in the reading proficiency of a selected group of college students. A major question is posed which reflects the problem of this study: Does use of a particular formula for measuring gains in reading proficiency contribute significant differences in the final measures of (a) gains in reading proficiency, and (b) correlates of gains in reading proficiency with selected measures of aptitude and achievement.

The Hypotheses

This study represents an attempt to clarify and expand on the available research concerning the effects two gain formulas have on measuring changes in the reading proficiency of the learner. In accordance with the problem of this study, three general hypotheses containing twenty subhypotheses are formulated, each to be tested at the .01 level of significance.

Hypothesis One

In a selected group of college students, there are no significant differences between initial and final

measures of reading proficiency in reading rate, reading vocabulary, reading comprehension, and total reading when measures of gain are determined by the crude gain formula. Four subhypotheses are proposed for testing this general hypothesis and are stated in the null form.

1. There is no significant difference between the means of initial and final measures of reading rate for a selected group of college students as measured by the crude gain formula.

2. There is no significant difference between the means of initial and final measures of reading vocabulary for a selected group of college students as measured by the crude gain formula.

3. There is no significant difference between the means of initial and final measures of reading comprehension for a selected group of college students as measured by the crude gain formula.

4. There is no significant difference between the means of initial and final measures of total reading for a selected group of college students as measured by the crude gain formula.

Hypothesis Two

In a selected group of college students, there are no significant differences between crude gains in reading proficiency and residual gains in reading proficiency when

proficiency is expressed as reading rate, reading vocabulary, reading comprehension, and total reading. Four null subhypotheses are proposed for the testing of this general hypothesis.

5. There is no significant difference between the means of crude gains and residual gains in reading rate for a selected group of college students.

6. There is no significant difference between the means of crude gains and residual gains in reading vocabulary for a selected group of college students.

7. There is no significant difference between the means of crude gains and residual gains in reading comprehension for a selected group of college students.

8. There is no significant difference between the means of crude gains and residual gains in total reading for a selected group of college students.

Hypothesis Three

In a selected group of college students, there are no significant differences between the correlations of crude gain with measures of aptitude and achievement and the correlations of residual gain with measures of aptitude and achievement. Twelve null subhypotheses are proposed for the testing of this general hypothesis.

9. There is no significant difference between the correlations of crude gains in reading rate with intelligence and residual gains in reading rate with intelligence for a

selected group of college students.

10. There is no significant difference between the correlations of crude gains in reading rate with English achievement and residual gains in reading rate with English achievement for a selected group of college students.

11. There is no significant difference between the correlations of crude gains in reading rate with mathematical achievement and residual gains in reading rate with mathematical achievement for a selected group of college students.

12. There is no significant difference between the correlations of crude gains in reading vocabulary with intelligence and residual gains in reading vocabulary with intelligence for a selected group of college students.

13. There is no significant difference between the correlations of crude gains in reading vocabulary with English achievement and residual gains in reading vocabulary with English achievement for a selected group of college students.

14. There is no significant difference between the correlations of crude gains in reading vocabulary with mathematical achievement and residual gains in reading vocabulary with mathematical achievement for a selected group of college students.

15. There is no significant difference between the correlations of crude gains in reading comprehension

with intelligence and residual gains in reading comprehension with intelligence for a selected group of college students.

16. There is no significant difference between the correlations of crude gains in reading comprehension with English achievement and residual gains in reading comprehension with English achievement for a selected group of college students.

17. There is no significant difference between the correlations of crude gains in reading comprehension with mathematical achievement and residual gains in reading comprehension with mathematical achievement for a selected group of college students.

18. There is no significant difference between the correlations of crude gains in total reading with intelligence and residual gains in total reading with intelligence for a selected group of college students.

19. There is no significant difference between the correlations of crude gains in total reading with English achievement and residual gains in total reading with English achievement for a selected group of college students.

20. There is no significant difference between the correlations of crude gains in total reading with mathematical achievement and residual gains in total

reading with mathematical achievement for a selected group of college students.

Operational Definitions

1. Reading proficiency is considered to be those factors measured by the Diagnostic Reading Tests Survey Section. These factors are expressed in raw scores representing reading rate, reading vocabulary, reading comprehension, and total reading. This test is being used in this study as it is the instrument used by Eastern New Mexico University for measuring the reading proficiency of each entering freshman student. An obtained score on the total reading subtest equivalent to the twentieth percentile or lower is the criterion established by the university in which a student is advised to enroll in General Education 111, Reading Development. Students scoring above this percentile may take the course as an elective.

2. Scholastic achievement is considered to be those factors measured by the American College Test. These factors are expressed in standard scores representing English achievement, mathematical achievement, natural science achievement, social science achievement, and composite achievement. Scaling and equating processes ensure equivalence between forms, and scores are adjusted to correct for differences attributed to different times of

test administration.[12] This test is used as part of the entrance requirements at Eastern New Mexico University. For the purpose of this study only those scores representing English and mathematical achievement are used.

3. Aptitude is considered to be those factors measured by the Otis Quick-Scoring Mental Ability Tests, Gamma Test: Form Am. This factor is expressed as a single raw score and is administered to each student prior to the beginning of instruction in GE 111, Reading Development.

Limitations of the Study

This study limits itself to an investigation into the reading proficiency characteristics of students enrolled in General Education 111, Reading Development, at Eastern New Mexico University.

All students were enrolled in one of four GE 111 classes taught by the author during the fall term of the 1967-1968 academic school year. All students received identical lessons presented in the same sequence of time. There was a concern for careful control of all aspects of each lesson so as to insure uniformity of teaching instruction throughout.

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[12]Letter from Oscar T. Lenning, Research Associate, American College Test, Iowa City, Iowa, October 11, 1968.

This study is confined to an investigation of measuring gains in reading proficiency. It is limited to an instructional situation in which the objective of instruction results in improvement rather than a final level of proficiency and where the measurement of improvement is a gains or difference criterion essential to the statistical design.

Assumptions

For the purpose of this study the following assumptions are made:

1. That teaching methodology of the author-instructor was uniform throughout each lesson and had the same effect on each of the subjects of the study.

2. That time of instruction was not a significant factor influencing the measurement of data.

3. That size of the class was not a contributing factor to the variations in measurement of data.

4. That all test instruments were administered in such a manner so as to conform to the criteria of standardization established by the authors.

CHAPTER II

REVIEW OF THE LITERATURE

A survey of the literature reveals much of the research in reading education to be devoted to measuring the reading characteristics of college students. There are two major directions of these studies; one toward measuring the gains in reading improvement which occur as a result of participation in a college reading course, and the other toward measuring the relationship of learner characteristics to these gains in reading proficiency. A common feature with all but a few of these studies is that conclusions concerning changes in the reading characteristics of the learner have been based on measures obtained from the crude gain formula. The concern of this investigation parallels these studies. However, the particular direction of this study is toward comparing the magnitude of differences that two different formulas for measuring gain would effect when applied to the same raw data.

Research Related to Crude Gains in Reading Proficiency

King and Dellande investigated the improvement in reading proficiency college students made as a result of

their enrollment in the University of Missouri reading program. The Cooperative English Test, Form C2Z was used as the criteria of reading proficiency. The crude formula was employed to determine the mean of the difference between pre- and post-test measures and a "t" test was used to assess the significance of differences between the means of correlated samples. A significant "t" was established at the .02 level of confidence. The authors concluded that the students who took the course were substantially better readers after instruction than they were before.[1]

Ray's study investigated the permanency of reading gains in a college reading program three months following completion of treatment and six months following treatment. The purpose of the study was to determine if gains made in a reading course would have lasting effect. Two samples of the original population were selected for retesting. One group was retested three months following completion of the course while the other was retested six months following the course's completion. Gains made during the period of instruction were significant and the final test for this phase of the study had the effect of being the initial measurement for the second, or retest phase. Gains

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[1]Paul T. King and William Dellande, "University of Missouri Reading Improvement Program," Journal of Reading, VIII, (April, 1965), 307-310.

for the retest phase were measured by a "t" test recommended by Garrett in which differences between means were determined by crude measurements. The Nelson-Denny Reading Test was used as the measure of reading proficiency in vocabulary, comprehension, rate, and total reading for the entire study. The sample group retested after three months showed no significant gains over the original gains when retested at the end of this period in any of the measures of reading. The sample group retested six months after the post-test measure showed a significant gain over original gains in vocabulary and rate. The author concluded that the increases were due to increased demands of college reading and to growth characteristics of the students involved.[2]

Research Related to Residual Gains in Reading Proficiency

Rankin and Tracy studied the differing effects use of residual and crude measurements had on evaluating individual differences in a college reading improvement course. Reading improvement scores from seventy-five subjects were contained in the study. Alternate forms of the Diagnostic Reading Test were used for measuring reading improvement with the total reading subscore used as the basis for comparison. Raw scores were obtained from each test from

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[2]Darrell D. Ray, "The Permanency of Gains Made in a College Reading Improvement Program," Journal of Educational Research, LIX, (September, 1965), 17-20.

which a correlation was run between the two and these were then converted to z-scores. Next, two sets of T-scores were assigned: z-scores reflecting residual gains and T-scores reflecting crude gains. Grades were then assigned to both sets of data based on an approximately normal curve with ranks assigned to each grade. A simple straight-line comparison was then made between the ranks and the percent of agreement-disagreement was determined for each of the letter grades.[3]

The authors found only slightly more than 50 per cent of all grades in agreement with the greatest agreement between crude and residual gains in the mid-range (C) grades. Greater disagreement was found at the extreme ranges of performance. Results of this study led the authors to conclude that for the purpose of evaluating individual performance, crude gain measurements created a tendency to over-evaluate the progress of those individuals in the lower extremes of improvement while at the upper level of improvement there was a tendency encouraged by crude gain measurements to under-evaluate progress in reading improvement.[4]

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[3]Earl F. Rankin, Jr., and R. J. Tracy, "Residual Gain as a Measure of Individual Differences in Reading Improvement," Journal of Reading, VII (March, 1965), 224.

[4]Ibid.

Research Related to Correlates of Crude Gain to Other Learner Variables

Schneyer investigated the relationship of scholastic aptitude and gains in reading proficiency. Subjects included seventy-one students enrolled in the seven-week University of Pennsylvania reading improvement course. The Cooperative English Test, C2: Reading Comprehension was used as the measure of reading proficiency. The Scholastic Aptitude Test was the measure of scholastic achievement. Crude differences were obtained between pre- and post-tests as the criterion of gain. The author found a negative correlation of -.26 between improvement in reading proficiency and verbal aptitude.[5]

Bloomer investigated several questions, among which was the relationship between reading gains and academic achievement. There were 38 and 39 in the experimental and control groups respectively. The Diagnostic Reading Test, Forms A and B, were used as the instruments measuring reading ability. A grade-point ratio was determined as the measure of academic achievement based on the American Council on Education Test scores. A negative correlation of -.53 was obtained between the American Council on Education Test scores and gains in reading comprehension. The

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[5]J. W. Schneyer, "The Relationship of Scholastic Aptitude Factors to Progress in a College Reading Course," Journal of Developmental Reading, VII, (Summer, 1964), 261-268.

author concluded that gains in reading skills were unrelated to improvement in academic achievement or to the single criterion of academic achievement.[6]

Research Related to Correlates of Residual Gain to Other Learner Variables

Manning and DuBois studied the differences in correlations obtained from three criteria of proficiency and selected measures of aptitude. Two hundred thirteen Navy trainees were used as subjects. One purpose of the study was to determine which of three selected criteria of learning proficiency was most correlated and which was least correlated with selected measures of aptitude. The three criteria of learning were crude gains, residual gains, and final test scores obtained from alternate forms of an aircraft ignition test. In order to answer the question, three Navy Basic Battery Tests served as the predictors. In addition to this first question, the authors sought to determine if measures from a simple learning task would contribute unique variance to the prediction of gain in a complex technical skill acquired as the result of training. The DuBois-Bunch Learning Test served as the instrument of measure for this portion of the test. Validities and

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[6]Richard H. Bloomer, "The Effects of a College Program on a Random Sample of Education Freshmen," Journal of Developmental Reading, V, (Winter, 1962), 110-118.

intercorrelations were determined by means of correlation computations.[7]

Treatment of the data revealed that correlations of predictors with crude gain were quite low and in only one of six predictors was statistical significance achieved. In the case of residual gains with the same six predictors, each of the terms was significant at the .01 level or higher. Correlations of final status with the predictor variables were generally higher than those of the residual criteria. Multiple correlations between each of the variables by analysis of variance revealed none of the correlations of crude gain were significant. All multiple correlations of residual gain with final status were significant beyond the .001 level. The authors concluded that the decision in the selection of a criterion of change rests primarily on logical considerations. However, they felt the residual gain offered itself as a more realistic criterion than did the more often-used measure of final standing or the inconsistent crude gain formula for the purpose of test validation.

Manning and DuBois investigated the relationships between various measured characteristics of learners and changes in performance of learned tasks. The study dealt with these relationships using residual gain as the criterion

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[7]Winton H. Manning and Philip H. DuBois, "Gain in Proficiency as a Criterion in Test Validation," Journal of Applied Psychology, Monograph Supplement, Vol. 42, No. 3, 191-194.

of change in proficiency. Gain in performance was investigated by means of multivariate correlational analysis. Among others, the purpose of the study was to investigate the prediction of residual gain in the knowledge of educational psychology from measures of academic aptitude and the influence of the instructor's rank on performance. Subjects were 161 students enrolled in one of the eight sections of the same educational psychology class at Washington University, St. Louis, Missouri. Since the purpose was to investigate the predictive ability of the residual gain criterion in knowledge of a subject matter from measures of aptitude and environment, it was hypothesized that measures from the Washington University Entrance Battery were correlated with residual gain in knowledge of educational psychology. A related hypothesis was that rank of the instructor would be related to the residual gain in knowledge of educational psychology. A residual gain was obtained from initial and final measurements of a test measuring knowledge in educational psychology. Information of subject's sex and instructor's rank were recorded. Scores from the Washington University Entrance Battery were obtained and served as the predictor variables. An intercorrelation matrix was obtained from which validities, means, and standard deviations were obtained. From this table were computed correlations between the "sex" and "instructor"

variates. Part correlations were obtained between subscores in the Washington University Entrance Battery Tests and residual gain in knowledge of educational psychology.[8]

Findings indicated the correlations between the residual gain and the predictor variables were all of sufficient magnitude to be significant at the .05 level and above. Multiple correlations proved less consistent. Each of these values were significant beyond the .05 level when scholastic aptitude, sex, and instructor type were the predictors. When scholastic aptitude was considered singularly, prediction of residual gain was significant beyond the .01 level. In no case did any of the correlations yield significance between sex, instructor type and residual gain. The authors concluded that in contrast to similar investigations their findings were quite different in that a positive relationship exists between residual gain in a learned performance and selected measures of aptitude. The authors further concluded that the difference in findings could be attributed to the differences in gain criteria.

Lasater studied fifty-one subjects in an investigation whose purpose was to determine the relationship of various learner characteristics to improvement in

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[8]W. H. Manning and P. H. DuBois, "Correlational Methods in Research on Human Learning," Perceptual and Motor Skills, XV, 1962, 296.

reading skills. The measure of improvement was the residual gain criteria. Initial and final measures of reading vocabulary, reading rate, reading comprehension, reading index, and total comprehension were obtained as measures of reading proficiency. The predictor variable consisted of thirty-one measurements among which were seven measures of aptitude. A matrix of intercorrelations was obtained and from this, part correlations were then determined between the predictor variables and the residual gain. Multiple correlations between the residual gain variates and the predictor group were obtained and their significance tested. The study revealed a correlation of .55 between the measures of aptitude and the residual criterion in reading comprehension, significant beyond the .05 level. The author concluded that change in reading skills could be predicted from selected variables in a research design employing residual gains as the criterion of change.[9]

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[9]J. M. Lasater, "Correlates of Change in Reading Skills," unpublished M.A. thesis, Texas Christian University, 1963.

CHAPTER III

PROCEDURE OF THE STUDY

The Population

The full-time enrollment of students at Eastern New Mexico University was 3,868 during the 1967-1968 academic school year. Of this enrollment, 1,393 were enrolled as freshmen, 727 as sophomores, 526 as juniors, and 450 as seniors. The remaining population was comprised of graduate, special, and unclassified students. The subjects of this study came from students who were enrolled as freshmen. Freshmen are classified as those students who have satisfactorily completed 0-29 hours of class credit.

Selection of the Subjects

There were 253 students enrolled in the four sections of GE 111 during the fall term of the 1967-1968 school year. The subjects for this study came from those freshmen enrolled in these classes. Of this total, 171 met the conditions imposed for inclusion in the study. The following conditions were established as those necessary for inclusion in the study:

1. All specified test instruments were administered and completed by each subject.
2. All subjects were classified as freshmen during the time they were enrolled in GE 111, Reading Development.
3. All subjects were enrolled for credit.
4. All subjects attended a minimum of two-thirds of the lessons.

An analysis of students eliminated from the study is shown in Table 1.

TABLE 1

STUDENTS ELIMINATED FROM THE STUDY

Criteria	Number	Per Cent
Other than freshmen	28	11.1
Freshmen not completing the course	16	6.3
Freshmen with incomplete test data	37	14.6
High school student	1	.4
Total	82	32.4

Instruments of Measure

This study employed the following test instruments as measures of the factors of reading proficiency, intelligence, and achievement:

The Diagnostic Reading Tests Survey Section, Forms A and B were used to determine the reading proficiency of each subject. This test is a measure of reading performance in four major areas: vocabulary, rate of reading, flexibility

of reading, and word recognition. There are eight forms of this test, A through H, and the items of each are equivalent in difficulty and validity. Results for each category of reading varied from .74 to .91.[1] The initial test was administered by personnel from the university's testing department during freshmen orientation week and the final was administered by the same office at the conclusion of instruction of GE 111, Reading Development.

The Otis Quick-Scoring Mental Ability Tests, Gamma Test: Form Am is designed to provide information about the subject's intellectual abilities. Intelligence is the thinking power or the degree of maturity of the mind.[2] The reliability coefficient is listed as .85 and was determined by the split-half method using the Spearman-Brown formula.[3] This test was administered to each subject during the first week of instruction.

The American College Test was used to determine the achievement factors of each subject. Only the English and Mathematics Usage subtests are employed in the design of

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[1]Frances O. Triggs, Robert M. Bear, George D. Spache, Agatha Townsend, Arthur E. Traxler, and Frederick L. Westover, Diagnostic Reading Tests Survey Section Directions for Administering, (New York: Science Research Associates, 1947), pp. 2-3.

[2]Arthur S. Otis, Manual of Directions of Gamma Test, Otis Quick-Scoring Mental Ability Tests, (New York: Harcourt, Brace & World, Inc., 1939, 1954).

[3]Ibid.

this study. The English Usage Test is a measure of the student's abilities in the use of the basic elements of the English language. The Mathematics Usage Test measures application of mathematical principles in the solution of quantitative problems. The reliability coefficients for these two tests are .90 and .89 respectively.[4] This test was administered by the student's local high school in all but a few cases. Where necessary it was administered to the student by the university's testing department.

Treatment of the Data

All data obtained from each of the one hundred seventy-one subjects consisted of raw scores measuring reading proficiency, intelligence, and achievement. Reading proficiency consisted of four raw scores obtained from the Diagnostic Reading Tests Survey Section, each of which was a measure of rate, comprehension, vocabulary, and total reading. Intelligence consisted of one raw-score measure obtained from the Otis Quick-Scoring Mental Ability Tests, Gamma Test: Form Am. Achievement consisted of two standard scores measuring English and mathematical achievement which were obtained from the American College Test.

Results of those test procedures which were necessary to satisfying the conditions of each statistical design prior

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[4]The Sixth Mental Measurements Yearbook, Oscar K. Buros (ed.), 6th ed., Highland Park, New Jersey: The Gryphon Press, 1965), p. 6.

to testing of the hypothesis are presented in Appendices B, C, and D. All statistical formulas used in each hypothesis are presented in Appendix E.

The first general hypothesis states: In a selected group of college students, there are no significant differences between initial and final measures of reading proficiency in reading rate, reading vocabulary, reading comprehension, and total reading when measures of gain are determined by the crude gain formula. In order to test this hypothesis, four subhypotheses were stated and listed as hypotheses one through four. To determine whether or not there were significant differences between the means of initial and final measures of reading proficiency, "t" tests recommended by Guilford[5] were computed. Results of this procedure are presented in Table 2.

Prior to application of the "t" tests, it was necessary to determine if the assumption concerning the homogeneity of variances of each hypothesis could be met. Guilford provides an appropriate "t" test for this procedure.[6] Application of this test indicated two of the four variances to slightly exceed the .01 level of significance. However, they did not exceed the value required for significance at the .001 level. Guilford points out that "t" tests of

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[5]J. P. Guilford, Fundamental Statistics in Psychology and Education, (2d ed.; New York: McGraw-Hill Book Company, Inc., 1956), p. 221.

[6]Ibid. (4th ed.), 193.

significance are not markedly affected where the sample is large and the variances are not too seriously in violation of the required significance level.[7] Therefore, the slight violation concerning the homogeneity of variances was accepted rather than resort to an alternate non-parametric statistical design.

The second general hypothesis states: In a selected group of college students, there are no significant differences between crude gains in reading proficiency and residual gains in reading proficiency when proficiency is expressed as reading rate, reading vocabulary, reading comprehension, and total reading. In order to test this general hypothesis, four subhypotheses were proposed and listed as hypotheses five through eight. To determine whether or not there were significant differences between the means of crude and residual gains in each measure of reading proficiency, "t" tests were computed.[8] Results of this procedure are presented in Table 3.

As a condition to testing this hypothesis, it was necessary to apply an F test to determine if the variances of the two populations were homogeneous.[9] Values of each test were non-significant which indicated the two groups

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[7] Ibid., 185.

[8] Ibid., (2d ed.), 220.

[9] Ibid., 224.

compared in each of the four hypotheses were homogeneous.

The third general hypothesis states: In a selected group of college students, there are no significant differences between the correlations of crude gain with measures of aptitude and achievement and the correlations of residual gain with measures of aptitude and achievement. In order to test this general hypothesis twelve subhypotheses were stated and listed as hypotheses nine through twenty. A "t" test designed by Hotelling[10] was used to determine if there were significant differences between the paired correlation values--one reflecting application of crude gains and the other reflecting application of the residual gains. Results of these tests are presented in Table 5.

Testing of the hypotheses was preceeded by the establishment of a matrix of intercorrelations expressing the relationship between each variable. These values are shown in Table 4. These relationships were determined by the Pearson Product-Moment formula suggested by Peatman.[11] Next, a test of significance was applied to the correlations to determine if the values could have been obtained with greater than chance possibilities.[12]

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[10] H. M. Walker, and Joseph Lev, Statistical Inference, (New York: Holt, Rinehart and Winston, Inc., 1953), pp. 256-257.

[11] J. G. Peatman, Introduction to Applied Statistics, (New York: Harper and Row, 1963), p. 93.

[12] Ibid., 219.

Prior to effecting any statistical procedure for this hypothesis, it was necessary to determine if three conditions underlying use of the Pearson Product-Moment coefficient of correlation could be met. First, there must be a linear relationship between the independent and dependent variables. Second, the variables must be normally distributed. Third, the dispersions must meet the demands of homoscedasticity. Nunally points out there is nothing to prevent use of the Pearson Product-Moment statistic even if one of the distributions is far from linear.[13] Due to the large sample size and to the observable trends in the data, there was reason to believe the necessary conditions were present which would permit the testing of each hypothesis.

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[13]Jum C. Nunally, Psychometric Theory, (New York: McGraw-Hill Book Company, Inc., 1967), pp. 125-126.

CHAPTER IV

RESULTS OF THE STUDY

This study was concerned with determining the effects two different gain formulas have on magnifying the differences in final measures of gains in reading proficiency. Three general and twenty subhypotheses were formulated for testing. The first general hypothesis contains four subhypotheses related to determining if significant differences exist between initial and final measures of reading proficiency as measured by the crude gain formula. The "t" ratios for this hypothesis are presented in Table 2. The second general hypothesis contains four subhypotheses related to determining if significant differences exist between measures of crude gains in reading proficiency and residual gains in reading proficiency. The "t" ratios for this hypothesis are presented in Table 3. The third general hypothesis contains twelve subhypotheses related to determining if significant differences exist between the correlation values reflecting crude and residual gains. The correlations for this hypothesis are presented in Table 4 and the "t" ratios are listed in Table 5.

Crude Gains in Reading Proficiency

Hypothesis one is that there is no significant difference between the means of initial and final measures of reading rate as measured by the crude gain formula. A "t" value of 5.077 was obtained which represented the difference between the means of the initial and final measures of reading rate. This obtained "t" value was greater than the 2.605 ratio required for significance at the .01 level. The hypothesis is rejected and the difference in reading rate shows there is a significant gain in this particular measure of reading proficiency.

Hypothesis two is that there is no significant difference between the means of initial and final measures of reading vocabulary as measured by the crude gain formula. A "t" value of 6.571 was obtained which represented the difference between the means of the initial and final scores of reading vocabulary. This "t" value was greater than the 2.605 ratio required for significance at the .01 level. The hypothesis is rejected and the difference in reading vocabulary shows there is a significant gain in this particular measure of reading proficiency.

Hypothesis three is that there is no significant difference between the means of initial and final measures of reading comprehension as measured by the crude gain formula. A "t" value of 4.438 was obtained which represented

TABLE 2

ANALYSIS OF DATA FOR CRUDE GAINS IN READING PROFICIENCY

N = 171

Areas	Means		Mean Difference	SS	S.D.	"t"*
	Pre-test	Post-test				
Rate	59.400	64.300	4.900	27180.120	12.599	5.077
Vocabulary	34.930	38.275	3.345	7540.749	6.641	6.571
Comprehension	26.444	28.175	1.731	4438.560	5.095	4.438
Total Reading	61.550	66.450	4.900	12065.310	8.400	7.608

*All are significant at the .01 level.

the difference between the means of initial and final scores of this reading comprehension. This "t" value was greater than the 2.605 ratio required for significance at the .01 level. The hypothesis is rejected and the difference in reading comprehension shows there is a significant gain in this particular measure of reading proficiency.

Hypothesis four is that there is no significant difference between the means of initial and final measures of total reading as measured by the crude gain formula. A "t" value of 7.608 was obtained which represented the difference between the means of initial and final scores of total reading. This "t" value was greater than the 2.605 ratio required for significance at the .01 level. The hypothesis is rejected and the difference in total reading shows there is a significant gain in this particular measure of reading proficiency.

Crude Vs. Residual Gains in Reading Proficiency

Hypothesis five is that there is no significant difference between the means of crude gains and the means of residual gains in reading rate. A "t" value of 3.769 was computed which represented the difference between the two means obtained from the measures of reading rate. This "t" value was greater than the ratio of 2.605 required for significance at the .01 level. The hypothesis is rejected and the difference between the means of the two gain scores is

TABLE 3

ANALYSIS OF DATA FOR DIFFERENCES BETWEEN GAIN CRITERIAS

N = 171

Areas	Means and SD: Crude Gain	S.D.	Residual Gain	S.D.	Mean Difference	SS	"t"
Rate	4.900	12.599	0.0	11.330	4.900	49131.470	3.769*
Vocabulary	3.345	6.641	0.0	6.340	3.345	144414.137	4.751*
Comprehension	1.731	5.095	0.0	4.328	1.731	7640.923	3.380*
Total Reading	4.900	8.400	0.0	8.089	4.900	23254.053	5.480*

*Significant of the .01 level.

attributed to the unique measuring characteristics of each formula.

Hypothesis six is that there is no significant difference between the means of crude gains and the means of residual gains in reading vocabulary. A "t" value of 4.751 was computed which represented the difference between the two means obtained from the measures of reading vocabulary. This "t" value was greater than the ratio of 2.605 required for significance at the .01 level. The hypothesis is rejected and the difference between the means of the two gain scores is attributed to the unique measuring characteristics of each formula.

Hypothesis seven is that there is no significant difference between the means of crude gains and the means of residual gains in reading comprehension. A "t" value of 3.380 was computed which represented the difference between the two means obtained from the measures of reading comprehension. This "t" value was greater than the ratio of 2.605 required for significance at the .01 level. The hypothesis is rejected and the difference between the means of the two gain scores is attributed to the unique measuring characteristics of each formula.

Hypothesis eight is that there is no significant difference between the means of crude gains and the means of residual gains in total reading. A "t" value of 5.480 was computed which represented the difference between the

two means obtained from the measures of total reading. This "t" value was greater than the ratio of 2.605 required for significance at the .01 level. The hypothesis is rejected and the difference between the means of the two gain scores is attributed to the unique measuring characteristics of each formula.

Crude Gain Correlations Vs. Residual Gain Correlations

Hypothesis nine is that there is no significant difference between the correlations of crude gains in reading rate with intelligence and residual gains in reading rate with intelligence. A "t" value of .824 was computed which represented the difference between the two correlation values. This ratio was less than the 2.605 required for significance at the .01 level. The hypothesis is accepted and it is concluded that use of a particular gain formula does not contribute to the magnitude of differences between the correlations of crude gains and residual gains with intelligence.

Hypothesis ten is that there is no significant difference between the correlations of crude gains in reading rate with English achievement and residual gains in reading rate with English achievement. A "t" value of 3.890 was computed which represented the difference between the two correlation values. This ratio was greater than the 2.605 required for significance at the .01 level.

TABLE 4

INTERCORRELATION MATRIX BETWEEN ALL VARIABLES

	Residual Gain Rate	Residual Gain Vocabulary	Residual Gain Comprehension	Residual Gain Total Reading	Intelligence	English	Mathematics
Crude Gain Rate	.95**				.07	.09	.05
Crude Gain Vocabulary		.95**			.08	-.14	.06
Crude Gain Comprehension			.84**		.19*	-.25**	.19*
Crude Gain Total Reading				.95**	.18*	-.25**	.16
Residual Gain Rate					.09	.18	.09
Residual Gain Vocabulary					.10	.05	.11
Residual Gain Comprehension					.23**	.08	.28**
Residual Gain Total Reading					.20**	-.04	.21**

*Significant at the .05 level.
**Significant at the .01 level.

TABLE 5

ANALYSIS OF DATA BETWEEN CORRELATES OF GAIN WITH MEASURES OF APTITUDE AND ACHIEVEMENT

N = 171

Variable Area	Gain Criteria		
	Crude r	Residual r	"t"
Intelligence with:			
Rate	.07	.09	.824
Vocabulary	.08	.10	.825
Comprehension	.19	.23	.942
Total Reading	.18	.20	.837
English with:			
Rate	.09	.18	3.890**
Vocabulary	-.14	.05	9.758**
Comprehension	-.25	.08	9.365**
Total Reading	-.25	-.04	11.730**
Mathematics with:			
Rate	.05	.09	1.657
Vocabulary	.06	.11	2.084*
Comprehension	.19	.28	2.156*
Total Reading	.16	.21	2.114*

*Significant at the .05 level.
**Significant at the .01 level.

The hypothesis is rejected and it is concluded that use of a particular gain formula does contribute to the magnitude of differences between the correlations of crude gains and residual gains with English achievement.

Hypothesis eleven is that there is no significant difference between the correlations of crude gains in reading rate with mathematical achievement and residual gains in reading rate with mathematical achievement. A "t" value of 1.657 was computed which represented the difference between the two correlation values. This ratio was less than the 2.605 required for significance at the .01 level. The hypothesis is accepted and it is concluded that use of a particular gain formula does not contribute to the magnitude of differences between the correlations of crude gains and residual gains with mathematical achievement.

Hypothesis twelve is that there is no significant difference between the correlations of crude gains in reading vocabulary with intelligence and residual gains in reading vocabulary with intelligence. A "t" value of .825 was computed which represented the difference between the two correlation values. This ratio was less than the 2.605 required for significance at the .01 level. The hypothesis is accepted and it is concluded that use of a particular gain formula does not contribute to the magnitude of differences between the correlations of crude gains and residual gains with intelligence.

Hypothesis thirteen is that there is no significant difference between the correlations of crude gains in reading vocabulary with English achievement and residual gains in reading vocabulary with English achievement. A "t" value of 9.758 was computed which represented the difference between the two correlation values. This ratio was greater than the 2.605 required for significance at the .01 level. The hypothesis is rejected and it is concluded that use of a particular gain formula does contribute to the magnitude of differences between the correlations of crude gains and residual gains with English achievement.

Hypothesis fourteen is that there is no significant difference between the correlations of crude gains in reading vocabulary with mathematical achievement and residual gains in reading vocabulary with mathematical achievement. A "t" value of 2.084 was computed which represented the difference between the two correlation values. This ratio was less than the 2.605 required for significance at the .01 level. The hypothesis is accepted and it is concluded that use of a particular gain formula does not contribute to the magnitude of differences between the correlations of crude gains and residual gains with mathematical achievement.

Hypothesis fifteen is that there is no significant difference between the correlations of crude gains in reading comprehension with intelligence and residual gains in reading comprehension with intelligence. A "t" value of .942

was computed which represented the difference between the two correlation values. This ratio was less than the 2.605 required for significance at the .01 level. The hypothesis is accepted and it is concluded that use of a particular gain formula does not contribute to the magnitude of differences between the correlations of crude gains and residual gains with intelligence.

Hypothesis sixteen is that there is no significant difference between the correlations of crude gains in reading comprehension with English achievement and residual gains in reading comprehension with English achievement. A "t" value of 9.365 was computed which represented the difference between the two correlation values. This ratio was greater than the 2.605 required for significance at the .01 level. The hypothesis is rejected and it is concluded that use of a particular gain formula does contribute to the magnitude of differences between the correlations of crude gains and residual gains with English achievement.

Hypothesis seventeen is that there is no significant difference between the correlations of crude gains in reading comprehension with mathematical achievement and residual gains in reading comprehension with mathematical achievement. A "t" value of 2.156 was computed which represented the difference between the two correlation values. This ratio was less than the 2.605 required for significance at the .01 level. The hypothesis is accepted and it is concluded that

use of a particular gain formula does not contribute to the magnitude of differences between the correlations of crude gains and residual gains with mathematical achievement.

Hypothesis eighteen is that there is no significant difference between the correlations of crude gains in total reading with intelligence and residual gains in total reading with intelligence. A "t" value of .837 was computed which represented the difference between the two correlation values. This ratio was less than the 2.605 required for significance at the .01 level. The hypothesis is accepted and it is concluded that use of a particular gain formula does not contribute to the magnitude of differences between the correlations of crude gains and residual gains with intelligence.

Hypothesis nineteen is that there is no significant difference between the correlations of crude gains in total reading with English achievement and residual gains in total reading with English achievement. A "t" value of 11.730 was computed which represented the difference between the two correlation values. This ratio was greater than the 2.605 required for significance at the .01 level. The hypothesis is rejected and it is concluded that use of a particular gain formula does contribute to the magnitude of differences between the correlations of crude gains and residual gains with English achievement.

Hypothesis twenty is that there is no significant difference between the correlations of crude gains in total reading with mathematical achievement and residual gains in total reading with mathematical achievement. A "t" value of 2.114 was computed which represented the difference between the two correlation values. This ratio was less than the 2.605 required for significance at the .01 level. The hypothesis is accepted and it is concluded that use of a particular gain formula does not contribute to the magnitude of differences between the correlations of crude gains and residual gains with mathematical achievement.

Summary

Each of the four subhypotheses of general hypothesis one was rejected on the basis of the obtained data. Results indicated that when the data measuring reading proficiency was treated with the crude gain formula, "t" values were highly significant. In each case these ratios exceeded both the .01 and .001 levels of significance.

Each of the four subhypotheses of general hypothesis two was rejected on the basis of the obtained data. Results indicated that when the data measuring reading proficiency was treated alternately with the crude and residual gain formulas and then tested for significant differences, that these differences would be highly significant. In each case these ratios exceeded both the .01 and .001 levels of

significance. Differences between the gain scores were attributed to the unique measuring characteristics of each formula.

General hypothesis three contained twelve subhypotheses, of which eight were accepted and four were rejected. Two sets of correlation values were obtained from the same raw data; one set reflecting application of the crude gain and the other set reflecting application of the residual gain formula. Differences in the correlations were measured by means of a "t" test. In each of the hypotheses rejected the independent variable was English achievement. These differences were significant beyond the .01 level. Results indicated that use of a particular gain formula does contribute to the magnitude of differences between correlations of crude and residual gains with English achievement. Differences between correlations of crude and residual gains with mathematical achievement were significant at the .05 level when gains were measures of vocabulary, comprehension, and total reading. When gains in reading rate were correlated with mathematical achievement, the differences between the two gain criteria were significant at the .10 level. In no case did the differences between the correlations approach significance where intelligence was the independent variable. With the exception of the four hypotheses rejected, it was concluded that use of a particular gain formula does not

contribute to the magnitude of differences between correlations of crude and residual gains with measures of intelligence and mathematical achievement.

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Measuring gains in reading proficiency is an essential task of those engaged in research. A critical portion of the research design is that related to the formula employed by the researcher for determining gains between two moments of observation. Findings in reading education are based on the universally-used crude gain formula--a formula whose reliability under certain conditions has been questioned. Confidence in this formula has been based on the assumption that its measures correspond to true change. Until recently no other formula was available to the researcher for measuring changes in reading proficiency. With the development of the residual gain measure by Manning and DuBois the researcher is now offered an alternative formula for measuring change.

Summary

The purpose of this study was to determine if the residual gain formula would contribute final measures that

were significantly different from those derived from the crude gain formula in measuring changes in the reading proficiency of the learner. This was affected by applying each of the formulas to the same raw data in alternate procedures and testing these differences for significance.

The subjects of the study were 171 college freshmen enrolled in the reading improvement course at Eastern New Mexico University. Gains in reading proficiency were measured by the rate, vocabulary, comprehension, and total reading subtests of the Diagnostic Reading Tests Survey Section. The measure of aptitude selected for the study were scores from the Otis Quick-Scoring Mental Ability Tests, Gamma Test: Form Am. Achievement was represented by scores obtained from the English and mathematical subtests of the American College Test. Three general hypotheses containing twenty subhypotheses were proposed for testing.

Results of hypotheses one through four indicated that gains as measured by the crude formula were significant. These findings are consistent with the results found in many other studies devoted to measuring changes in the reading proficiency of college students.

Results of hypotheses five through eight indicated that gains in reading proficiency were significantly different when comparisons were made between gain formulas. Specifically, final measures which reflected application of

two different gain formulas to the same raw data obtained "t" values that indicated there was a significant difference between the sets of gain scores.

Results of hypotheses nine, twelve, fifteen, and eighteen indicated that when the correlations of crude gains with intelligence were compared with the correlations of residual gains with intelligence, that no significant differences developed between the correlation terms. Gains measured were in the areas of rate, vocabulary, comprehension, and total reading.

Results of hypotheses ten, thirteen, sixteen, and nineteen indicated that when the correlations of crude gains with English were compared with the correlations of residual gains with English, that significant differences developed between the correlation terms. Gains measured were in the areas of rate, vocabulary, comprehension, and total reading. Significance was obtained beyond the .01 level.

Results of hypotheses eleven, fourteen, seventeen, and twenty indicated that when the correlations of crude gains with mathematical achievement were compared with the correlations of residual gains with mathematical achievement, that no significant differences developed between the correlation terms. Significance was obtained, however, at the .05 level in the areas of vocabulary, comprehension,

and total reading; and significance was obtained at the .01 level for reading rate.

Conclusions

On the basis of the obtained data, the following conclusions are made:

1. Use of the crude or residual formula has an effect on the final tabulated data in measuring gains in reading proficiency. The differences may be attributed to the unique characteristics of each formula for measuring gains.

2. Use of the crude or residual formula for measuring gain has an effect on differences between the correlates of crude gains in reading proficiency with English achievement and the correlates of residual gains in reading proficiency with English achievement. The differences may be attributed to the unique characteristics of each formula for measuring gain.

3. Use of the crude or residual formula for measuring gains does not contribute to the significant differences between the correlates of crude gains with mathematical achievement and the correlates of residual gains with mathematical achievement. Use of either gain criteria in correlation with mathematical achievement has no effect on the differences in the final tabulated data.

4. Use of the crude or residual formula for measuring gain does not contribute significant differences between

the correlates of crude gains with intelligence and the correlates of residual gain with intelligence. Use of either gain criteria in correlation with intelligence has no effect on the differences in the final tabulated data.

Implications

The findings in this study support the belief that measures of gains in reading proficiency are sensitive to the unique characteristics of the formula. Entire reading improvement programs have been structured on the basis of knowledge obtained from research employing a formula for measuring gains that has been subject to question. The method of measuring gains has been based on a widely-used formula whose reliability has been in doubt. Methods of teaching reading skills may be resting on knowledge that is faulty at best. The differences found in this study suggest that those engaged in reading research ought to re-evaluate some of the present research in terms of the inadequacies of crude measurements.

Recommendations

Based upon the conclusions drawn from this study, the following recommendations are made:

1. To conduct a similar study using a different college population to determine if the differences in measuring characteristics between the two formulas remains the same.

2. To conduct a longitudinal study to determine if the relationships between the correlation values of this study are similar to the correlation values found in another study conducted over a longer period of time.

3. To conduct another study to determine if use of different test instruments influence the differences in the measuring characteristics of the two formulas.

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APPENDIX A

APPENDIX A

RAW SCORE DATA FOR SUBJECTS OF THE STUDY

Subject	Rate[1]	Rate[2]	Vocab.[1]	Vocab.[2]	Comp.[1]	Comp.[2]	Total[1]	Total[2]	Intelligence	English	Mathematics
1	69	80	34	39	25	31	59	70	46	14	19
2	50	72	28	30	22	19	50	49	12	10	11
3	64	68	32	40	27	24	59	64	46	09	16
4	54	59	27	33	26	25	53	58	36	15	15
5	48	74	33	44	28	29	61	73	37	06	15
6	51	48	31	27	28	25	59	52	47	16	13
7	63	52	33	34	25	28	58	62	42	16	12
8	55	81	19	18	20	19	39	37	36	05	12
9	69	79	40	39	23	29	63	68	37	18	14
10	70	56	37	27	26	30	63	57	36	17	05
11	49	44	38	37	18	22	56	59	51	16	20
12	68	111	21	20	25	25	46	45	36	10	05
13	48	41	37	36	26	28	63	64	42	15	13
14	64	49	30	38	21	26	51	64	32	14	21
15	75	89	40	39	20	23	60	62	45	19	10
16	51	53	30	28	35	33	55	61	30	15	07

APPENDIX A (continued)

Subject	Rate[1]	Rate[2]	Vocab.[1]	Vocab.[2]	Comp.[1]	Comp.[2]	Total[1]	Total[2]	Intelligence	English	Mathematics
17	81	83	33	33	25	26	58	59	39	13	08
18	67	56	36	32	23	27	59	59	46	15	19
19	71	54	24	21	23	25	47	46	32	14	07
20	57	58	30	29	32	31	62	60	41	15	11
21	55	49	28	39	28	20	56	59	46	16	17
22	71	71	19	26	16	10	35	36	34	06	16
23	71	49	37	39	25	29	62	68	47	20	11
24	36	91	28	30	31	24	59	54	45	17	15
25	36	50	25	28	20	25	45	53	41	17	17
26	56	73	36	47	32	30	68	77	55	17	15
27	66	71	35	39	32	35	67	74	50	19	17
28	45	60	34	35	33	26	67	61	33	14	16
29	61	69	36	46	29	21	65	67	32	16	15
30	46	60	42	43	26	27	68	70	37	13	14
31	55	51	36	42	33	30	69	72	46	15	21
32	52	82	42	49	31	25	73	74	43	16	14
33	70	75	44	44	32	28	76	72	41	15	11

APPENDIX A (continued)

Subject	Rate[1]	Rate[2]	Vocab.[1]	Vocab.[2]	Comp.[1]	Comp.[2]	Total[1]	Total[2]	Intelligence	English	Mathematics
34	61	75	37	44	36	37	73	81	49	18	33
35	58	47	28	42	23	30	51	72	45	19	08
36	70	78	47	44	34	33	81	77	50	15	02
37	59	62	46	37	32	36	78	73	57	23	30
38	61	79	46	46	32	31	78	77	28	16	15
39	56	56	41	42	37	31	78	73	48	22	20
40	94	81	52	42	30	27	82	69	56	16	23
41	45	44	41	36	30	25	71	61	51	17	20
42	53	60	47	42	32	32	79	74	43	14	15
43	83	79	48	52	34	35	82	87	59	20	23
44	55	51	31	30	22	11	53	41	38	13	13
45	71	74	30	31	27	33	57	64	30	14	13
46	62	49	29	29	24	26	53	55	30	14	21
47	63	66	25	34	16	16	41	50	42	17	19
48	58	58	27	26	21	22	48	48	35	07	10
49	60	60	34	36	29	11	63	47	25	18	17
50	44	58	31	41	27	23	58	64	36	14	16

APPENDIX A (continued)

Subject	Rate[1]	Rate[2]	Vocab.[1]	Vocab.[2]	Comp.[1]	Comp.[2]	Total[1]	Total[2]	Intelligence	English	Mathematics
51	43	58	29	30	22	17	51	47	39	14	12
52	47	49	30	37	22	20	52	57	35	14	20
53	52	44	36	34	28	32	64	66	41	17	13
54	57	71	22	42	26	24	48	66	36	08	23
55	52	51	33	35	19	20	52	55	43	13	15
56	52	55	29	29	24	20	53	49	40	10	17
57	67	85	21	32	27	26	48	58	42	14	13
58	33	44	35	46	27	26	62	72	50	14	21
59	52	83	37	55	26	30	63	85	48	22	23
60	60	54	35	47	26	36	61	83	50	20	22
61	56	82	34	39	22	22	56	61	51	14	23
62	52	50	37	41	27	22	64	63	33	16	16
63	55	50	27	38	20	28	47	66	36	07	14
64	59	64	35	34	27	26	62	60	40	15	01
65	66	69	37	44	23	30	60	74	29	14	07
66	51	49	38	33	23	29	61	62	40	18	11
67	53	66	32	40	30	31	62	71	48	19	27

APPENDIX A (continued)

Subject	Rate[1]	Rate[2]	Vocab.[1]	Vocab.[2]	Comp.[1]	Comp.[2]	Total[1]	Total[2]	Intelligence	English	Mathematics
68	52	58	27	34	07	28	54	62	41	11	11
69	60	60	31	44	34	32	55	76	41	20	16
70	64	79	36	46	25	31	61	77	39	16	11
71	44	53	32	26	26	27	58	53	42	13	15
72	48	53	37	31	22	23	59	54	39	17	18
73	52	50	33	34	26	27	59	61	48	10	15
74	54	74	31	39	20	23	51	62	42	18	16
75	73	70	38	40	24	35	62	75	45	22	17
76	52	60	29	33	25	30	54	63	44	17	11
77	54	45	24	20	13	18	37	38	29	10	05
78	73	67	38	31	25	30	63	61	46	18	18
79	53	46	32	28	12	23	44	51	31	07	05
80	69	57	37	41	26	29	63	70	38	15	20
81	72	53	39	42	25	26	64	68	52	17	21
82	59	56	38	52	23	27	61	79	45	21	17
83	37	38	27	28	26	27	53	55	41	17	12
84	73	75	35	51	29	34	64	85	53	19	07

APPENDIX A (continued)

Subject	Rate[1]	Rate[2]	Vocab.[1]	Vocab.[2]	Comp.[1]	Comp.[2]	Total[1]	Total[2]	Intelligence	English	Mathematics
85	49	58	33	41	27	23	60	64	43	16	21
86	55	58	43	47	30	35	73	82	50	19	27
87	74	79	36	43	30	30	66	73	51	17	15
88	49	55	40	44	25	32	65	76	48	13	22
89	57	59	31	30	34	26	65	56	37	15	08
90	95	88	55	49	38	39	93	88	56	24	28
91	56	70	42	35	26	31	68	66	50	19	17
92	53	50	43	44	32	30	75	74	43	16	10
93	82	69	41	56	35	36	76	92	64	22	23
94	69	74	51	50	28	28	79	78	47	15	11
95	74	81	40	41	35	33	75	74	38	23	14
96	64	72	41	37	32	33	73	70	46	16	16
97	55	58	39	43	30	30	69	73	39	17	07
98	50	62	43	39	34	34	77	73	50	10	15
99	65	59	40	51	29	34	69	85	48	15	15
100	55	75	46	48	26	25	72	73	49	22	17
101	51	55	42	45	33	36	75	81	52	14	13

APPENDIX A (continued)

Subject	Rate[1]	Rate[2]	Vocab.[1]	Vocab.[2]	Comp.[1]	Comp.[2]	Total[1]	Total[2]	Intelligence	English	Mathematics
102	65	75	29	34	21	28	50	62	43	15	10
103	55	70	30	37	28	26	58	63	35	21	15
104	55	56	36	41	24	27	60	68	41	19	17
105	65	62	37	43	27	31	64	74	40	19	10
106	57	49	28	40	25	26	53	66	48	17	21
107	59	66	31	45	20	29	51	74	43	17	15
108	62	69	34	48	20	32	54	80	42	15	11
109	48	50	22	44	26	31	58	75	37	13	15
110	55	49	28	24	25	30	63	54	35	11	13
111	44	47	26	40	22	29	48	69	34	17	11
112	42	63	36	46	24	32	60	78	62	11	15
113	60	63	38	34	18	21	56	55	45	17	16
114	50	53	35	34	24	24	59	58	43	21	14
115	60	50	33	29	31	36	64	65	43	12	16
116	54	56	40	39	25	34	65	73	43	10	18
117	71	65	38	39	28	31	66	70	57	21	18
118	77	79	44	42	37	34	81	76	60	20	23

APPENDIX A (continued)

Subject	Rate[1]	Rate[2]	Vocab.[1]	Vocab.[2]	Comp.[1]	Comp.[2]	Total[1]	Total[2]	Intelligence	English	Mathematics
119	67	77	47	56	35	35	82	91	58	22	17
120	65	65	38	43	37	34	75	77	41	16	13
121	44	51	40	45	33	30	73	75	53	18	20
122	82	67	39	30	21	27	60	57	46	14	15
123	51	69	40	47	29	34	69	81	47	17	14
124	58	83	36	39	36	35	72	74	60	21	15
125	39	38	38	40	17	28	55	68	34	12	07
126	62	56	21	30	26	29	47	59	36	17	14
127	53	60	28	34	27	32	55	66	42	19	16
128	38	61	28	36	29	28	57	64	42	08	11
129	59	58	31	41	27	35	58	76	47	14	16
130	56	65	35	47	26	31	61	78	55	18	05
131	65	69	35	34	21	21	56	55	38	13	11
132	58	72	34	35	28	30	62	65	43	13	14
133	57	65	21	23	23	21	44	44	34	17	13
134	76	57	22	17	16	18	38	35	30	05	16
135	66	63	30	34	19	32	49	66	44	15	18

APPENDIX A (continued)

Subject	Rate[1]	Rate[2]	Vocab.[1]	Vocab.[2]	Comp.[1]	Comp.[2]	Total[1]	Total[2]	Intelligence	English	Mathematics
136	56	78	32	38	23	26	55	64	41	10	19
137	54	53	31	31	31	31	62	62	43	15	17
138	59	72	34	47	26	21	60	68	35	18	13
139	45	53	30	32	23	26	53	58	44	12	10
140	78	66	38	33	10	26	48	59	38	18	10
141	54	45	31	42	28	32	59	74	38	12	21
142	54	104	31	29	24	22	55	51	33	01	11
143	66	74	36	41	21	32	57	73	58	19	20
144	64	62	36	39	26	34	62	73	41	19	10
145	63	63	31	27	28	28	59	55	38	15	01
146	63	52	32	40	27	33	59	73	42	10	18
147	61	97	44	33	20	24	64	57	29	17	16
148	81	61	41	37	17	30	58	67	55	17	18
149	73	65	28	30	26	31	54	61	34	21	18
150	65	63	32	35	21	25	53	60	44	16	14
151	50	59	27	32	28	30	55	62	45	13	18
152	52	48	33	36	22	27	55	63	39	06	12

APPENDIX A (continued)

Subject	Rate[1]	Rate[2]	Vocab.[1]	Vocab.[2]	Comp.[1]	Comp.[2]	Total[1]	Total[2]	Intelligence	English	Mathematics
153	66	78	35	55	28	32	63	87	46	15	17
154	45	45	31	37	26	29	57	66	32	17	13
155	46	71	34	43	26	30	60	73	48	18	14
156	67	63	38	49	28	29	66	78	47	13	18
157	89	89	40	41	25	33	65	74	48	16	01
158	44	82	36	40	31	28	67	68	51	20	13
159	60	73	34	41	33	33	67	74	36	19	19
160	66	68	35	36	30	33	65	69	38	08	14
161	59	58	42	54	29	35	71	89	57	13	15
162	63	85	50	49	33	28	83	77	56	22	21
163	66	76	42	48	29	29	71	77	44	23	11
164	51	53	47	29	27	27	74	56	47	15	24
165	52	53	42	44	33	32	75	76	61	17	24
166	85	95	45	51	37	34	82	85	49	19	14
167	66	85	35	52	34	28	69	80	60	23	24
168	73	100	41	49	32	29	73	78	56	19	19
169	57	66	36	25	35	28	71	53	44	17	16

APPENDIX A (continued)

Subject	Rate[1]	Rate[2]	Vocab.[1]	Vocab.[2]	Comp.[1]	Comp.[2]	Total[1]	Total[2]	Intelligence	English	Mathematics
170	74	90	44	44	27	32	71	76	53	23	15
171	62	77	39	42	30	32	69	74	59	17	17
Mean	59.40	64.30	34.930	38.275	26.444	28.175	61.550	66.450	43.27	15.60	15.08
Standard Deviation	11.257	13.725	6.726	7.920	5.153	5.073	10.091	11.287	8.280	4.120	5.190

[1]Pre-test score.

[2]Post-test score.

APPENDIX B

APPENDIX B

TABLE 6

APPLICATION OF T TESTS FOR HOMOGENEITY OF VARIANCE FOR MEASURES OF READING PROFICIENCY

N = 171

Areas	Pre-test		Post-test		r_{12}	"t"
	Variance	S.D.	Variance	S.D.		
Rate	126.70	11.257	188.14	13.725	.48	2.943*
Vocabulary	45.242	6.726	62.723	7.920	.60	2.666*
Comprehension	25.741	5.153	26.554	5.073	.48	-.230
Total Reading	101.823	10.091	127.400	11.287	.77	2.280

*Significant at the .01 level.

APPENDIX C

APPENDIX C

TABLE 7

APPLICATION OF F TESTS FOR HOMOGENEITY OF VARIANCE BETWEEN GAINS OF READING PROFICIENCY

N = 171

Areas	Variances		F
	Crude Gain	Residual Gain	
Rate	158.948	128.370	1.238
Vocabulary	44.097	40.195	1.097
Comprehension	25.956	18.727	1.386
Total Reading	70.557	65.431	1.078

*Significant at the .01 level.

APPENDIX D

APPENDIX D

TABLE 8

T VALUES FOR DIFFERENCES BETWEEN CRUDE AND RESIDUAL CORRELATIONS

N = 171

	Variable		
	Intelligence	English	Mathematics
Rate	.824	3.890**	1.657
Vocabulary	.825	9.758**	2.084*
Comprehension	.942	9.365**	2.156*
Total Reading	.837	11.730**	2.114*

*Significant at the .05 level.
**Significant at the .01 level.

APPENDIX E

APPENDIX E

FORMULAS USED IN TESTS OF SIGNIFICANCE

Hypotheses One through Four

Formula 1 (T test for homogeneity of variance):

$$t = \frac{(s_2^2 - s_1^2)\sqrt{N - 2}}{2 s_1 s_2 \sqrt{1 - r^2_{12}}}$$

where:

$s_2^2 - s_1^2$ = estimates of population variance

$2 s_1 s_2$ = two times the products of the two sample standard deviations

r^2_{12} = correlation of pre and post raw scores squared

N = number of observations

Formula 2 ("t" test for difference between correlated pairs of means):

$$t = \frac{Md}{\sqrt{\frac{\sum x_d^2}{N (N - 1)}}}$$

where:

Md = mean of paired differences

$\sum x_d^2$ = sums of squares of paired differences

N = number of pairs of observations

Hypotheses Five through Eight

Formula 1 (F test for homogeneity of variance):

$$F = \frac{\text{larger variance}}{\text{smaller variance}}$$

Formula 2 ("t" test for differences between uncorrelated means in samples of equal size):

$$t = \frac{M_1 - M_2}{\sqrt{\frac{\sum x_1^2 + \sum x_2^2}{N_i (N_i - 1)}}}$$

where:

M_1 and M_2 = means of the two samples

$\sum x_1^2$ and $\sum x_2^2$ = sums of squares of the two samples

N_i = size of either sample

Hypotheses Nine through Twenty

Formula 1 (Pearson product-moment correlation coefficients for relationship between each pair of variables):

$$r = \frac{\frac{\sum xy}{1} - (\bar{x}\,\bar{y})}{\sqrt{\frac{\sum x^2}{n_x} - (\bar{x})^2} \sqrt{\frac{\sum y^2}{n_y} - (\bar{y})^2}}$$

where:

$\sum xy$ = sum of the products of each x and y variate

$\bar{x}$ and $\bar{y}$ = mean of each x and y variate

$\sum x^2$ = sum of each x variate squared

$(\bar{x})^2$ = mean of each x variate squared

$\sum y^2$ = sum of each y variate squared

$(\bar{y})^2$ = mean of each y variate squared

n_x and n_y = number of samples in each variate

Formula 2 ("t" test for significance of a correlation coefficient):

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

where:

r = coefficient of correlation between two variates

N = number of pairs of observations

Formula 3 ("t" test for significant differences between coefficients of correlation):

$$t = (r_{xz} - r_{yz})\sqrt{\frac{(N - 3)\ (1 + r_{xy})}{2\ (1 - r_{xy}^2 - r_{xz}^2 - r_{yz}^2 + 2r_{xy}r_{xz}r_{yz})}}$$

where:

x = score obtained from dependent variate, crude criteria

y = score obtained from dependent variate, residual criteria

z = predictor variate of I.Q., English, and mathematical achievement

N = number of observations