COLORADO STATE TEACHERS COLLEGE

THE APPLICABILITY OF THE SPEARMAN-BROWN FORMULA TO COLLEGE MARKS

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Arts

by

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1933

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ABSTRACT

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Bailey, Iva M. The Applicability of the Spearman-Brown Formula to College Marks, Master of Arts Thesis, Colorado State Teachers College, Greeley, Colorado, 1933, pp.45

The prophecy formula is one of the results of certain experiments carried on by C. Spearman and Wm. Brown simultaneously. It has its origin in the correlation of sums. It is used to predict mathematically the effect upon reliability to be gained by lenthening a test or by a stated number of repetitions and duplications of a test. It assumes that the items of a test are homogeneous and of equal reliability. There is a tendency at present to apply this formula to material other than tests.

The purpose of this study is to test the applicability of the Spearman-Brown formula to college marks. We are of the opinion that college marks are not sufficiently reliable to answer the requirements of the formula. Further, that the average marks for quarters can not be considered as equivalent to average scores on test forms inasmuch as they do not represent judgments arrived at by standardized and comparable procedure upon homogeneous material.

The data used to carry out the investigation were secured from the official records of the grades of the June graduating class of 1932 of Colorado State Teachers College. One hundred fifteen complete and comparable records for each of twelve quarters were examined and grades transmuted into score points, which were averaged.

In transmuting the letter grades into score points, the letter grades were assigned the following values: "A" 5 "B" 4, "C" 3, "D" 2, "F" 1. Unit and half-unit courses in music and physical education were ignored as grades in these were not considered comparable to those secured in the more strictly academic fields. Extension courses were eliminated for the same reason.

Zero-order correlations were computed for each of these independent variables: each odd quarter with its succeeding even quarter; each even quarter with its succeeding even quarter; and each odd quarter with its succeeding odd quarter. These coefficients ranged from .41 P.E. .05 to .70, P.E. .03. The initial coefficient was .59 P.E. .04. This was also the value of the average r for the first six quarters. It was used as the basic r for prediction.

Higher order correlations were computed for combined averages for series of two, three, four, and six quarters. For purposes of comparison with the coefficients of these series the Spearman-Brown formula was applied, using the initial r and stepping up the formula 2, 3, 4, and 6 times corresponding to the number of quarters in each amalgamated series. The differences between the actual r's and the predicted r's and the probable errors of the differences were computed. This latter computation necessitated the calculation of the probable error of the predicted r's. The actual and predicted r's showed close agreement up to the end of

the second year. Thereafter true differences were indicated. The data showed an over-prediction from this point, gradually increasing with each additional amalgamation until the final difference of .155 was reached. The probable error of this highest difference was .0302 giving a $\frac{D}{P.E._{dif.}}$ of 5.13, which means that the obtained difference between actual and predicted marks is not only completely reliable but is 28 per cent greater than need be to insure a true difference greater than zero.

From this interpretation we conclude that the cumulative coefficients of reliability of quarter marks above the second year do not follow the law of the Spearman-Brown formula and that therefore the application of the formula to college marks is uncertain. Effort should be made to increase the reliability of college marks to at least .70 for any quarter before they will answer the requirements of the formula. It is apparent that injustices due to inaccurate marks in any quarter are not removed by multiplying the number of marks given.

We should recommend that until college marks are based upon more homogeneous procedures and more reliable instruments of measurement the application of the Spearman-Brown formula be made with extreme caution. It may be applied to the self-correlation coefficient of first and second quarter marks but its predictive value above the second year is doubtful.

PREFACE

It is nearly a quarter of a century since the development of a "prophecy" formula by Spearman and Brown simultaneously. Since then other equations have been developed as devices for prediction in order to assist personnel workers in gaining such advanced information as will best enable them to advise students. However, investigators recognizing the possibilities of the Spearman-Brown formula have sought to apply it in ever more extended fields. This study has been made to test the applicability of the formula to college marks.

I take this opportunity to express my appreciation to Dr. J. D. Heilman of the Personnel Department of Colorado State Teachers College, who initiated my interest in the problem and who was my teacher of statistical methods. I am also grateful to Dr. W. T. Waite for reading the report. I acknowledge my indebtedness to Mr. Roy M. Carson and his assistants for their courtesy in permitting the use of the records of the registrar's office.

Iva M. Bailey

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CHAPTER I

THE HISTORY OF THE SPEARMAN-BROWN FORMULA

The origin of any statistical device is of some concern to any one presuming to apply that device in order to understand and interpret the data it may yield. A historical sketch of the Spearman-Brown "prophecy" formula is appropriate to this study.

The prophecy formula has its origin in the correlation of sums. Its algebraic derivation is a natural outgrowth of the fundamental work on probable errors [1] developed by Pearson and others, the approach and underlying theory of which was published in papers by that author in 1898.

In 1904 Spearman published an article on the objective determination and measurement of general intelligence, in which he carefully described his procedure in deducing results including methods of correlation, elimination of observational errors, and elimination of irrelevant factors.[2] He particularly called attention to the way in which inaccuracies in test scores reduce or attenuate correlation. In a second article published in 1910 in the British Journal of

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1 Walker, H. M. Studies in the History of Statistical Method, p.112. The Williams and Wilkins Company, Baltimore, 1929.

2 Spearman, C. "General Intelligence Objectively Determined and Measured." American Journal of Psychology, Vol. 15, pp.252-293 (June, 1904).

Psychology, on a report of correlation calculated from faulty data he introduced the term "reliability coefficient", which he defined as the coefficient between one half and the other half of several measurements of the same thing.[3]

The mold from which the prophecy formula was cast is that for the correlation of x and y when x is determined by p and y by q independent measurements, it being assumed that any one series of measurements of a variable yields the same mean and the same standard deviation as any other series.[4]

" Let $\bar{r}_{xy}$ = the mean of all the pq different correlations which can be obtained between one series of measurements of x and one series of measurements of y,

and $\bar{r}_{x_1x_2}$ = the mean of all the correlations which can be obtained between two different series of measures of x,

and $\bar{r}_{y_1y_2}$ = the mean of all the correlations which can be obtained between two different series of measures of y.

Then $$r(x_1x_2+..+xp)(y_1-y_2+..+yq) = \frac{pq\,\bar{r}_{xy}}{\sqrt{p+p(p-1)\bar{r}_{x_1x_2}}\sqrt{q+q(q-1)\bar{r}_{y_1y_2}}}$$

When p = q = infinity, this reduces to the correlation for attenuation. When p = 1 and q is infinite, it yields the correlation between an observed score in x and a "true score"

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3 Spearman, C. "Correlation Calculated From Faulty Data." British Journal of Psychology, Vol.III, pp.271-295 (October, 1910).

4 Walker, H. M. Op. cit., Studies in the History of Statistical Method, p.112

in y, that is $\frac{\bar{r}_{xy}}{\sqrt{\bar{r}_{y_1y_2}}}$. When p = q and x and y are measurements of the same variable, this becomes the Spearman-Brown prophecy formula."

In general, these formulae are used to measure the untoward effect of errors of observation upon statistical work, particularly when data is faulty due to unreliability in testing measurements;or to predict mathematically the advantages which might be gained by a stated amount of increase in the reliability of the tests.

Spearman approaches the matter in this way,[5] " It is often very useful to be able to estimate how much the reliability coefficient will probably be increased by any given additional number of measurements,or how much it will probably be reduced by any given diminuation in the number of measurements. It can be shown that the following relation holds good:

$$r_{x(p).x(p)} = \frac{p.r_{x(q),x(q)}}{q+(p-q).r_{x(q),x(q)}},$$

where $r_{x(q),x(q)}$ is the known reliability coefficient of x when the latter has been measured 2q times i times, i being any number, and $r_{x(p),x(p)}$ is the required most probable reliability coefficient if x be measured 2p times i times."

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5 Spearman, C. Op. cit., Correlation Calculated from Faulty Data, p.290.

The following form occurs in an appendix to the article from which the quotation is taken:

$$\frac{p.r_{x(1),x(1)}}{1+(p-1)r_{x(1),x(1)}} .$$

In the same number of the British Journal of Psychology Brown published an article [6] reporting some experimental results in the correlation of mental abilities. In the report he has a table, one column of which is headed "Rel.coeff.(r) for amalgamated pairs of tests, $r_2 = \frac{2r_1}{1+r_1}$." In a footnote he gives this explanation: " r measures the extent to which the amalgamated results of the two tests would correlate with a similar amalgamated series of two applications of the same test. If x_1, x_2, x'_1, x'_2 be two pairs of results(x denoting, as usual, derivations from the mean value) we may assume that $\sigma x_1 = \sigma x_2 = \sigma x'_1 = \sigma x'_2 = \sigma x$ (say), and that $S(x_1x'_1) = S(x_1x'_2) = S(x_2x'_1) = S(x_2x'_2) = n\sigma_{x_2}r_1$. Hence we get $r_2 = \frac{2r_1}{1 + r_1}$. It is easily seen that the amalgamation of 4 tests gives a reliability coefficient $= \frac{4r_1}{1 + 3r_1}$; and,in general,for n tests we have $r_n = \frac{nr_1}{1+(n-1)r_1}$. The last formula furnishes a ready means of determining from

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6 Brown, Wm.,"Some Experimental Results in the Correlation of Mental Abilities." British Journal of Psychology, Vol. III, pp.296-322 (October, 1910).

the reliability coefficient of a single test, the number of applications which would be necessary to give an amalgamated result of any desired degree of reliability." Thus, we see that Brown gives first the special case of n equals two and generalizes this to obtain the prophecy formula, while Spearman deduces the formula as a particular case of a more general theory.

CHAPTER II

INTRODUCTION TO THE STUDY

1. Review of Previous Studies

Since the development of the "prophecy formula" simultaneously by Spearman and Brown there has been great interest in testing the formula and in finding new applications for it in extended fields. Originally Spearman employed the formula to ascertain to what degree a test must be lengthened to produce a required reliability, assuming that the test items remained equally reliable. His theory was that an amalgamation of several sets of measurements constantly emphasizes whatever elements are common to them all and simultaneously obliterates all that are not common: thus in the normal case of their correlations to the other series amalgamations will continually raise the correlation toward its full amount.

In 1923, Karl J. Holzinger carried on an investigation in which he used ten components of the Terman Group Test of Mental Ability as material for testing the reliability of the application of the formula. He found that reliability increases very rapidly with the first four or five pooled tests, but increases thereafter more slowly than the pre-

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[7] Holzinger, Karl J. "Note on the Use of the Spearman prophecy Formula for Reliability." Journal of Educational Psychology, Vol. 14, pp.302-305 (May, 1923).

dictive formula would lead us to expect. He suggested that the assumptions underlying the proof of the formula be examined and tested.

Later Holzinger and Clayton made a second study[8] in which the main concern was the applicability of the formula to components which more fully met the conditions of equal length and reliability. In their first experiment equal time units were secured with the Otis Self-administering Test of Mental Ability. The results showed that the components were very unequal as to reliability and difficulty. When the first coefficient from the experimental series was substituted in the equation a significant over-prediction resulted, but when a suitably chosen value for r_{xx} was employed fairly good agreement between experimental and theoretical results was obtained. For the second experiment carefully graded, homogeneous material from the Buckingham Extension of the Ayres Spelling Scale was used. In this case, the agreement between observed and expected values was remarkably close when either the initial or "best" value for r_{xx} was substituted in the equation. His conclusion was that with suitable material Spearman's Prophecy

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8 Holzinger, Karl J. and Clayton, Blythe "Further Experiments in the Application of Spearman's Prophecy Formula." Journal of Educational Psychology, Vol. 16, pp.289-299 (May, 1925).

Formula may give excellent results; with unhomogeneous or poorly graduated material the application of the law is uncertain.

Kelley, using Gordon's data in group judgments in the field of lifted weights, found that the increase in reliability with group judgments is that forecast by the Spearman Brown Formula.[9]

In 1926, Ruch, Ackerson and Jackson at the University of Iowa applied the formula to educational test material.[10] They found that in test material sufficiently homogeneous to induce fairly equivalent unitary SD's and r's, or in case a "best" value of the unitary r is obtained, the Spearman-Brown formula gave a meaningful prediction.

Another study,[11] in a somewhat different field, was made by Lanier at the University of New York in 1927. He used tests of mental and special ability, particularly in the

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9 Kelley, Truman L. "The Applicability of the Spearman-Brown Formula For the Measurement of Reliability." Journal of Educational Psychology, Vol. 16, pp.300-303 (August, 1925).

10 Ruch, Giles M., Ackerson, Luton and Jackson, Jessie D. "An Empirical Study of the Spearman-Brown Formula as Applied to Educational Test Material. "Journal of Educational Psychology, Vol. 17, pp.309-313 (May, 1926).

11 Lanier, Lyle H. "Prediction of the Reliability of Mental Tests and Tests of Special Abilities. "Journal of Experimental Psychology, Vol. 10, pp.69-113 (April, 1927).

field of music. He found that lengthening the tests did increase reliability far from that predicted by the formula; and that there appears no ground for the assumption of a general increase in reliability proportionate to the increase in the number of subjects, such as the prediction formula gives.

Farnsworth, at Stanford University, working in the field of music, applied the formula to the Seashore Tests.[12] On the retests he found that the formula predicted with considerable accuracy in most instances.

Remmers, Shock, and Kelly tested the validity of the formula using judges as equivalent to test items in the sense required by the formula.[13] Their study concerned itself with correlations between groups of judgments varying from one to thirteen. These judgments were obtained by having members of a fraternity rate each other on the Purdue Personnel Rating Scale. Their conclusion was that the formula predicts within two probale errors or one standard deviation the empirical reliability obtained by experiment up to and including thirteen judges.

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12 Farnsworth, Paul R. "The Spearman-Brown Prophecy Formula and the Seashore Tests." Journal of Educational Psychology, Vol. 19, pp.586-588 (November, 1928).

13 Remmers, H. H., Shock, N.W., and Kelly, E. L. "An Empirical Study of the Validity of the Spearman-Brown Formula As Applied to the Purdue Rating Scale." Journal of Educational Psychology, Vol. 18, pp.187-195 (March, 1927).

Later Remmers undertook another study[14] in which, assuming the Spearman-Brown formula to apply, the number of judges was considered large enough to give ratings sufficiently reliable for practical purposes. The students of the University of Purdue rated their instructors on the Purdue Personnel Scale for Instructors. His problem was,"Do judgments which students record concerning their instructors follow the law represented by the Spearman*Brown prophecy formula?" or in other words, "Is it valid to assume that judgments are the equivalent of test items in the sense required by the formula?" He found that reliabilities were predicted within the allowable error up to thirty judgments and that in general, ratings by from ten to twenty students on a single trait for instructors differing sensibly in the amount of the trait possessed yield reliabilities which compare rather favorably with the reliabilities reported for standardized mental and educational tests. He concludes that "It is probable that in the majority of situations in which subjective judgments are used--personnel ratings,debate judging, stock judging, beauty contests, jury verdicts, political polls, etc.,--the Spearman-Brown prophecy formula indicates the number of judgments required for a given re-

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14 Remmers, H. H. "The Equivalence of Judgments to Test Items In the Sense of the Spearman-Brown Formula." Journal of Educational Psychology, Vol. 22,pp.66-71 (January, 1931).

liability, although here it must be admitted that we are going beyond the known facts."

2. The Problem

The problem of the present study is to determine the applicability of the Spearman-Brown Prophecy Formula to college marks. It is contended by some investigators that the "prophecy formula" is applicable to college grades; that it is even more applicable to this situation than to a lengthened test. This assumes that, though high agreement is not present between first and second quarter marks, as marks accumulate throughout college life there is a fairly high degree of reliability. Further, it assumes that quarters are equivalent to test forms in the sense required by the formula.

The purpose of this study is to determine to what extent these accumulated coefficients of reliability correspond to those predicted by the Spearman-Brown formula. After the correspondence of the actual and predicted coefficients based on cumulated data is discovered, we shall use this data in proving or disproving the contention. It is our opinion that the cumulative correlation coefficients do not follow the law of the prophecy formula because the summed estimates of college marks do not answer the requirements of the formula as to reliability and homogeniety.

3. Procedure and Technic

In order to test the application of the Spearman-Brown formula to college marks the marks of 115 members of the graduating class of June 1932 at Colorado State Teachers College were studied.

The grading system now in effect at Colorado State Teachers College is a five-point scale in which the five letter grades, "A", "B", "C", "D", "E", and "F" are used. In order that college marks might be used in this study it was necessary to transmute the letter grades into numerical values. Accordingly, the marks were weighted in this manner: five points for each hour of "A", four points for each hour of "B", three points for each hour of "C", two points for each hour of "D", and one point for each hour of "F". For example, a student carries a total load of sixteen hours during a single quarter, consisting of three four-hour courses and two two-hour courses. He receives an "A" in one four-hour course, a "B" in another, and a "C" in the third: In the two-hour courses he receives a "D" and an "F". The computation of the points would be as follows:

4 hours	with a grade of "A" multiplied by 5	20
4 hours	with a grade of "B" multiplied by 4	16
4 hours	with a grade of "C" multiplied by 3	12
2 hours	with a grade of "D" multiplied by 2	4
2 hours	with a grade of "F" multiplied by 1	2
16		54

Dividing the sum of the weighted values, in this case 54,

by 16, the number of hours carried, we get 3.38, the average mark in points of the student for this particular quarter.

Whereever marks were given on a grading scale different from that used in Colorado State Teachers College at present, the proper adjustment in equivalent score points was determined. Unit and half-unit courses in music and physical education were ignored as these were not comparable to grades earned in the more academic fields. Marks secured through extension work and transferred marks from other institutions were not considered for the same reason.

Selection having been made upon the basis stated above, 115 complete and comparable records were available. The average marks, in points, for each of the twelve quarters of college life for each of the 115 students was computed.

Correlation coefficients were found for pairs of quarter averages; between the first and second quarters; between successive even quarters and the successive odd quarters; also, between the successive alternations of odd and even quarters.

The relationship between the first and second quarter averages was used as the zero-order correlation to which the prophecy formula was to be applied to obtain predicted marks The correlation of other pairs of quarters was found in order to study the extent of agreement, but these coefficients

were not used in the final prediction of marks.

All correlations were made by the Pearson Product Moment formula.[15] The probable error of the predicted r's was found by using the Shen formula.

The Spearman-Brown formula was applied to the initial r stepping it up 2, 3, 4, and 6 times in order to compare the predicted correlation with the actual correlations found for corresponding lengths of time.

The grades of different pairs of quarters were amalgamated and correlations made between the new averages found. Then the marks for a series of three quarters were averaged and the combined averages correlated. Combinations of four and of six-quarter marks were made and correlations found.

The prophecy formula was applied to the correlation coefficient of these series stepping it up $1\frac{1}{2}$, 2, and 3 times as the case might be. The predicted r's were compared with the actual r's found for such amalgamations.

The difference and probable error of the difference between the actual and predicted r's was determined in order to interpret the data. The probable error of the difference was computed by the short formula, data for the long formula not being available.

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15 Garrett, H. E. Statistics in Psychology and Education, Chapter IV, Longmans, Green and Company, New York, 1931.

CHAPTER III

STATISTICAL RESULTS

Of the class of June 1932, graduating from Colorado State Teachers College, there were 115 who had complete records for four years' work at that institution. Their grades for each of the twelve quarters of undergraduate work were obtained and the numerical average determined in each case. The average college marks and number of hours carried are listed in Appendix II.

1. Zero-order correlations

In order to apply the Spearman-Brown Prophecy Formula it was necessary to calculate the correlation between the average grade of the first quarter and the average grade of the second quarter. This coefficient of correlation is .59. It is called the "initial r" throughout the study and is the value substituted in the equation:

$$r_x = \frac{Nr}{1+(N-1)r} .$$

The zero-order coefficients were calculated for successive pairs of quarter-averages, for successive odd quarter averages, and for successive even quarter averages. In this way the averages of each and every quarter were used at least twice as one of the variables on a correlation chart. The zero-order coefficients are shown in Table I. The prob-

TABLE I

INTERCORRELATIONS AMONG QUARTER AVERAGES OF 115 GRADUATES OF COLORADO STATE TEACHERS COLLEGE TOGETHER WITH THE ARITHMETIC MEAN SND SIGMA OF EACH QUARTER

Quarters	2	3	6	7	10	11	Mean	Sigma
1	2	3	4	5	6	7	8	9
1	.59±04	.59±04					3.33	.6300
2							3.33	.6665
3							3.31	.6165
4	.51±05	.52±05	.63±04				3.30	.6128
5		.59±04	.70±03	.51±05			3.35	.6263
6							3.34	.5808
7							3.51	.5443
8				.52±04	.41±05		3.39	.5583
9				.46±05	.50±05	.50±05	3.52	.5443
10							3.69	.5862
11							3.57	.5923
12					.52±04	.44±05	3.49	.5860

able error of the several coefficients was computed. They are shown in the columns with the several r's. The mean for each quarter is shown in column 8 of Table I. The sigma is given in column 9 of this table. It may be seen that the coefficients range from .41 with a probable error of .05, in column 10, to .70 with a probable error of .03, in column 6. The smallest of these coefficients is between the eighth and tenth quarters as shown in column 10. It will be noted that this occurs near the end of the third or junior year. The highest coefficient is found between the fifth and sixth quarters, column 6, thatiis at the end of the second or sophomore year. It will be seen that the value of the initial r occurs three times. This frequency is equalled by only one coefficient, that having the value .52. This value comes nearest being the average r (were it permissible to average the r's)but .59 is the value which best fits the situation for prediction and has the smaller probable error as well. Moreover, it is representative of the lower years where the work is much more comparable than that of the advanced years in which specialization occurs to a degree.

If we average the r's covering the first six quarters or two years, and this is permissible since the means and sigmas are approximately equal,as shown in columns 8 and 9 of Table I, we obtain this same value, .59. The coeffi -

cients are .59, .51, .52, .63, .59, and .70. Adding we get 3.54. Dividing this sum by six we obtain .59. It would seem that this value is the fairest one to be used as the basis of prediction.

2. Amalgamation of two-quarter marks.

For the purpose of obtaining actual r's comparable with the predicted r's the numerical values of the marks of each individual for two quarters were combined. The average mark for this period of time was determined. Correlations were then found among these amalgamated sets of averages. These are shown in Table II. It will be seen that these variables show a higher relationship than is between single quarters, as is to be expected, and that the r's are practically equal, two of them being .76 and the other .74, each having a probable error of .03. In column 5 is the predicted r for this number of quarters. Applying the formula using two for N and substituting .59 for r, we get

$$r_x = \frac{2 \times .59}{1 + .59} = \frac{1.18}{1.59} = .742,$$

for the predicted r. This compares very favorably with the actual r's obtained for an amalgamation of two quarters.

3. Under to over prediction at three-quarters

The second series of combined averages represents the marks obtained during a period of three quarters. Here successive sets of three and alternating sets of three-quarter

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TABLE II

ACTUAL CORRELATIONS AMONG AMALGAMATED QUARTER AVERAGES TOGETHER WITH THE PREDICTED DEGREE OF RELATIONSHIP

Variables	Actual r's Obtained			Predicted r
	Third and Fourth Quarters	Second and Fourth Quarters	Sixth and Eighth Quarters	
1	2	3	4	5
First and Second Quarters	.74 ± .03			.742
First and Third Quarters		.76 ± .03		.742
Fifth and Seventh Quarters			.76 ± .03	.742

TABLE III

CORRELATIONS BETWEEN AMALGAMATED SETS OF THREE QUARTER MARKS TOGETHER WITH THE CORRESPONDING PREDICTED COEFFICIENTS; ALSO THE DIFFERENCE AND THE PROBABLE ERROR OF THE DIFFERENCE BETWEEN THE ACTUAL AND PREDICTED r's

Variables	Fourth Fifth and Sixth Quarters	Second Fourth and Sixth Quarters	Predicted r	Difference	PE (dif.)
1	2	3	4	5	6
First Second and Third Quarters	.70 ± .03		.81 ±.01	.11	.0316
First Third and Fifth Quarters		.79 ± .02	.81 ±.01	.02	.0224

averages, covering the first two years, were obtained and the correlations computed. These are given in Table III. The first, second and third quarter averages combined are correlated with the fourth, fifth and sixth quarter averages combined. The first, third and fifth quarter averages combined are correlated with the second, fourth, and sixth quarter averages combined. The result shows an agreement of .70 with a probable error of .03 in the first case, and of .79 with a probable error of .02 in the second case. Predicting the coefficient likely to occur for an amalgamation of three quarters, by means of the Spearman-Brown formula, we substitute .59 for r and use three for N obtaining:

$$r_x = \frac{3 \times .59}{1 + 2(.59)} = \frac{1.77}{2.18} = .81 .$$

Or, using .74, the coefficient found for amalgamations of two quarters, (See Table II, column 2), and multiplying by one and one-half since three quarters are one and one-half times as long as two quarters, we get:

$$r_x = \frac{1\frac{1}{2} \times .74}{1 + \frac{1}{2}(.74)} = \frac{1.11}{1.37} = .81 .$$

In either case the predicted r for amalgamations of three quarters is .81. Referring to column 2 and to column 3 on Table III we see that the actual r's obtained are .70, P.E. .03 and .79, P.E. .02. At this point the formula tends to over-predict, though but slightly if the higher co-

efficient,.79, is used for comparison. In column 5 of this table the differences between the actual and predicted r's are seen to be .11 and .02. This first difference,if reliable, would seem to be significant. Dividing .11 by .0316, that is the difference by the reliability of the difference, shown in column 6, we get 3.48. This means that there are 99 chances out of 100 that there is a true difference greater than zero. If we take the smaller difference,.02, and divide by the probable error of the difference, .0224, as shown in column 6,TableIII, we get .90 which means that there are 73 chances out of 100 that there is a true difference. This indicates that there is a true difference between marks obtained for three quarters and marks predicted for three quarters. Further,if injustice has occured due to inaccuracy of marks for one quarter, this injustice is not rectified by the cumulation of grades at the end of the year.

4. Erratic behavior at the four-quarter level

The amalgamation of marks for four quarters was the next step in our investigation. The first, second, third, and fourth quarter grades were combined for new averages to be used as the y-variable, while the grades for the fifth, sixth, seventh, and eighth quarters were combined to form the x-variable in the new correlation. The coefficient

TABLE IV

CORRELATIONS BETWEEN AMALGAMATED SERIES OF FOUR QUARTER MARKS TOGETHER WITH THE CORRESPONDING PREDICTED COEFFICIENTS; ALSO THE DIFFERENCES AND THE PROBABLE ERROR OF THE DIFFERENCES BETWEEN THE ACTUAL AND PREDICTED r's

Variables	Fifth Sixth Seventh and Eighth Quarters	Second Fourth Sixth and Eighth Quarters	Predicted r	Difference	PE (dif.)
1	2	3	4	5	6
First Second Third and Fourth Quartrs.	.72 ± .03		.85±005	.13	.0304
First Third Fifth and Seventh Quarters		.80 ± .02	.85±005	.05	.0206

found is .72 with a probable error of .03. Another pair of variables of similar length of time or number of quarters was used. These consisted of the combined averages of first, third, fifth, and seventh quarter marks and of the combined averages of second, fourth, sixth, and eighth quarter marks. The result was a coefficient of .80 with a probable error of .02. This is shown in Table IV.

This first coefficient, .72, appears to be much lower than would be expected if cumulated marks really increase in reliability. Applying the prophecy formula we find the predicted r for four quarters to be .85. This gives a difference of .13 as shown in column 5 of Table IV. The probable error of the difference is .0304, given in column 6. Dividing the difference by the probable error of the difference we obtain 4.27. Since a $\frac{D}{PE_{diff.}}$ of 4 indicates complete reliability, it follows that our obtained difference is not only completely reliable but is larger than necessary to show that there is a true difference greater than zero. In the case of the coefficient given in column 3, which is .80, the obtained difference is .05. This is much lower but there is still more than a fifty-fifty chance that we have a true difference. In fact our quotient 2.42 means that there are 95 chances out of a hundred that there is a true difference between predicted marks and actual

marks for four quarters. It should be noted that the actual correlations found for four quarters are not significantly higher than those found for three quarters; and that in using quarters as equivalent to test forms, when the number of judgments has been increased 25 percent, the reliability remains practically the same. Obviously, this piece of data runs contrary to the contention offered by some investigators that by increasing the number of judgments reliabilities as near 1.00 as we please can be secured.

5. Amalgamations of two years

There remains the amalgamation of six quarters, or of the first two years and the second two years. Determining the average marks for this period and making the necessary correlation we get a coefficient of .74 with a probable error of .03. See Table V. This coefficient is about equal to that found for combinations of two quarters, and is also equal to the midpoint of the range between correlations found for combinations of three quarters. Applying the prediction formula, using first the initial r,(the average r for six quarters), we have:

$$r_x = \frac{6 \times .59}{1+5(.59)} = \frac{3.54}{3.95} = .896 .$$

Or, using the r found for the first amalgamation of two quarters, we have:

$$r_x = \frac{3 \times .74}{1+2(.74)} = \frac{2.22}{2.48} = .895 .$$

TABLE V

THE CORRELATIONS BETWEEN THE FIRST TWO YEARS AND THE SECOND TWO YEARS TOGETHER WITH THE PREDICTED COEFFICIENT; ALSO THE DIFFERENCE AND THE PROBABLE ARROR OF THE DIFFERENCE BETWEEN THE ACTUAL AND PREDICTED COEFFICIENT FOR TWO YEARS

Quarters	Seventh Eighth Ninth Tenth Eleventh and Twelfth	Predicted r	Difference	PE (dif.)	D / PE (dif.)
1	2	3	4	5	6
First Second Third Fourth Fifth and Sixth	.74±.03	.895±.0025	.155	.0316	5.13

Again an over-prediction, this time of .155 as shown in column 4, Table V. The $\frac{D}{PE_{diff.}}$ is 5.13, which means that the obtained difference is not only completely reliable but is 1.13 or about 28 per cent larger than is necessary in order to insure a true difference. Evidently a further increase in the number of quarters has not brought us nearer the predicted reliability coefficient. In fact, .74 is as near 1.00 as we can consistently come. Repeated computations have shown this in so far as the college marks of this particular group of subjects is concerned.

6. Summary

Summarizing our findings we see that the cumulated marks up to the end of the sophomore year show an increase in reliability consistent with that predicted by the Spearman-Brown formula applied either to the reliability coefficient of the first and second quarters, or to the average coefficient of the first six quarters. After the second year the agreement is erratic, it being no greater for the lengthened time of twelve quarters than for four quarters. Not only is a true difference shown between actual and predicted marks but the difference divided by the probable error in the final computation gives a quotient that exceeds the necessary reliability by 28 per cent.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

1. Conclusion

The purpose of this investigation has been to determine the applicability of the Spearman-Brown formula to college marks. If the actual self-correlation found for specific and increasing periods of time agree closely with those predicted by the formula for corresponding specific and increasing periods we may conclude that the increase in reliability follows the law of the prophecy formula and that therefore the formula is applicable to college marks.

The self-correlation of the first and second quarter marks is .59. Doubling the time, that is using four quarters should increase the coefficient to .742 . Referring to Table VI, in which our findings are summarized, we see that this point is reached, the formula giving a slight underprediction in two out of three cases, item 2,column 2.

When the length is increased three times, as in amalgamations of three quarter marks, we should expect a coefficient of .81. However the coefficients actually obtained are .70 and .79. Here we have an over-prediction of .11 in the one case and of .02 in the other. See item 3, column 2. This over-prediction is perhaps too slight to be significant but it should be noted that this is the point at which the prediction changes from under to over, near

TABLE VI

COMPARISON OF OBTAINED AND PREDICTED CORRELATIONS OF ALL AMALGAMATIONS OF QUARTER MARKS MADE TOGETHER WITH DATA FOR THEIR INTERPRETATION AND EVALUATION

Variables	Actual r's	Predicted r's	Difference	PE (dif.)	$\frac{D}{PE}$ (dif.)
1	2	3	4	5	6
1. Initial	.59±04				
2. Two Quarters	.74±03				
	.76±03	.742±0430	-.02	.05	
	.76±03				
3. Three Quarters	.70±03	.81 ±.0100	.11	.0316	3.48
	.79±02	.81 ±.0100	.02	.0224	.90
4. Four Quarters	.72±03	.85±.0050	.13	.0304	4.27
	.80±02	.85±.0050	.05	.0206	2.42
5. Six Quarters	.74±03	.895±.0025	.155	.0316	5.13

the beginning of the junior year.

When we quadrupled the number of grades, (item 4 column 2, Table VI), we got .72 and .80 as against the predicted .85, shown in column 3. This is an over-prediction of from .05 to .13, as seen in column 4. Moreover, this coefficient is substantially the same as that for trebling judgments. This agrees with what Holzinger finds with four or five pooled tests. To suppose, with this evidence in view, that continued applications, lengthening of the time or increasing the number of judgments would make it possible eventually to obtain a correlation approaching 1.00 is untenable.

The final computation of relationship, item 5, that between six quarters or two years, gives .74. The predicted r is .895 as shown in column 3. This time the over-prediction amounts to .155 and the actual self-correlation for two years is no greater than for four quarters. The exact difference is .02 and the probable error is .02. Further, this particular coefficient is only .04 higher than that for amalgamations of two quarters. While there has been an increase as the result of the combination of quarters this increase has taken place more slowly than the prediction formula would lead us to expect.

It appears that cumulated marks are not sufficiently reliable to warrant the application of the Spearman-Brown

formula, nor does merely lengthening the time and thereby increasing the number of average marks affect the intercorrelations according to the law of the formula.

Considering the work of successive quarters as equivalent to duplications of reliable tests is not correct due to the differences in the components of the work itself. The work of the first two years agrees with the expectations from the formula. This work is probably more homogeneous in itself and more comparable in the procedure of arriving at marks than is that of the later two years where the work has become more specialized.

To consider quarter marks as equivalent to judgments expressed as rankings of individuals or as ratings on specific points under standardized directions and techniques seems equally unallowable. Errors other than those directly attributable to observation must enter into the mark. The fact that the same instructor may give judgment several times during the course of four years somewhat invalidates the idea of several separate judgments. After all an instructor being human may judge the individual rather than the piece of work represented by the quarter mark.

The element of time or length would seem to be the sole item fulfilling the conditions of the underlying

theory of the formula. But upon referring to the findings of Holzinger and other investigators, as well as to the results of this study, we have proof that merely lengthening will not attain any desired degree of reliability.

Our conclusion then is (1) that college marks do not answer the conditions of homogeneity and reliability demanded by the formula, (2) that when we assume that they do and proceed to test the application of the formula to college marks the results obtained do not follow the rate of increase predicted by the Spearman - Brown formula after the second year, and (3) that injustices to students due to inaccurate grades are not removed by multiplying the number of grades given.

2. Recommendations

In view of the conclusions reached we should recommend that until college marks are based upon homogeneous procedures and more reliable instruments of measurement the application of the Spearman-Brown formula be made with extreme caution. It may be applied to the self-correlation coefficient of first and second quarter marks but its predictive value above the second year is doubtful.

Futher effort toward increasing the average intercorrelation of college marks to approximately .70 or

more should be made before the prophecy formula is applicable.

We should face the fact that college marks are often inconsistent and inaccurate. A more scientific attitude toward marking in general and further study of the low reliabilities in the upper years is desirable. It is time to stop excusing our inaccuracies and consequent injustices upon the ground that in the long run college marks are fair estimates of the student's achievement in the courses taken.

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APPENDIX I

ANNOTATED BIBLIOGRAPHY

ANNOTATED BIBLIOGRAPHY

1. Brown, Wm., "Some Experimental Results in the Correlation of Mental Abilities." British Journal of Psychology, Vol. III,pp.296-322 (October, 1910).

This is the original article in which Brown developed the prophecy formula.

2. Farnsworth, Paul R., "The Spearman-Brown Prophecy Formula and the Seashore Tests." Journal of Educational Psychology, Vol. 19,pp.586-588 (November, 1928).

This article discusses the application of the formula to Special Ability Tests in the field of music.

3. Garrett, H. E., Statistics in Psychology and Education. Longmans, Green and Company, New York, 1931.

This book contains information on the various statistical methods of Education and Psychology.

4. Holzinger, Karl J., "Note on the Use of the Spearman-Prophecy Formula for Reliability." Journal of Educational Psychology, Vol. 14,pp.302-305 (May, 1923).

The results obtained from applying the prophecy formula to the Terman Group Test of Mental Ability are given.

5. Holzinger, Karl J., and Clayton, Blythe , "Further Experiments in the Application of Spearman's Prophecy Formula." Journal of Educational Psychology, Vol. 16,pp.289-299 (May 1925).

He shows that the formula is applicable to carefully grades homogeneous material but with unhomogeneous material the application of the law is uncertain.

6. Kelley, Truman L., "The Applicability of the Spearman-

Brown Formula for the Measurement of Reliability," Journal of Educational Psychology, Vol. 16,pp.300-303(August, 1925).

Kelley applies the formula to Gordon's data in the field of lifted weights. Judgments are considered as equivalent to test items in the sense required by the formula.

7. Lanier, Lyle H., "Prediction of the Reliability of Mental Tests and Tests of Special Ability." Journal of Experimental Psychology, Vol. 10,pp 69-113(April, 1927).

The article says there is no ground for the assumption of a general increase in reliability proportionate to the increase in the number of subjects.

8. Remmers, H. H., Shock, N.W., and Kelly, E.L., "An Empirical Study of the Validity of the Spearman-Brown Formula As Applied to the Purdue Rating Scale." Journal of Educational Psychology, Vol. 18,pp.187-195(March, 1927).

The formula is applied to judgments supplied by the members of a fraternity concerning personality traits.

9. Remmers, H. H., "The Equivalence of Judgments to Test Items in the Sense of the Spearman-Brown Formula." Journal of Educational Psychology, Vol. 22,pp.66-71(January, 1931).

Remmers concludes that in situations in which subjective judgments are used the Spearman-Brown formula indicates the number of judgments required for a given reliability.

10. Ruch, Giles M., Ackerson, Luton and Jackson, Jessie D.,

"An Empirical Study of the Spearman-Brown Formula as Applied to Educational Test Material." Journal of Educational Psychology, Vol. 17,pp.309-313 (May, 1926).

Contribution indicated in the title.

11. Shen, Eugene "Note on the Standard-Error of the Spearman-Brown Formula." Journal of Educational Psychology, Vol. 15,pp.462-465 (October, 1924).

The formula given for the standard error of an estimated r is $\frac{a(1-r_{1I})^2}{\sqrt{N}(1-(a-1)r_{1I})^2}$

12. Spearman, C., "Correlation Calculated from Faulty Data." British Journal of Psychology, Vol. III,pp.271-295 (October, 1910).

Spearman's original article in which he develops the formula.

13. Spearman, C., "General Intelligence Objectively Determined and Measured." American Journal of Psychology, Vol. 15,pp.252-293 (June, 1904).

Gives background for understanding the development of the formula.

APPENDIX II

LIST OF DATA USED IN APPLYING THE SPEARMAN-BROWN FORMULA

APPENDIX II

DATA OBTAINED FROM 115 GRADUATES OF THE JUNE 1932 CLASS IN COLORADO STATE TEACHERS COLLEGE, GREELEY, COLORADO, SHOWING AVERAGE COLLEGE MARKS AND HOURS CARRIED FOR EACH OF THE TWELVE QUARTERS

Student	First Quarter		Second Quarter		Third Quarter		Fourth Quarter	
	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.
1	2		3		4		5	
1 A.A.	4.22	9	4.31	8	3.47	15	5.00	14
2 A.C.	3.47	15	3.20	15	3.57	14	2.50	16
3 A.S.	4.80	15	4.79	14	4.70	16	4.25	16
4 B.B.	3.20	15	2.19	16	2.80	15	2.87	15
5 B.M.	3.14	14	2.75	16	2.75	16	2.46	13
6 B.J.	3.43	14	3.20	15	3.29	14	3.75	16
7 B.R.	3.00	12	3.69	13	2.43	14	3.00	16
8 B.I.	3.20	15	3.33	15	3.00	14	2.46	13
9 B.C.	2.38	16	3.90	10	4.40	10	4.00	14
10 B.M.	3.53	15	2.87	15	3.27	15	3.13	15
11 B.M.	4.00	12	3.38	16	3.29	14	3.57	14
12 B.D.	3.00	11	3.60	15	2.60	15	3.00	16
13 B.R.	3.00	14	3.20	15	3.00	16	3.47	15
14 B.I.	3.27	11	3.13	16	2.71	14	2.73	15
15 B.E.	3.23	13	4.67	15	3.19	16	4.07	14
16 B.H.	3.33	12	4.00	16	4.19	16	4.25	16
17 C.G.	3.87	15	3.73	15	4.23	17	4.00	12
18 C.M.	3.07	15	2.93	15	2.77	13	2.75	16
19 C.A.	3.00	8	3.56	18	3.22	18	2.56	18
20 D.H.	3.29	14	3.21	14	2.21	14	3.00	15
21 D.N.	3.27	15	2.83	12	3.00	13	2.50	16
22 D.W.	2.77	13	3.36	11	2.77	13	3.71	14
23 D.E.	3.73	15	3.19	16	3.50	14	3.00	16
24 D.N.	4.31	16	4.47	15	4.60	15	3.75	16
25 D.H.	3.13	16	2.00	14	2.00	14	3.00	15
26 D.W.	3.42	12	3.27	15	3.00	12	2.75	16
27 E.G.	4.07	15	3.80	15	3.50	16	3.25	16
28 E.G.	3.47	15	3.80	15	3.60	15	4.00	16
29 E.N.	3.57	14	4.06	16	4.00	15	3.50	14
30 E.M.	3.07	15	3.80	15	3.19	16	2.75	16
31 F.M.	3.80	15	3.56	16	3.50	14	3.00	16
32 G.P.	2.82	17	2.74	15	3.13	15	3.00	15
33 G.E.	3.07	14	2.80	15	3.38	16	2.71	14
34 G.E.	3.00	15	3.50	16	3.40	15	3.50	16
35 G.P.	2.33	15	3.13	16	3.00	14	3.29	14

APPENDIX II (CONTINUED)

Student	First Quarter		Second Quarter		Third Quarter		Fourth Quarter	
	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.
1	2		3		4		5	
36 G.E.	3.30	10	2.71	14	2.75	12	2.47	15
37 G.M.	2.67	15	3.20	15	3.27	15	2.25	16
38 H.E.	3.00	14	2.63	16	2.80	15	2.80	15
39 H.L.	1.33	12	2.36	11	2.69	13	2.00	12
40 H.T.	2.86	14	2.80	15	3.19	16	3.07	15
41 H.M.	2.29	14	2.07	15	2.21	14	2.33	15
42 H.M.	3.29	14	2.20	15	2.87	15	3.75	16
43 H.R.	3.29	14	4.00	14	4.24	17	4.13	16
44 H.F.	3.20	15	3.07	14	3.47	15	3.50	16
45 H.W.	2.73	15	2.73	15	3.00	15	3.25	16
46 H.P.	3.80	15	4.33	15	4.00	15	4.00	16
47 H.K.	3.29	14	2.80	15	2.56	16	3.00	14
48 H.C.	4.27	15	3.23	13	2.31	13	5.00	12
49 J.V.	2.73	15	2.31	16	2.29	14	3.00	16
50 J.O.	2.80	15	3.33	15	2.67	15	2.50	16
51 K.D.	3.81	16	3.06	16	3.94	16	4.47	15
52 K.L.	3.79	14	3.00	16	3.00	15	3.00	16
53 K.A.	3.79	14	4.27	15	3.38	16	3.25	16
54 L.A.	4.00	15	3.46	13	3.35	17	3.47	17
55 L.T.	2.81	16	2.69	16	2.92	13	3.27	15
56 L.C.	4.25	16	4.50	16	4.25	16	3.88	16
57 L.A.	4.73	15	5.00	16	4.73	15	4.53	15
58 L.B.	4.00	15	3.50	16	3.19	16	3.63	16
59 M.F.	3.19	16	2.71	14	3.50	16	3.00	16
60 M.R.	3.58	12	3.20	15	2.73	15	2.25	16
61 M.H.	2.69	16	3.21	14	3.00	16	3.50	16
62 M.I.	3.47	15	3.94	16	3.67	15	4.20	15
63 M.M.	3.43	14	3.21	14	4.00	16	3.25	16
64 M.B.	4.50	14	3.80	10	4.00	8	3.33	12
65 M.M.	4.00	15	4.25	16	3.94	16	3.50	16
66 M.R.	3.50	16	3.38	16	2.79	14	3.50	16
67 M.J.	4.00	15	4.00	12	3.77	13	4.08	13
68 M.D.	3.20	15	2.54	13	3.00	16	3.00	8
69 M.M.	4.00	16	4.29	14	4.13	16	4.00	12
70 M.R.	2.08	13	3.38	16	2.92	13	2.46	13
71 M.G.	2.71	14	2.57	14	2.81	16	3.14	14
72 M.M.	3.60	15	3.47	15	3.10	10	3.53	15
73 N.E.	4.27	15	3.73	15	4.29	14	4.00	14
74 N.H.	2.33	12	2.60	10	1.64	14	2.85	13
75 N.L.	3.20	15	3.33	12	3.25	16	2.88	16

APPENDIX II (CONTINUED)

Student	First Quarter		Second Quarter		Third Quarter		Fourth Quarter	
	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.
1	2		3		4		5	
76 O.M.	3.33	15	2.54	13	2.94	16	3.50	16
77 P.P.	2.53	15	2.88	16	3.00	16	2.38	16
78 P.L.	2.79	14	2.81	16	2.77	13	3.25	16
79 P.N.	3.36	8	3.00	8	3.00	8	3.38	16
80 P.L.	2.67	15	2.93	15	2.60	15	2.67	15
81 P.B.	4.73	15	4.47	15	4.47	15	3.75	16
82 P.M.	3.07	14	2.64	11	3.47	15	3.00	16
83 P.A.	4.13	15	4.54	13	3.46	13	3.81	16
84 P.J.	3.07	14	2.81	16	3.27	15	3.00	16
85 R.M.	3.00	13	4.00	11	3.85	13	3.21	14
86 R.D.	3.00	14	3.06	16	3.07	15	3.57	14
87 R.E.	2.07	14	2.21	14	2.27	15	3.60	15
88 R.L.	3.38	13	3.27	15	2.87	15	2.75	16
89 R.B.	3.56	16	3.67	15	2.94	16	2.64	14
90 S.F.	4.00	14	4.00	15	4.07	15	4.00	13
91 S.E.	3.00	15	3.00	14	3.14	14	2.71	14
92 S.E.	3.93	15	2.93	14	3.84	19	3.79	14
93 S.C.	4.00	8	2.50	16	4.00	16	4.00	16
94 S.M.	3.82	17	5.00	17	4.11	18	4.57	17.5
95 S.F.	2.87	15	2.75	16	3.33	15	2.60	15
96 S.I.	3.38	16	3.21	14	3.47	15	3.21	14
97 S.G.	4.21	14	3.69	16	3.36	14	4.15	13
98 S.C.	2.93	15	3.50	16	3.47	15	2.75	16
99 S.M.	2.73	11	3.25	12	3.00	16	3.23	13
100 S.E.	3.31	13	3.00	12	3.20	15	3.00	14
101 S.R.	2.18	11	3.53	15	3.41	17	2.75	16
102 T.H.	3.73	15	3.47	17	3.27	15	3.47	15
103 T.L.	2.50	16	2.31	16	2.64	14	3.00	14
104 T.A.	2.80	15	2.88	16	3.57	14	2.86	14
105 T.M.	4.13	15	3.87	15	4.38	15	3.79	14
106 T.P.	2.67	12	3.00	15	3.07	15	3.00	15
107 T.G.	3.00	14	3.53	15	2.93	15	3.38	16
108 T.M.	4.73	15	4.53	15	4.81	16	4.25	16
109 U.O.	3.71	14	3.33	15	4.25	16	3.38	16
110 W.H.	2.53	17	3.38	14	3.56	9	3.44	16
111 W.B.	4.00	16	3.88	16	4.19	16	3.25	16
112 W.D.	3.29	14	3.00	16	3.00	13	3.62	13
113 W.H.	3.20	15	3.75	12	4.07	14	3.00	17
114 W.R.	3.07	15	3.71	14	3.00	16	3.50	16
115 Y.F.	3.27	15	2.64	11	3.29	14	2.75	16

APPENDIX II (CONTINUED)

Student	Fifth Quarter		Sixth Quarter		Seventh Quarter		Eighth Quarter	
	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.
1	6		7		8		9	
1	4.19	16	4.06	16	4.00	15	4.00	16
2	3.57	14	3.00	16	3.67	12	3.75	16
3	4.75	16	4.75	16	4.25	16	4.50	16
4	2.44	16	3.14	14	3.50	16	3.67	18
5	2.93	15	2.81	16	3.00	14	2.75	16
6	2.57	14	3.50	16	3.75	16	3.75	16
7	2.71	14	2.57	14	2.88	16	2.75	16
8	3.50	16	3.64	14	3.67	12	3.00	7
9	4.00	14	3.83	12	4.29	14	3.25	16
10	2.60	15	3.00	15	3.00	16	3.00	16
11	3.23	13	3.35	14	3.25	14	3.75	16
12	3.63	16	3.25	16	3.38	16	3.13	16
13	3.29	14	2.75	16	3.25	16	3.00	16
14	2.75	16	3.00	15	3.07	15	3.00	16
15	3.81	16	3.75	16	3.50	16	3.50	16
16	4.25	16	4.13	16	4.43	14	4.29	14
17	3.75	16	3.50	16	3.50	16	4.25	16
18	2.43	14	3.00	16	3.00	12	2.71	14
19	4.00	16	3.25	16	2.75	16	2.75	16
20	2.60	15	3.33	15	3.00	16	3.60	15
21	3.50	16	2.71	14	3.80	20	4.50	16
22	3.29	14	3.00	15	3.80	15	3.25	16
23	3.40	15	3.00	16	4.00	16	3.25	16
24	4.75	16	4.44	18	4.00	9	4.67	12
25	3.44	16	3.57	14	3.75	16	3.00	16
26	3.29	14	3.75	16	4.00	16	3.38	16
27	3.63	16	3.25	16	3.13	16	3.00	18
28	4.29	14	3.75	16	3.50	16	3.75	16
29	3.75	16	3.75	16	3.50	16	3.75	16
30	2.63	16	3.25	16	3.50	16	3.25	16
31	4.50	16	3.75	16	4.25	16	4.25	16
32	3.15	13	2.42	12	2.06	16	3.50	16
33	3.00	16	3.25	16	3.25	16	2.13	16
34	3.71	14	3.50	16	3.50	16	4.00	16
35	2.75	16	3.43	14	2.31	13	3.67	12

THE LIBRARY
COLORADO STATE TEACHERS COLLEGE

APPENDIX II (CONTINUED)

Student	Fifth Quarter		Sixth Quarter		Seventh Quarter		Eighth Quarter	
	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.
1	6		7		8		9	
36	2.79	14	2.36	14	2.92	13	2.54	13
37	3.13	16	3.63	16	3.13	16	3.38	16
38	3.00	16	2.75	16	3.00	16	2.75	16
39	2.00	14	2.50	16	3.29	14	3.29	14
40	3.71	14	3.50	16	3.75	16	2.88	16
41	2.36	14	2.50	16	2.88	16	2.75	16
42	3.00	14	3.25	16	3.25	16	2.50	16
43	4.00	14	4.25	16	4.25	16	3.75	16
44	3.25	16	3.25	16	3.88	16	3.75	16
45	3.80	15	3.82	17	3.67	18	3.17	18
46	4.00	16	4.57	12	4.00	16	3.67	18
47	3.25	16	1.75	16	2.57	15	2.86	14
48	2.67	12	3.25	8	2.38	16	3.38	16
49	3.56	16	3.53	15	2.50	16	2.88	16
50	2.50	16	2.75	16	3.13	16	3.00	16
51	4.73	15	4.00	15	4.25	16	4.50	16
52	3.50	16	3.57	14	3.50	16	3.25	16
53	3.75	16	4.00	14	3.50	16	3.50	16
54	3.79	15	3.06	16	3.00	14	3.38	16
55	3.60	15	3.33	18	2.80	20	2.50	16
56	4.00	16	4.22	18	4.63	16	3.75	16
57	4.80	15	4.14	14	4.33	18	4.00	16
58	2.88	16	2.75	16	3.00	14	3.25	16
59	2.88	16	2.88	16	3.50	16	2.75	16
60	3.00	14	2.75	16	3.25	16	3.25	16
61	4.25	16	3.67	12	3.00	16	3.00	16
62	3.53	15	3.93	15	4.00	16	3.25	16
63	3.46	13	3.92	13	4.28	14	3.67	12
64	3.27	15	3.00	12	4.00	16	3.13	16
65	3.94	16	3.56	16	4.08	13	2.50	16
66	3.21	14	3.07	15	3.13	8	3.25	16
67	4.00	12	4.25	16	4.25	16	4.75	16
68	2.87	15	3.00	13	2.92	12	3.00	13
69	4.00	16	2.81	16	3.78	9	2.75	16
70	3.07	15	2.87	15	3.23	13	3.38	13
71	3.00	16	2.20	15	2.75	16	2.50	16
72	2.57	14	3.36	14	3.50	16	2.73	15
73	4.00	14	3.86	14	3.43	14	4.00	14
74	3.50	14	3.08	13	3.08	13	3.50	12
75	3.18	17	3.00	16	3.00	16	3.50	16

APPENDIX II (CONTINUED)

Student	Fifth Quarter		Sixth Quarter		Seventh Quarter		Eighth Quarter	
	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.
1	6		7		8		9	
76	3.00	11	2.71	14	3.75	16	3.44	9
77	2.75	16	2.25	16	3.13	16	2.75	16
78	3.50	16	3.00	14	3.50	16	3.25	16
79	3.00	12	2.86	14	3.50	16	4.00	16
80	3.13	16	2.81	16	3.13	16	2.00	8
81	4.71	14	4.57	14	4.00	12	4.43	14
82	3.00	16	3.00	14	3.50	16	3.50	16
83	3.63	16	3.75	16	4.25	16	3.75	16
84	3.36	14	2.88	16	2.93	15	3.00	16
85	3.50	14	3.38	13	3.25	12	3.63	8
86	2.50	16	3.75	16	4.00	16	2.88	16
87	2.53	15	2.50	16	3.00	16	2.71	14
88	3.13	16	3.13	16	3.57	14	3.50	16
89	3.31	13	2.86	14	3.40	10	4.00	15
90	3.87	15	3.60	15	4.25	16	3.57	14
91	2.86	14	3.40	15	3.29	14	3.07	15
92	3.47	17	3.33	18	4.00	10	3.80	15
93	3.75	16	4.67	18	4.22	18	4.11	18
94	3.33	9	3.89	9	4.89	18	4.33	18
95	1.50	14	2.47	15	2.63	16	2.00	16
96	3.50	12	3.42	13	3.18	11	3.43	14
97	3.15	13	3.38	13	3.43	14	4.25	16
98	3.00	15	3.53	15	4.38	16	3.69	16
99	3.27	15	3.67	15	3.75	16	2.85	13
100	3.25	16	3.08	13	4.00	13	3.31	13
101	2.00	16	2.29	14	3.25	16	3.25	16
102	4.00	16	3.56	16	3.43	14	3.00	16
103	3.00	14	3.20	15	3.50	16	2.75	16
104	2.40	15	2.71	14	3.86	14	3.75	16
105	4.33	15	4.20	15	3.88	16	4.00	16
106	2.86	14	2.80	15	3.63	16	2.75	16
107	3.47	15	3.50	16	3.14	14	3.47	17
108	4.25	16	4.00	15	4.63	16	4.25	16
109	3.75	16	4.25	16	4.00	16	4.00	16
110	3.57	14	4.00	16	3.50	16	3.73	15
111	3.06	16	3.13	16	2.79	14	3.75	16
112	3.56	16	4.00	14	3.53	15	2.93	15
113	3.33	12	3.33	12	3.71	14	2.57	14
114	3.50	16	4.00	16	4.00	16	4.29	14
115	3.25	16	3.00	16	3.50	16	3.50	16

APPENDIX II (CONTINUED)

Student	Ninth Quarter		Tenth Quarter		Eleventh Quarter		Twelfth Quarter	
	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.
1	10		11		12		13	
1	4.38	13	4.33	15	4.50	14	4.25	16
2	2.75	16	3.75	16	4.75	16	3.25	16
3	4.75	16	4.22	18	5.00	16	4.25	16
4	3.40	22	3.50	16	2.80	10	2.67	18
5	2.75	16	3.50	16	3.11	18	3.75	16
6	3.00	16	3.25	16	4.17	16	4.00	16
7	2.75	16	2.75	16	2.25	16	3.00	16
8	3.00	16	4.00	16	3.63	16	4.50	16
9	3.50	16	4.25	16	3.20	20	3.50	16
10	4.25	16	3.75	16	4.25	16	2.88	16
11	4.25	16	3.25	16	3.00	16	3.00	16
12	3.63	16	3.86	14	2.50	16	3.93	15
13	2.88	16	3.50	16	3.00	16	3.25	16
14	2.75	16	3.50	16	3.00	16	3.25	16
15	3.50	12	4.00	16	3.50	16	3.29	14
16	4.67	16	4.00	14	4.43	14	3.89	18
17	3.25	16	4.00	16	4.14	14	4.00	20
18	3.00	16	2.75	16	2.63	16	2.47	15
19	3.00	16	2.88	16	3.00	14	3.40	15
20	3.75	16	4.50	16	3.00	16	3.00	16
21	3.38	16	3.25	16	3.00	16	3.00	16
22	3.43	14	2.73	11	3.00	16	3.00	16
23	4.00	16	3.00	16	3.63	16	3.50	16
24	4.67	6	4.33	12	4.78	18	3.89	9
25	3.71	14	4.00	16	3.00	16	3.17	12
26	3.00	16	3.75	16	3.00	16	3.50	16
27	3.50	16	3.00	16	3.75	16	3.00	16
28	4.00	16	4.25	16	4.25	16	3.25	16
29	4.00	16	3.50	16	4.25	16	3.25	16
30	3.25	16	3.00	16	3.63	16	3.75	16
31	4.25	16	4.63	16	3.75	16	4.50	16
32	3.06	17	2.85	13	3.38	13	3.57	14
33	2.50	16	3.25	16	2.25	16	3.25	16
34	3.25	16	4.25	16	3.75	16	3.25	16
35	3.71	14	3.20	15	3.73	15	3.33	12

APPENDIX II (CONTINUED)

Student	Ninth Quarter		Tenth Quarter		Eleventh Quarter		Twelfth Quarter	
	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.
1	10		11		12		13	
36	3.00	16	3.18	11	3.29	14	3.75	16
37	3.25	16	3.38	16	3.25	16	3.00	16
38	2.75	16	3.00	16	2.75	16	2.50	16
39	3.67	12	2.50	16	3.75	16	2.50	16
40	3.00	16	2.75	16	3.75	16	3.40	15
41	3.00	16	4.25	16	3.50	16	2.88	16
42	3.25	16	3.50	16	4.25	16	3.00	16
43	4.00	12	4.33	18	4.33	18	3.75	16
44	3.00	16	3.75	16	3.75	16	3.25	16
45	3.76	17	4.44	18	4.22	18	4.50	16
46	3.75	16	4.25	16	3.89	18	4.14	14
47	3.25	16	3.00	15	3.38	16	4.00	16
48	3.50	16	3.50	16	3.00	16	2.50	8
49	3.00	16	3.25	16	2.75	16	3.83	14
50	3.25	16	2.50	16	3.00	16	2.50	16
51	4.11	18	3.89	18	3.11	18	4.00	8
52	3.50	16	4.25	16	4.25	16	4.00	16
53	4.00	16	3.88	16	3.50	16	3.56	16
54	4.50	16	4.75	16	4.00	17	4.00	8
55	3.83	12	3.00	16	3.14	14	3.50	8
56	4.25	16	4.50	16	4.00	16	4.40	20
57	4.38	16	4.25	16	4.50	16	4.25	16
58	2.75	16	2.88	16	3.63	16	3.38	16
59	3.75	16	3.25	16	3.00	16	2.50	12
60	3.50	16	2.75	16	3.00	16	3.25	16
61	3.25	16	3.67	12	3.67	12	3.00	16
62	3.25	16	4.25	16	4.00	18	3.33	18
63	4.88	16	3.25	16	3.60	20	3.50	16
64	3.00	8	3.50	8	4.00	18	4.00	16
65	3.57	14	3.25	16	3.75	16	3.75	16
66	3.25	16	4.75	16	3.00	18	3.00	16
67	4.00	22	4.00	14	4.71	14	4.43	14
68	3.00	9	3.25	16	3.50	16	3.75	16
69	4.00	16	4.00	16	4.00	16	4.25	16
70	3.33	19	3.94	17	4.50	16	3.38	14
71	3.00	16	2.75	16	3.00	16	2.75	24
72	3.14	14	3.94	17	3.25	16	3.88	16
73	4.00	16	3.75	16	3.50	16	3.86	14
74	3.25	16	3.25	16	3.43	14	3.67	18
75	3.63	16	3.75	16	3.50	16	4.25	16

APPENDIX II (CONTINUED)

Student	Ninth Quarter		Tenth Quarter		Eleventh Quarter		Twelfth Quarter	
	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.	Av.	Hrs.
1	10		11		12		13	
76	4.07	15	3.53	15	3.94	18	3.44	18
77	2.50	16	3.25	16	2.63	16	3.46	13
78	4.00	16	4.00	16	3.63	16	3.90	18
79	3.00	16	3.50	16	3.50	16	3.13	16
80	3.00	14	4.40	15	2.75	16	2.50	16
81	4.67	12	4.75	16	4.13	16	4.50	16
82	3.50	16	4.00	16	4.00	16	2.75	16
83	4.00	12	3.50	16	4.50	16	2.88	16
84	3.25	16	4.00	16	3.50	16	3.75	16
85	4.15	13	3.63	16	3.29	14	3.29	14
86	2.86	14	2.75	16	2.75	16	2.50	16
87	2.83	12	3.33	12	2.50	16	2.67	12
88	3.00	16	4.14	14	3.50	12	3.27	15
89	3.75	16	4.00	16	3.50	16	4.25	16
90	3.14	14	4.29	14	3.63	16	3.00	12
91	3.71	14	2.63	16	3.29	14	3.00	16
92	3.93	15	4.79	15	3.00	16	2.75	16
93	4.33	18	3.90	20	4.00	13	4.75	16
94	4.40	10	4.00	12	5.00	18	5.00	18
95	2.75	16	2.75	16	3.00	16	3.33	15
96	3.50	8	3.13	15	3.18	11	3.43	14
97	3.25	16	3.75	16	4.00	16	4.25	16
98	4.43	16	3.71	14	3.33	12	3.25	16
99	2.75	16	3.00	16	3.60	10	3.00	16
100	2.71	14	2.83	12	3.25	16	3.00	14
101	3.25	16	2.75	20	3.25	16	2.50	16
102	3.88	16	4.25	16	3.65	17	3.25	16
103	3.44	16	3.00	16	2.57	14	3.63	16
104	2.50	16	3.75	16	3.75	16	3.25	16
105	4.00	16	4.00	18	4.00	18	3.75	16
106	3.13	16	2.75	16	3.56	18	3.67	18
107	4.00	16	3.25	16	3.27	15	3.50	16
108	4.00	16	4.63	16	4.75	16	3.86	16
109	3.25	16	3.50	16	4.00	16	4.00	16
110	3.06	17	2.50	16	4.00	16	3.25	8
111	4.00	16	3.78	18	3.56	18	4.06	16
112	3.43	14	4.29	14	3.75	16	3.30	20
113	3.14	14	3.57	14	4.00	14	3.71	14
114	4.13	16	3.50	16	4.25	16	4.10	20
115	3.50	16	3.00	16	3.50	16	3.25	16