Proceedings of the Iowa Academy of Science

Volume 49 | Annual Issue Article 93

1942

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THE USE OF THE STANDARD PARTIAL REGRESSION COEFFICIENT IN CONSTRUCTING GENERAL BOTANY ACHIEVEMENT TESTS

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Since 1926, various aspects of the general botany teaching program at Iowa State College have been studied. Victor (1933) and Dietz (1935) described studies dealing with teaching procedures and techniques and evaluation practices. Kreutzer (1935) and Dietz and Gould (1939) reported on certain phases of the testing program, particularly the practice of grouping students enrolled in Botany 101 according to scores made on pretests. Bragonier (1941) described the methods used in constructing and evaluating the pretests. The value of grouping the students for instructional purposes is generally acknowledged within the botany department, however, the means by which the students are grouped is not as well accepted and, consequently, was chosen as the subject for this study.

A pretest consisting of fourteen problems was constructed for use in grouping the students enrolled for the fall quarter, 1939, in Botany 101. After the test had been administered, the responses to the fourteen problems were studied for purposes of improving the pretest. At the beginning of the winter quarter, 1941, a test of twelve revised problems was used to group the Botany 101 students. The responses of 94 students were used in studying the various problems in the test, and the data which follow are based on those responses.

The pretest is evaluated on the basis of its validity and reliability. Wert (1938) described validity as the extent to which a test measures that which it is supposed to measure, and reliability as the degree to which the test is accurate in measuring whatever it happens to measure. Accordingly, the pretest to be valid and reliable should provide an accurate estimate of probable achievement in botany.

The use of the coefficient of validity makes it necessary to have some criterion with which the pretest may be statistically compared. The criterion used as a measure of achievement in botany is the botany grade given to each student in the winter quarter, 1940. Two additional criteria used as measures of general achievement are the grade-point average of each student in the winter

quarter and the score of each on the American Council on Education Psychological Examination, Form 1938, (hereafter referred to as the aptitude test). Each student's score on the aptitude test is available shortly after his registration in Iowa State College.

The coefficients of validity for the pretest are the correlation coefficients between the pretest and the criteria. These coefficients are presented in Table 1.

Table 1. Coefficients of validity for the pretest used to group the students enrolled in Botany 101, winter quarter, 1940.

Criteria used as measures of achievement	Coefficients of validity for the pretest. winter quarter, 1940
Botany grades for the winter quarter, 1940	.60
Grade-point averages in all subjects for the winter quarter, 1940	.66
Aptitude test scores	.60
(1% level of significance = .267)	(Fisher, 1937)

The data in Table 1 show that the coefficients of validity are highly significant values. Since these coefficients fall within the limits suggested by Dunlap (1939), it may be concluded that the pretest is probably a valid estimate of achievement as measured by the botany grades, the grade-point averages, and the aptitude test scores.

Wert (1938) and Dunlap (1939) suggested the split-half reliability coefficient and the index of reliability as measures for estimating the reliability of a test, and they described the methods for computing these values. The coefficient of correlation between the two halves of the pretest, .66, is substituted in the Spearman-Brown formula to obtain a split-half reliability coefficient of .80. The split-half reliability coefficient furnishes an estimate of the reliability of the whole test from the reliability of each half.

The index of reliability is obtained by extracting the square root of the reliability coefficient, .80, and is equal to .89. It furnishes an estimate of the correlation expected between scores on the pretest and true achievement scores.

The values of these estimates of reliability fall within the limits suggested by Dunlap (1939). It may be concluded, therefore, that the pretest score probably provides a reliable estimate of achievement in botany.

Since the coefficients of validity, reliability, and the index of reliability are all values that are highly significant according to Fisher (1937) (1% level of significance = .267), and since they fall within the limits set by Dunlap (1939), it may be concluded that the pretest is probably a valid and reliable estimate of achievement in botany.

Considerable time was involved in administering and scoring twelve pretest problems, and a method involving less time and less expense was desirable. Cox (1940) suggested using scores from a shortened pretest in conjunction with the scores on the aptitude test since such scores were readily available at no additional expense from the office of the Dean of the Junior College. In acting upon this suggestion, a method for selecting the more desirable problems from the pretest becomes necessary.

Hawkes, Lindquist and Mann (1936) suggested that the best constructed test, theoretically, is one in which the individual problems correlate highly with the criteria and show low intercorrelations. On this basis, a shortened pretest would be composed of problems that correlate highly with the botany grade, the grade-point average in all subjects, and the aptitude test scores, and which show low intercorrelations.

To rank the pretest problems, a tabulation of the number of intercorrelations and correlations with the criteria was made. These data are presented in Table 2.

Table 2. Rank of each problem of the pretest used for grouping the students enrolled in Botany 101, winter quarter, 1940, according to the number of significant and highly significant intercorrelations and correlations with the criteria.[1]

Problem Number	Number of intercorrelations		Number of correlations with the criteria[1]		
	Highly Significant	Significant	Highly Significant	Significant	Rank
1	6	2	3	0	8
2	3	2	3	0	3
3	3	0	3	0	2
4	4	3	3	0	5
5	7	2	3	0	10
6	4	1	0	1	12
8	0	1	0	1	11
9	1	2	2	1	1
10	4	1	3	0	4
11	8	0	3	0	9
12	7	0	3	0	6
13	7	0	3	0	7

[1]Botany grades, aptitude test scores, and grade-point averages in all subjects for the winter quarter, 1940, are the criteria.

The data in Table 2 show that problem 9 ranks first on the basis of showing three significant intercorrelations and correlating significantly with the criteria. Problem 6 ranks twelfth because it shows only one significant correlation with the criteria and five significant intercorrelations as compared with problem 8 (rank eleven) which shows one intercorrelation and one correlation with the criteria, both of which are significant.

Since only three of the twelve problems do not show highly significant correlations with all three criteria, the other nine problems must be ranked on the basis of the number of intercorrelations. The data show, however, that problems 4, 12, and 13 have the same number of intercorrelations; therefore, these problems have to be ranked on the basis of very small differences between the correlation coefficients.

The difficulties encountered in attempting to select problems on the basis of low intercorrelation and high correlation with the criteria make it necessary to find some other method for selecting the most desirable pretest problems to be used in conjunction with the aptitude test scores for grouping the students enrolled in Botany 101.

Cox (1940) suggested use of the betas (standard partial regression coefficients) for purposes of ranking the problems according to predictive value. The beta of a problem gives an indication of the extent to which that problem contributes to the value of the test as an instrument for predicting achievement.

The betas are independent of the units of measure and are directly comparable values. The beta of each variable is dependent on the contribution of every other variable present in the multiple regression. When a variable with a low beta is removed from the regression, new betas must be computed for all variables. Some of the new betas may be higher or lower than they were before, since part of the influence contributed by the variable that was removed may be added to or subtracted from the betas of other variables.

The method outlined by Wallace and Snedecor (1933) was used for computing the betas presented in Table 3.

Table 3. Rank of each pretest problem, winter quarter, 1940, according to the standard partial regression coefficient (beta),—botany grade dependent variable.

Problem number	Beta	Rank of problem	Problem number	Beta	Rank of problem
1	.1550	7	8	-.0166	12
2	.1357	8	9	.1766	6
3	.2410	2	10	.1929	4
4	.3127	1	11	.2212	3
5	.0516	10	12	.1338	9
6	.0269	11	13	.1811	5
*R (problems 1-6) = .5617			*R (problems 8-13) = .5781		

(Significance levels of R: 5% = .358, 1% = .409) (Fisher, 1937)
*R = the multiple correlation coefficient

The data in Table 3 show the rank of each problem according to the size of the beta, although some error may be involved as the betas were computed for each half of the test in separate regressions. Since the multiple correlation coefficients (R) for each half are nearly the same in value, there is little cause for concern in this regard.

The data in Table 3 indicate that the problems which contribute least toward predicting the botany grades are problems 6 and 8. If these two problems were deleted from the test and new betas were computed, one would expect little change in the predictive value of the test as a whole.

Since the ultimate goal is to obtain a short pretest to use in conjunction with the aptitude test, the computation of betas for the remaining ten problems plus the aptitude test would provide data that might indicate the extent to which there were common elements present in the two tests. The data from such a computation would show which problems were contributing least in the way of elements different from those present in the other problems and the aptitude test.

Table 4. Rank of each of ten pretest problems,** winter quarter, 1940, according to the standard partial regression coefficient (beta) computed in the presence of the aptitude test,—botany grade dependent variable.

Problem number	Beta	Rank of each problem
1	.0489	7
2	.0405	8
3	.1345	2
4	.1692	1
5	-.1261	5
9	.1335	3
10	.1279	4
11	.0305	9
12	.0259	10
13	.0827	6
Aptitude test	.4483	
	*R = .7207	

(Significance levels of R: 5% = .576, 1% = .615) (Fisher, 1937)
*R = the multiple correlation coefficient

Judging from the size of the multiple correlation coefficient (R) shown in Table 4, it may be concluded that the combination of the ten problems and the aptitude test furnishes a better basis for predicting botany grades than does either half of the pretest (Table 3). Furthermore, the betas of problems 1, 2, 11, 12, and 13 as given in Table 4 show there is little in the way of predictive value to be gained by use of these five problems when the aptitude test is being used. Consequenty, elimination of these problems should result in no appreciable change in the predictive value of the combination and would result in a reduction of the time necessary for administration and scoring of the pretest problems.

Table 5. Results of the study of five pretest problems, winter quarter, 1940, showing the coefficients of standard partial regression, and multiple correlation in the presence of the aptitude test scores with the botany grades as the dependent variable.

Problem number	Beta
3	.1397
4	.2055
5	-.0888
9	.1555
10	.1350
Aptitude test	.4838
	*R = .7089

(Significance level of R: 1% = .409) (Fisher, 1937)
*R = multiple correlation coefficient

**Problems 6 and 8 have been eliminated.

In Table 5 are presented the data obtained when problems 3, 4, 5, 9, and 10 and the aptitude test are present in a multiple regression. These data show that the multiple correlation coefficient (.7089) is smaller than that in Table 4 by only .0118. It would seem, then, that elimination of five problems (problems 1, 2, 11, 12, and 13) results in only a slight change in the predictive value of the combination, and the labor involved has been greatly reduced in that the pretest now consists of five problems instead of ten.

The five-problem pretest was administered to each student enrolled in Botany 101, fall quarter, 1941. The score from the pretest was combined with the aptitude test score, and the resulting master score was used in placing the students in high and low groups for purposes of instruction. After the completion of the fall quarter, 1941, the records of eighty-four students were studied to determine the manner in which the scores from the pretest should be combined with those from the aptitude test, and to determine the validity coefficients for the master scores, the aptitude test, and the five-problem pretest.

To determine the method for combining the aptitude test and the pretest scores so that a valid master score would result, a multiple regression equation was computed for predicting botany grade from the two variables. This equation revealed that the aptitude test score should be doubled and added to the pretest score to obtain the master score. New master scores were computed from the records of the fall-quarter students and the coefficient of validity for the new master score was obtained. This coefficient and the coefficients of validity for the aptitude test and five-problem pretest are presented in Table 6.

Table 6. Coefficients of validity for the various estimates of probable achievement in botany. Data based on the records of eighty-four students enrolled in Botany 101, fall quarter, 1940.

Criteria used as measures of achievement	Coefficients of validity for the master score (two times the aptitude test score plus the pretest score)	Coefficients of validity for the aptitude test	Coefficients of validity for the five-problem pretest
Botany grades	.53	.52	.39
Grade-point averages in all subjects	.54	.57	.39
Final test scores	.61	.62	.49

(Significance levels: 5% = .217, 1% = .283) Fisher (1937)

The data in Table 6 show that the practice of doubling the aptitude test score and adding the product to the pretest score will probably result in a valid master score for predicting achievement in Botany 101. The data in Table 6 also show that the coefficients of validity for the aptitude test are for all practical purposes as large as those for the master score. The question immediately arises as to the advisability of giving a pretest when there is little or no additional increase in predictive value over that available from the aptitude test alone.

Beginning with the fall quarter, 1941, the Botany 101 students have been grouped on the basis of the aptitude test scores. As far as can be determined without extended research, this method is satisfactory.

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