THE USE OF PLACEMENT TESTS

IN

FRESHMAN MATHEMATICS

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By

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PREFACE

I greatly appreciate the supervision and guidance given me by Professor Carl E. Marshall and Dr. James H. Zant in making this study and hope it will be helpful in placing future freshmen in the proper mathematics courses.

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INTRODUCTION

The policy of using guidance programs for college students is rapidly being adopted in some form or other throughout the United States. It varies according to the college and its purpose, and even in the various departments of the college.[1]

It is very common to expect the freshmen to go through a series of pre-enrollment examinations in order to assist their advisors in counselling them concerning courses they should take. This is especially true in mathematics as the colleges are receiving students whose ability in this field vary widely. This requires the sectioning of students into two or three groups depending upon their ability in mathematics. O'Quinn[2] reports that twenty-seven state universities, out of forty-three replying to his questionnaire, used some method for grouping students according to mathematical ability or previous training in mathematics. The criteria used for grouping students in mathematics courses, varied widely among the universities. Hence arises the question as to what criteria should be used to best perform this grouping.

The purpose of this paper is to report on the results of an experiment conducted at Oklahoma Agricultural and Mechanical College, in which an attempt was made to determine what kind of tests and at what time they should be given in order to best determine the mathematics course in which beginning students should enroll.

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[1] M. W. Keller and H. F. S. Jonah, "Measure for Predicting Success in a First Course in College Mathematics," The Mathematics Teacher, XLI (December 1948) 350-355.

[2] Ralph O'Quinn, "Status and Trends of Ability Grouping in the State Universities," The Mathematics Teacher, XXXIII (May 1940) 213-215

Several studies have been made to determine the effectiveness of various factors for predicting a student's success in mathematics. In a study at the University of Oregon, C. F. Kossack[3] states that of the different factors he considered for determining a student's probable success in a first course in college mathematics, the two most important ones were the student's grade on a placement or training test and his high school mathematics score. He found that the score on a psychological test, the high school scholastic rank, and the number of years since graduation were not significant.

Scott and Gill[4] of the University of Alabama, considered only the two factors, the number of units of high school mathematics and number of years intervening between the last year of high school algebra and entrance into college; of these only the number of units of high school mathematics was significant in predicting probable success in college mathematics.

Douglass and Michaelson[5] found that the average mark in high school mathematics had a definite correlation with the average college mark in every field. They also concluded from their studies that the success of students in college mathematics cannot be predicted with any high degree of accuracy from the number of terms of mathematics taken in high school,

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[3] C. F. Kossack, "Mathematics Placement at the University of Oregon," The American Mathematical Monthly, XLIX (April 1942) 234-237.

[4] W. M. Scott and J. P. Gill, "A Prediction of Pupil Success in College Algebra," The Mathematics Teacher, XXXIV (December 1941) 357-359.

[5] H. R. Douglass and J. H. Michaelson, "The Relation of High School Mathematics to College Marks and of Other Factors to College Marks in Mathematics," School Review, XLIV (1936) 615-619.

rank on the psychological examination of the American Council on Education or a combination of these factors.

Orleans[6] reports that the correlations between scores on a test of specific ability in algebra or in geometry and marks representing achievement are in general higher than those between I. Q.'s and marks in achievement.

Placing students according to scores made on a placement test was tried at the University of Pittsburg. Held[7] reports that for the year he made his study failures were reduced from 21 per cent to 6 per cent by sectioning according to their score on the placement test. From the results of this investigation Held concluded that the use of a single criterion, the grade on a placement test in mathematics given prior to enrollment was quite satisfactory.

At a few schools tests have been given after a brief review of the subject matter. At the University of Illinois[8] an experiment was conducted in which students were given a five day's review of the fundamentals of trigonometry, after which they were given a placement test. Unfortunately the Illinois report gives no specific information as to whether sectioning in terms of a score on a test given after a review of the subject is more effective than sectioning on the basis of a similar test given before enrollment.

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[6] J. B. Orleans, "A Study of Prognosis of Probable Success in Algebra and Geometry," The Mathematics Teacher, XXVII (1934) 165-180; 225-246.

[7] O. C. Held, "A College Mathematics Placement Test," Journal of Higher Education, XIII (1942) 39-40.

[8] H. W. Bailey, "Trigonometry in High School," The Mathematics Teacher, XXV (1932) 303-308.

In the Purdue University[9] an experiment was conducted in which a mathematics placement test was given to all engineering students before enrollment, and then another was given after a brief review of mathematics. Students were sectioned according to scores of the pre-enrollment test and changes were made as appeared necessary from scores made on the test given after the review. The later proved to be much more effective in predicting the grade students made in beginning college mathematics.

In this study at Oklahoma Agricultural and Mechanical College a test was given at the end of three weeks of instruction. This was similiar to the procedure at Purdue University, although no attempt was made to section students according to scores made on the test. However, data is included in the following pages which attempts to determine its effectiveness in predicting grades.

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9 H. W. Keller and H. F. S. Jonah, loc. cit.

DESIGN OF EXPERIMENT

All students who enrolled at Oklahoma Agricultural and Mechanical College for the fall term of 1948 and who were entering a school or division in which mathematics is required, were required to take two mathematics placement tests previous to enrolling. They were the Cooperative Algebra Test, Revised Series Form S, and the Cooperative General Mathematics Test, Revised Series Form O, distributed by the American Council on Education. The tests will hereafter by known as T_1 and T_2 respectively.

These tests were graded by a mechanical grading machine and the raw scores were recorded. Students were then enrolled in mathematics courses according to the raw score they made on T_1 and the number of semesters of high school algebra they had taken, as follows:

TABLE I

Student Placement in Courses

Raw Score On T_1	Semesters of High School Algebra			
	4	3	2	1-0
Over 35	165 (If they chose)			
Over 30	173	173	173	033
(13-30)	173	143	143	033
Less 13	173	143	033	033

A brief explanation of what each course consisted is as follows:

Math 033 - Elementary Algebra

Math 143 - Intermediate Algebra

Math 173 - College Algebra

Math 165 - A combination of College Algebra and Trigonometry.

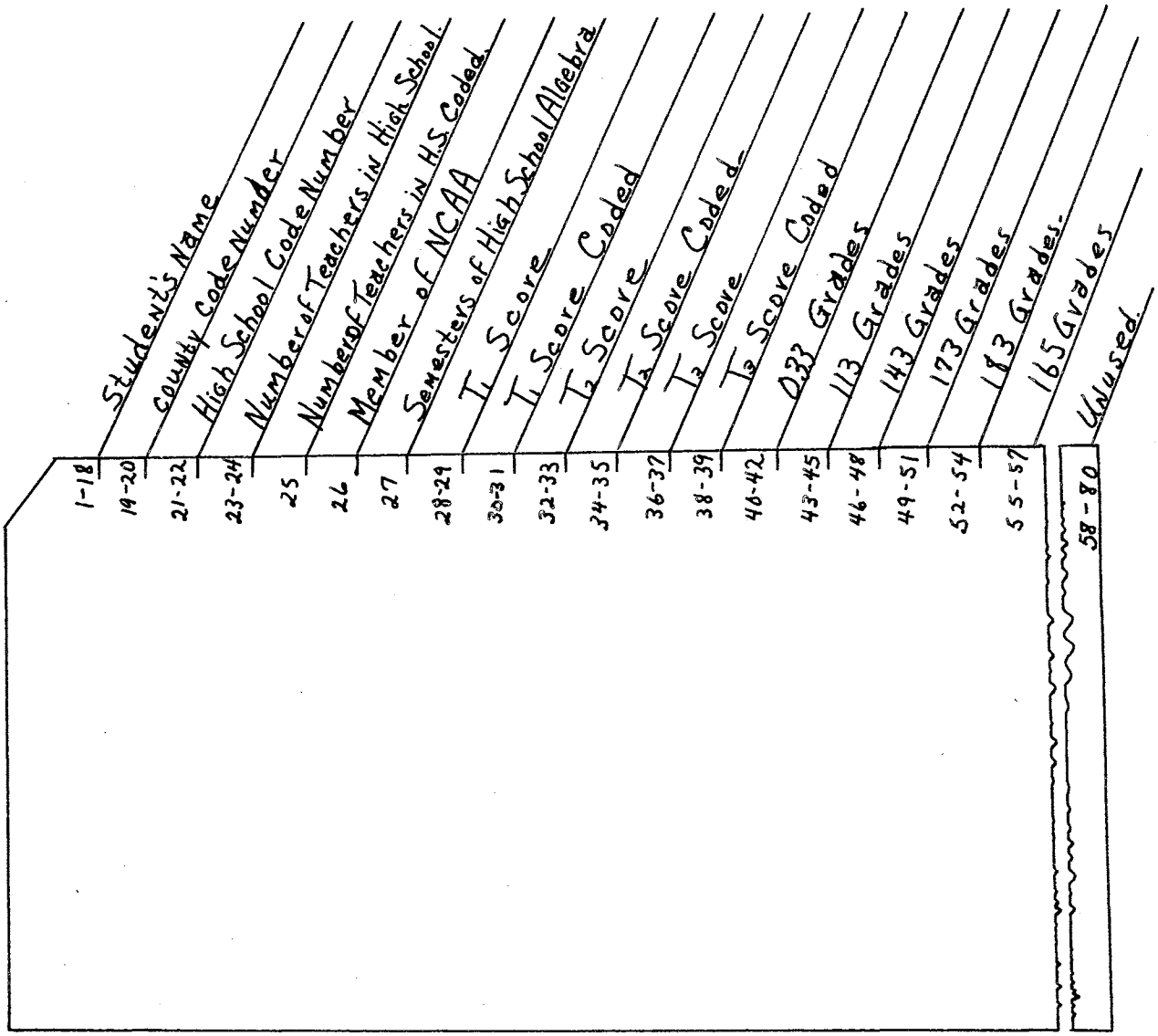
Students were allowed to take Math 183, Trigonometry, if they had credit in or were currently enrolled in Math 173. Students in the School of Commerce were required to take Math 113, Business Arithmetic, the first semester. The placement tests were not used in sectioning these students.

During the third week of school the Cooperative Intermediate Algebra Test, Revised Series Form T, hereafter known as T_3, was given to each student during the regular class hour. These were scored as were the first tests, but no effort was made to reassign students into courses according to score achieved on this test.

At the end of the semester each teacher reported letter grades, A, B, C, D, W, and F, for all students and a numerical grade for all students completing the course. It was impossible to determine scores for the W's and many of the F's; therefore, they were not reported or used in the correlation study. Making use of the percentage scores reported proved to be a problem, for many teachers did not use the college catalog standard for determining the numerical grade and they had to be converted to the college catalog standard before they could be used.

Other information gathered concerning the student include: the high school from which he graduated, the number of teachers in the high school, whether the school is a member of the North Central Accrediting Association, and the number of semesters of high school algebra they have had.

All this information was assembled and put on International Business Machine punch cards as follows:



The counties were coded by numbering them from 1 to 77 according to alphabetical order. Out-of-state students were given the number 78 in the place of a county number and the high school and teachers spaces were left blank for these students. Students from parochial schools were given the number 79 in place of a county number. High schools were coded according to alphabetical order within each county. The number of teachers in the school from which the student graduated were coded as follows:

0-9	1	30-39	4
10-19	2	40-49	5
20-29	3	50-Up	6

In the case where the school from which a student graduated does not belong to the North Central Accrediting Association a 0 was assigned. If the school does belong to the Association the number 1 was assigned. For out-of-state students and students from parochial schools a 2 was assigned as it was not known whether that school was a member of the Association. All test scores were coded as follows:

00-04	01	35-39	08
05-09	02	40-44	09
10-14	03	45-49	10
15-19	04	50-54	11
20-24	05	55-59	12
25-29	06	60-64	13
30-34	07		

The highest coded score obtained on any test was 13.

The following are samples of the data found on the punch cards:

```
Adams Benjamin FJr72123441435082005230500000000A93000000
Adams Leveta Inez 55107061332081003120300OA93000000000000
Alcott James Arth 60064351448103107310700000000B85A95000
-----------------------------------------------------------
Zink Don Keith    74016061331071303150400000000F  W  000
Zoldoske Billy Jac59061221436081704190400000000078000000
```

The International Business Machines Calculator was used to calculate all data to be used in the formulas.

ANALYSIS

For the purpose of clarity the following is an outline of the analysis which was made of this data, which will be explained in detail later in the report.

1. A simple correlation analysis was made between the placement tests.

2. A correlation analysis was made between the grades the students made in each course and each of the three placement tests.

3. The linear regression equations for predicting a student's grade, based upon his score on each of the three placement tests were computed.

4. The standard error of estimate for each of the linear regression equations was computed.

5. The multiple regression equations for predicting a student's grade in Math 143 and in Math 173 using T_1 and T_3 as criteria were computed.

6. The multiple regression equations for predicting a student's grade in Math 143 and in Math 173 using T_1, T_2, and T_3 as criteria were computed.

7. The rank correlation of the grades made by students who took both Math 173 and Math 183 was computed.

8. A check was made to determine what percentage of the students who had four semesters of high school Algebra failed Math 173.

In computing all of the correlation coefficients in this study Karl Pearson's[1] formula was used.

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[1] John F. Kenney, Mathematics of Statistics, p. 173

$$r = \frac{N\Sigma XY - (\Sigma X \Sigma Y)}{\left\{\left[N\Sigma X^2 - (\Sigma X)^2\right]^{\frac{1}{2}}\left[N\Sigma Y^2 - (\Sigma Y)^2\right]^{\frac{1}{2}}\right\}}$$

Correlations will be indicated in the following manner. $r_{t_1 t_2}$ symbolizes the correlation between scores on T_1 and T_2. $r_{173\, t_1}$ symbolizes the correlation between scores on T_1 and the grades made in Math 173, etc. Also * indicates significance of correlation coefficient at the 5 per cent level and ** indicates significance of correlation coefficient at the 1 per cent level.

In testing the correlation coefficient for significance Fisher's[2] table of significance was used.

A Simple Correlation Analysis Between the Placement Tests T_1, T_2, and T_3

The correlations in this section were based on all the students who took all three tests regardless as to whether they passed the course in which they enrolled.

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[2] George W. Snedecor, Statistical Methods, p. 149.

These two-way tables giving the number of persons who scored within certain intervals, as explained in the coding on punch cards, along with the total frequencies in each class interval should be of assistance in helping any one visualize what has taken place.

TABLE II

T_1 and T_2 Class Interval Frequencies

T_1 Class Interval	T_2 Class Interval									Total Class Freq. T_1
	1	2	3	4	5	6	7	8	9	
1	11	4	0	0	0	0	0	0	0	15
2	15	15	5	0	0	0	0	0	0	35
3	22	23	29	8	0	1	0	0	0	83
4	17	45	33	11	2	0	0	0	0	108
5	7	25	29	22	6	2	0	0	0	91
6	2	15	30	18	7	2	0	0	0	74
7	0	2	14	34	12	4	0	0	0	66
8	0	1	7	22	16	8	2	1	0	57
9	0	1	4	7	20	9	2	0	0	43
10	0	0	0	1	8	11	7	1	2	30
11	0	0	0	0	2	4	8	4	2	20
12	0	0	0	0	0	8	5	6	1	20
13	0	0	0	0	0	1	1	2	1	5
	73	132	152	123	73	50	25	13	6	647
	Total Class Freq. T_2									

$$r_{t_1 t_2} = .794^{**}$$

TABLE III

S_1 and S_3 Class Interval Frequencies

S_1 Class Interval	S_3 Class Interval 1	2	3	4	5	6	7	8	9	10	11	12	Total Class Freq. S_1
1	10	4	0	1	0	0	0	0	0	0	0	0	15
2	23	11	1	0	0	0	0	0	0	0	0	0	35
3	38	34	9	0	2	0	0	0	0	0	0	0	83
4	22	43	36	7	0	0	0	0	0	0	0	0	108
5	7	25	41	13	4	1	0	0	0	0	0	0	91
6	3	16	24	19	11	1	0	0	0	0	0	0	74
7	3	2	12	24	16	7	0	0	0	0	0	0	66
8	0	1	7	20	14	9	4	2	0	0	0	0	57
9	1	1	1	10	11	9	6	4	0	0	0	0	43
10	0	0	0	2	7	9	6	4	2	0	0	0	30
11	0	0	0	0	3	3	5	7	1	0	0	1	20
12	0	0	0	0	1	0	4	6	3	3	1	0	20
13	0	0	0	0	0	0	2	1	0	2	0	0	5
	107	137	131	96	71	39	27	26	6	5	1	1	647
	Total Class Freq. S_3												

$$r_{t_1 t_3} = .630^{**}$$

TABLE IV

T_2 and T_3 Class Interval Frequencies

T_3 Class Interval	T_2 Class Interval									Total Class Freq. T_3
	1	2	3	4	5	6	7	8	9	
1	38	33	27	7	2	0	0	0	0	107
2	23	54	39	17	2	2	0	0	0	137
3	8	35	49	32	5	2	0	0	0	131
4	3	8	21	37	18	8	1	0	0	96
5	1	2	13	16	22	12	3	2	0	71
6	0	0	3	8	15	8	3	2	0	39
7	00	0	0	5	5	7	9	1	0	27
8	0	0	0	1	4	8	9	3	1	26
9	0	0	0	0	0	2	0	1	3	6
10	0	0	0	0	0	1	0	3	1	5
11	0	0	0	0	0	0	0	1	0	1
12	0	0	0	0	0	0	0	0	1	1
	73	132	152	123	73	50	25	13	6	647
	Total Class Freq. T_2									

$$r_{t_2t_3} = .680^{**}$$

TABLE V

Summary of Placement Test Correlations

Tests	Correlation	Significance
T_1T_2	.794	1%
T_1T_3	.630	1%
T_2T_3	.680	1%

Correlation Analysis, Regression Equations With Standard Errors of Estimate Involving Mathematics Courses and Placement Tests

The following correlation coefficients and regression equations are based upon numerical grades made by only those students who passed the courses in which they were enrolled. The failures and withdrawals are shown in the correlation tables as a matter of evidence, but they were not included in making the computations, as it was impossible to use them without introducing data based upon unsound assumptions.

Mathematics 033, Elementary Algebra

Math 033 classes were made up of those students who made a score of 13 or less on T_1, and those who did not do well the first few weeks in Math 143. Many of these students had little or no high school algebra.

The simple analysis of correlation between the three test scores and the students grades in Math 033, the linear regression equation for predicting the grades and the standard error of estimate for such equations and correlation tables are as follows:

TABLE VI

Math 033 Grades and T_1 Scores

T_1 Scores	Math 033 Grades					
	A	B	C	D	F	W
1	1	0	1	1	3	2
2	1	8	2	9	0	0
3	2	12	3	4	2	4
4	0	1	0	0	0	0
5	0	0	0	1	0	0

$r_{033t_1} = .046$

$\hat{G}_{033} = \bar{G}_{033} + b(T_1 - \bar{T}_1)$ †

$\hat{G}_{033} = 80.98 + .102(T_1 - 9.58)$

$\hat{G}_{033} = 71.2 + .102T_1$

$S_{033} = 8.25$ (Standard Error of Estimate)

† G_{033} is the predicted grade; $\bar{G}_{033}$ is the mean of all grades made in Math 033; b is the slope of the line and $\bar{T}_1$ is the mean of T_1 scores. As an example Walton James made a score of 12 on T_1. His predicted score on Math 033 is as follows:

$\hat{G}_{033} = 80.98 + .102(12 - 9.58) = 81.23$

TABLE VII

Math 033 Grades and T_2 Scores

T_2 Scores	Math 033 Grades					
	A	B	C	D	F	W
1	1	5	3	7	2	3
2	1	9	2	6	2	2
3	2	4	1	1	1	1
4	0	3	0	1	0	0

$r_{033\,t_2} = .180$

$\hat{G}_{033} = \bar{G}_{033} + b(T_2 - \bar{T}_2)$

$\hat{G}_{033} = 80.96 + .32(T_2 - 6.74)$

$\hat{G}_{033} = 78.8 + .32T_2$

$S_{033} = 8.12$

TABLE VIII

Math 033 Grades and T_3 Scores

T_3 Scores	Math 033 Grades					
	A	B	C	D	F	W
1	2	12	5	14	3	5
2	2	8	1	1	2	1
3	0	1	0	0	0	0

$r_{033\,t_3} = .314^*$

$$\hat{G}_{033} = G_{033} + b(T_3 - \bar{T}_3)$$

$$\hat{G}_{033} = 80.98 + .937(T_3 - 3.37)$$

$$\hat{G}_{033} = 77.82 + .937T_3$$

$$S_{033} = 7.87$$

TABLE IX

Summary of Math 033 Grades and Placement Tests Analysis

Course & Test	Corr.	Sign.	Regression Equation	Standard Errors
$033T_1$	.046	Non	$G_{033} = 71.20 - .102T_1$	8.25
$033\ T_2$	.180	Non	$G_{033} = 78.80 - .320T_2$	8.12
$033\ T_3$	.314*	5%	$G_{033} = 77.82 - .937T_3$	7.87

In case the correlation coefficient is quite small and the standard error of estimate is quite large, little use can be made of a linear regression equation in predicting grades. This is the case for the correlation coefficients in Math 033. Hence no confidence can be placed upon any prediction made concerning the expected grade. The tests do not give a distribution of scores from which grades can be predicted.

Mathematics 113, Business Mathematics

Since Math 113 is an elementary course in Business Mathematics, required of all sudents in the School of Commerce, no restrictions as

far as scores on entrance examinations are concerned, were made upon who should take the course. Therefore the range of scores on all tests is quite large.

Correlation tables and analysis results follows:

TABLE X

Math 113 Grades and T_1 Scores

T_1 Scores	Math 113 Grades					
	A	B	C	D	F	W
1	0	0	0	2	1	0
2	1	2	3	1	1	1
3	3	4	6	6	5	0
4	3	7	6	3	2	1
5	3	0	2	3	0	0
6	2	3	3	1	1	0
7	1	2	1	0	0	0
8	2	1	1	2	0	0
9	1	0	0	0	0	0
10	0	1	0	0	0	0
11	1	0	0	0	0	0

$$r_{113\,t_1} = .260^{**}$$

$$\hat{G}_{113} = \bar{G}_{113} + .215\,(T_1 - \bar{T}_1)$$

$$\hat{G}_{113} = 83.22 + .215(T_1 - 19.96)$$

$$\hat{G}_{113} = 78.9 + .215T_1$$

$$S_{113} = 7.97$$

TABLE XI

Math 113 Grades and T_2 Scores

T_2 Scores	Math 113 Grades					
	A	B	C	D	F	W
1	1	1	1	1	7	1
2	4	7	7	6	0	1
3	7	8	9	4	2	0
4	3	3	4	4	1	0
5	1	1	1	0	0	0
6	0	0	0	0	0	0
7	1	0	0	0	0	0

$r_{113t_2} = .110$

$$\hat{G}_{113} = \bar{G}_{113} + b(T_2 - \bar{T}_2)$$

$$\hat{G}_{113} = 83.22 + .295(T_2 - 11.35)$$

$$\hat{G}_{113} = 79.9 + .295T_2$$

$$s_{113} = 6.10$$

TABLE XII

Math 113 Grades and T_3 Scores

T_3 Scores	Math 113 Grades					
	A	B	C	D	F	W
1	4	3	10	4	8	0
2	7	10	4	9	0	1
3	3	4	7	5	2	1
4	2	2	1	0	0	0
5	1	0	0	0	0	0
6	0	1	0	0	0	0

$r_{113t_3} = .2099$

$\hat{G}_{113} = \bar{G}_{113} + b(T_3 - \bar{T}_3)$

$\hat{G}_{113} = 83.22 + .32(T_3 - 7.63)$

$\hat{G}_{113} = 78.5 + 32T_3$

$S_{113} = 7.97$

TABLE XIII

Summary of Math 113 Grades and Placement Test Analysis

Course & Test	Corr.	Sign.	Regression Equation	Standard Errors
$113T_1$	.260	5%	$\hat{G}_{113} = 78.9 + .21T_1$	7.97
$113T_2$	.110	Non	$\hat{G}_{113} = 79.0 + .29T_2$	8.10
$113T_3$	.209	Non	$\hat{G}_{113} = 78.5 + .32T_3$	7.97

The correlation coefficient $r_{11,3\,t_1} = .260$ is the only one of the Math 113 correlations which tests to be significantly different from zero at the 5 per cent level. The standard errors of estimate also continue to be large as in Math 033. Again the correlation coefficients are too small and the standard errors of estimate are too large to be of value in predicting the grades from the placement test scores.

Mathematics 143, Intermediate Algebra

The correlation tables and analysis for Math 143 grades and test scores follows:

TABLE XIV

Math 143 Grades and T_1 Scores

T_1 Scores	Math 143 Grades					
	A	B	C	D	F	W
1	0	0	1	2	0	0
2	0	0	1	3	1	1
3	0	1	11	11	7	2
4	6	9	22	15	17	2
5	3	13	17	12	8	5
6	10	11	11	4	0	2
7	5	4	2	1	1	1
8	0	2	0	0	1	0
9	0	1	0	0	0	0
10	0	0	0	0	0	1

$r_{143t_1} = .417^{**}$

$$\hat{G}_{143} = \bar{G}_{143} + b(T_1 - \bar{T}_1)$$

$$\hat{G}_{143} = 80.19 + .567(T_1 - 20.9)$$

$$\hat{G}_{143} = 68.40 + .567T_1$$

$$S_{143} = 8.2$$

TABLE XV

Math 143 Grades and T_2 Scores

T_2 Scores	Math 143 Grades					
	A	B	C	D	F	W
1	0	2	5	7	7	2
2	5	8	23	20	11	3
3	6	12	21	16	9	3
4	8	16	14	3	5	3
5	3	3	1	2	2	2
6	2	0	1	0	1	1

$$r_{143t_2} = .347^{**}$$

$$\hat{G}_{143} = G_{143} + b(T_2 - \bar{T}_2)$$

$$\hat{G}_{143} = 80.19 + .55(T_2 - 11.22)$$

$$\hat{G}_{143} = 74.00 + .55T_2$$

$$S_{143} = 8.46$$

TABLE XVI

Math 143 Grades and T_3 Scores

T_3 Scores	Math 143 Grades					
	A	B	C	D	F	W
1	1	2	12	8	6	2
2	4	6	26	15	14	5
3	9	22	19	15	15	4
4	7	8	7	4	0	2
5	3	2	1	3	0	0
6	0	0	0	0	0	0
7	0	1	0	0	0	1

$r_{143t_3} = .347^{**}$

$\hat{G}_{143} = \bar{G}_{143} + b(T_3 - \bar{T}_3)$

$\hat{G}_{143} = 80.19 + .483(T_3 - 10.24)$

$\hat{G}_{143} = 75.2 + .483T_3$

$S_{143} = 8.67$

TABLE XVII

Summary of Math 143 Grades and Placement Tests Analysis

Course & Test	Corr.	Sign.	Regression Equation	Standard Errors
$143T_1$	.417	1%	$\hat{G}_{143} = 66.40 + .567T_1$	8.20
$143T_2$	.347	1%	$\hat{G}_{143} = 74.00 + .550T_2$	8.46
$143T_3$	.276	1%	$\hat{G}_{143} = 75.20 + .483T_3$	8.67

In the case of Math 143, all correlation coefficients test to be different from zero at the one per cent level of significance, but T_1 appears to be the best for predicting grades as can be seen by it having the highest correlation coefficient and the smallest standard error of estimate. T_2 and T_3, being much more difficult tests, do not seem to give a distribution which can be depended upon to predict grades in Math 143.

Mathematics 173, College Algebra

Correlation tables and analysis of Math 173 grades and placement test scores follow:

TABLE XVIII

Math 173 Grades and T_1 Scores

T_1 Scores	Math 173 Grades					
	A	B	C	D	F	W
1	0	0	1	0	0	0
2	0	0	0	0	0	0
3	0	1	0	1	2	0
4	0	1	5	3	2	1
5	0	2	8	7	5	0
6	2	3	5	5	7	0
7	1	10	18	10	4	2
8	3	9	13	7	5	2
9	4	11	11	6	1	0
10	6	6	5	0	3	0
11	4	2	5	0	1	0
12	9	5	1	0	0	0
13	3	0	1	0	0	0

$$r_{173\,t_1} = .5017^{**}$$

$$\hat{G}_{173} = \bar{G}_{173} + b(T_1 - \bar{T}_1)$$

$$\hat{G}_{173} = 82.3 + .39(T_1 - 37.05)$$

$$\hat{G}_{173} = 68.9 + .39T_1$$

$$S_{173} = 7.75$$

TABLE XIX

Math 173 Grades and T_2 Scores

T_2 Scores	Math 173 Grades					
	A	B	C	D	F	W
1	0	1	3	0	2	0
2	0	2	9	4	4	1
3	1	6	12	11	9	2
4	2	10	13	11	7	2
5	7	13	18	11	4	0
6	9	13	10	2	2	0
7	6	3	6	0	1	0
8	5	2	2	0	1	0
9	4	0	0	0	0	0

$$r_{173\,t_2} = .42^{**}$$

$$\hat{G}_{173} = \bar{G}_{173} + b(T_2 - \bar{T}_2)$$

$$\hat{G}_{173} = 82.3 + .445(T_2 - 20.43)$$

$\hat{G}_{173} = 73.2 + .445T_2$

$S_{173} = 8.10$

TABLE XX

Math 173 Grades and T_3 Scores

T_3 Scores	Math 173 Grades					
	A	B	C	D	F	W
1	2	2	3	2	2	0
2	0	1	5	3	3	1
3	0	1	7	5	9	0
4	2	10	18	16	5	4
5	5	14	22	7	8	0
6	3	9	13	5	3	0
7	6	4	4	1	0	0
8	10	8	1	0	0	0
9	2	1	0	0	0	0
10	4	0	0	0	0	0

$r_{173\,t_3} = .437^{**}$

$\hat{G}_{173} = \bar{G}_{173} + b(T_3 - \bar{T}_3)$

$\hat{G}_{173} = 62.3 + .455(T_3 - 22.47)$

$\hat{G}_{173} = 72.1 + .455T_3$

$S_{173} = 7.81$

TABLE XXI

Summary of Math 173 Grades and Placement Test Analysis

Course & Test	Corr.	Sign.	Regression Equation	Standard Errors
$173T_1$	.502	1%	$\hat{G}_{173} = 68.9 + .390T_1$	7.75
$173T_2$	.420	1%	$\hat{G}_{173} = 73.2 + .445T_2$	8.10
$173T_3$	.487	1%	$\hat{G}_{173} = 72.1 + .455T_3$	7.81

Notice that the standard errors of estimate connected with r_{173t_1} and r_{173t_3} are considerably smaller than the standard errors of estimate with r_{173t_2} which indicates that the linear regression equations involving T_1 and T_3 are much better for predicting grades in Math 173.

Mathematics 183, Trigonometry

Correlation tables and analysis for Math 183 grades and placement test scores follow:

TABLE XXII

Math 183 Grades and T_1 Scores

T_1 Scores	Math 183 Grades					
	A	B	C	D	F	W
1	0	0	0	0	0	0
2	0	0	0	1	0	0
3	0	0	0	1	0	0
4	0	0	2	2	1	0
5	0	1	0	4	4	0
6	1	1	11	2	2	0
7	2	10	13	2	2	2
8	6	5	6	2	1	0
9	7	8	6	1	1	0
10	7	1	2	0	0	0
11	4	2	1	0	0	0
12	5	1	0	1	0	0

$$r_{183\,t_1} = .637^{**}$$

$$\hat{G}_{183} = \bar{G}_{183} + b(T_1 - \bar{T}_1)$$

$$\hat{G}_{183} = 84.3 + .387(T_1 - 34.6)$$

$$\hat{G}_{183} = 70.9 + .387T_1$$

$$s_{183} = 6.60$$

TABLE XXIII

Math 183 Grades and T_2 Scores

T_2 Scores	Math 183 Grades					
	A	B	C	D	F	W
1	0	0	1	1	1	0
2	0	2	2	7	3	0
3	2	1	11	2	2	1
4	2	10	8	4	3	1
5	12	5	10	0	1	0
6	7	8	6	2	1	0
7	4	2	3	0	0	0
8	3	1	0	0	0	0
9	2	0	0	0	0	0

$r_{183\,t_2} = .559^{**}$

$\hat{G}_{183} = \bar{G}_{183} + b(T_2 - \bar{T}_2)$

$\hat{G}_{183} = 84.3 + .50(T_2 - 19.6)$

$\hat{G}_{183} = 74.5 + .50T_2$

$s_{183} = 7.07$

TABLE XXIV

Math 183 Grades and T_3 Scores

T_3 Scores	Math 183 Grades					
	A	B	C	D	F	W
1	1	1	2	0	1	0
2	0	0	5	6	0	0
3	0	3	3	3	6	0
4	2	6	17	2	2	2
5	8	10	8	2	1	0
6	6	5	4	1	1	0
7	5	1	1	1	0	0
8	6	3	1	1	0	0
9	3	0	0	0	0	0
10	1	0	0	0	0	0

$$r_{183\,t_3} = .524^{**}$$

$$\hat{G}_{183} = \bar{G}_{183} + b(T_3 - \bar{T}_3)$$

$$\hat{G}_{183} = 84.3 + .44(T_3 - 20.8)$$

$$\hat{G}_{183} = 75.1 - .44T_3$$

$$S_{183} = 6.93$$

TABLE XXV

Summary of Math 183 Grades and Placement Test Analysis

Course & Test	Corr.	Sign.	Regression Equation	Standard Errors
$183T_1$	.637	1%	$\hat{G}_{183} = 70.9 + .387T_1$	6.60
$183T_2$	.559	1%	$\hat{G}_{183} = 74.5 + .500T_2$	7.07
$183T_3$	.524	1%	$\hat{G}_{183} = 75.1 + .440T_3$	6.93

All correlation coefficients between Math 183 grades and placement tests scores test to be different from zero at the one per cent level of significance. Hence, they may be used in predicting Math 183 grades.

Mathematics 165, College Algebra & Trigonometry

Correlation tables and analysis of Math 165 grades and placement scores follow:

TABLE XXVI

Math 165 Grades and T_1 Scores

T_1 Scores	Math 165 Grades					
	A	B	C	D	F	W
8	0	3	3	3	0	0
9	0	3	2	1	0	0
10	0	1	2	2	0	0
11	1	5	1	0	0	0
12	3	1	1	0	0	0
13	0	1	0	0	0	0

$r_{165t_1} = .573^{**}$

$$\hat{G}_{165} = \bar{G}_{165} + b(T_1 - \bar{T}1)$$

$$\hat{G}_{165} = 83.78 + .55(T_1 - 46.5)$$

$$\hat{G}_{165} = 58.2 + .55T_1$$

$$S_{165} = 6.17$$

TABLE XXVII

Math 165 Grades and T_2 Scores

T_2 Scores	Math 165 Grades					
	A	B	C	D	F	W
3	0	0	0	1	0	0
4	0	4	2	2	0	0
5	0	2	0	1	0	0
6	2	1	3	2	0	0
7	1	4	2	0	0	0
8	1	2	1	0	0	0
9	0	1	1	0	0	0

$$r_{165\,t_2} = .393^{**}$$

$$\hat{G}_{165} = \bar{G}_{165} + b(T_2 - \bar{T}_2)$$

$$\hat{G}_{165} = 83.78 + .355(T_2 - 27.15)$$

$$\hat{G}_{165} = 74.2 + .355T_2$$

$$S_{165} = 6.93$$

TABLE XXVIII

Math 165 Grades and T_3 Scores

T_3 Scores	Math 165 Grades					
	A	B	C	D	F	W
4	0	0	1	1	0	0
5	0	1	0	2	0	0
6	0	2	1	1	0	0
7	1	6	2	2	0	0
8	1	2	4	0	0	0
9	1	0	1	0	0	0
10	1	1	0	0	0	0
11	0	1	0	0	0	0
12	0	1	0	0	0	0

$$r_{165t_3} = .619^{**}$$

$$\hat{G}_{165} = \bar{G}_{165} + b(T_3 - \bar{T}_3)$$

$$\hat{G}_{165} = 83.78 + .507(T_3 - 33.33)$$

$$\hat{G}_{165} = 66.8 + .507T_3$$

$$S_{165} = 5.91$$

TABLE XXIX

Summary of Math 165 Grades and Placement Test Analysis

Course & Test	Corr.	Sign.	Regression Equation	Standard Errors
$165T_1$	.573	1%	$\hat{G}_{165} = 58.2 + .550T_1$	6.17
$165T_2$	.393	5%	$\hat{G}_{165} = 74.2 + .355T_2$	6.93
$165T_3$	.619	1%	$\hat{G}_{165} = 66.8 + .507T_3$	5.91

$r_{165t_1} = .573$ and $r_{165t_3} = .619$ test to be different from zero at the one per cent level of significance while $r_{165t_2} = .393$ test to be different from zero only at the five per cent level of significance. Notice that the standard errors of estimate support this fact. Hence, they may be used to predict grades for Math 165 students, although T_2 cannot be depended upon as well as T_1 and T_3.

Comparision of the Effectiveness of T_1 and T_3 separately with Combination of T_1 and T_3 for Predicting Math 143 and Math 173 Grades

In an effort to determine whether the combination of a test given before enrollment and one given after a review of the subject matter would be better for predicting grades than either one alone, multiple regression equations involving both tests were computed for Math 143 and Math 173.

In terms of a dependent variable Y and independent variables X_1 and X_2, the multiple regression equation formula[3] is

$$\hat{Y} = \bar{Y} + b'_{y1.2}\frac{\sqrt{\Sigma(Y-\bar{Y})^2}}{\sqrt{\Sigma(X_1-\bar{X}_1)^2}}(X_2-\bar{X}_2) + b'_{y2.1}\frac{\sqrt{\Sigma(Y-\bar{Y})^2}}{\sqrt{\Sigma(X_2-\bar{X}_2)}}\left(X_2-\bar{X}_2\right)$$

where $b'_{y1.2} = \frac{r_{y1} - r_{y2}r_{12}}{1 - r_{12}^2}$

is defined as the standard partial regression coefficient, which indicates the standard re-

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[3] Ibid., p. 343.

gression of Y on X_1 independent of X_2. The b's are important in that their numerical size can be compared to determine which of the independent variables is the most effective in the prediction.

The multiple regression equations for the two courses are as follows:

$\hat{G}_{143} = 80.2 + .500(T_1 - 20.9) + .128(T_3 - 10.2)$

$\hat{G}_{143} = 68.4 + .500T_1 + .128T_3$

$\hat{G}_{173} = 82.3 + .246(T_1 - 37.0) + .252(T_3 - 22.47)$

$\hat{G}_{173} = 66.6 + .246T_1 + .252T_3$

In order to determine whether the use of two variables is more reliable for predicting grades than the use of one, the multiple correlation coefficient was computed and compared with the simple correlation coefficient. $R_{143\ 13}$, the multiple correlation coefficient for Math 143 T_1 and T_3, is arrived at by this formula[4]

$$R^2_{143\ 13} = (r_{143\ t_1})(b'_{143\ t_1 \cdot t_3}) + (r_{143\ t_3})(b'_{143\ t_3 t_1})$$

$$R = .418$$

Recalling that $r_{143\ t_1} = .417$ and that $r_{143\ t_3} = .2775$, and comparing with $R = .418$, we see that nothing is gained by using T_1 and T_3 over using T_1 alone. This fact is verified further when the standard error of estimate is computed.

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[4] Ibid., p. 347.

$$S_{143\ 13} = \sqrt{\frac{(1-R^2)(\Sigma \text{deviations } 143 \text{ Grades})^2}{N-3}}$$

$S_{143\ 13} = 8.2$ which is the same as the standard error of estimate of the linear regression equation involving Math 143 grades and T_1 scores.

Using the same process as above, we find

$$R_{143\,13} = .538$$

$$S_{173\ 13} = 7.55$$

For a comparison recall that $r_{173\,t_1} = .5017$, $r_{173\,t_3} = .487$. $S_{173T1} = 7.75$, and that $S_{173T3} = 7.81$. In each case the correlation coefficients with one independent variable is slightly smaller than with two independent variables and the corresponding standard error of estimate is slightly larger. Hence, the two tests used together are very little better than either one alone.

Regression equations depending upon all three tests were also computed for Math 143 and Math 173, to determine if using three variables (T_1, T_2, and T_3) is any better for predicting grades in those courses. The following results were obtained.

$$\hat{G}_{143} = 80.2 + .675(T_1 - 20.9) + .413(T_2 - 11.2) + .02(T_3 - 10.2)$$

$$\hat{G}_{143} = 61.3 + .675T_1 + .413T_2 + .02T_3$$

$$\hat{G}_{173} = 82.3 + .293(T_1 - 37) - .052(T_2 - 20.4) + .262(T_3 - 22.47)$$

$$\hat{G}_{173} = 66.7 + .293T_1 - .052T_2 + .262T_3$$

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[5] Snedecor, loc. cit.

$b'_{143\ 1.23} = .500$ $\quad$ $b'_{173\ 1.23} = .376$

$b'_{143\ 2.13} = .260$ $\quad$ $b'_{173\ 2.13} = -.049$

$b'_{143\ 3.12} = .021$ $\quad$ $b'_{173\ 3.12} = .279$

$R_{143\ 123} = .55$ $\quad$ $R_{173\ 123} = .55$

$S_{143\ 123} = 7.55$ $\quad$ $S_{173\ 123} = 7.50$

By comparing these correlation coefficients and standard errors of estimate with those where predictions were attempted with one test, we see that the use of three tests appears some better for predicting grades, but not really enough to merit a great deal of consideration.

Comparison of Math 173 Students With and Without Four Semesters of High School Algebra

A comparative study, by tables, was made of those Math 173 students who have had four semesters of high school algebra against those who have not had as much as four semesters of high school algebra. The tables follow:

TABLE XXX

Math 173 Grades and T_1 Scores for Students With Four Semesters of High School Algebra

Class Interval T_1	Grades					
	A	B	C	D	F	W
1	0	0	1	0	0	0
2	0	0	0	0	0	0
3	0	0	0	1	0	0
4	0	1	5	2	0	1
5	0	2	7	6	1	0
6	0	3	3	5	2	0
7	1	4	16	6	1	0
8	3	7	5	5	0	0
9	2	8	7	6	1	0
10	7	4	5	0	0	0
11	4	2	5	0	0	0
12	6	5	1	0	0	0
13	1	0	1	0	0	0
Totals	24	36	56	31	5	1
%	15.7	23.5	36.6	20.3	3.2	.6

TABLE XXXI

Math 173 Grades and T_1 Scores for Students with Less Than Four Semesters of High School Algebra

Class Interval T_1	Grades					
	A	B	C	D	F	W
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	1	0	0	2	0
4	0	0	0	1	2	0
5	0	0	1	1	4	0
6	2	0	2	0	5	0
7	0	6	2	4	3	2
8	0	2	8	2	5	2
9	2	3	4	0	0	0
10	1	2	0	0	3	0
11	0	0	0	0	1	0
12	3	0	0	0	0	0
13	2	0	0	0	0	0
Totals	10	14	17	8	25	4
%	12.8	18.0	21.7	10.2	32.0	5.1

TABLE XXXII

Math 173 Grades and T_2 Scores for Students With Four Semesters of High School Algebra

Class Interval T_2	Grades					
	A	B	C	D	F	W
1	0	1	3	0	0	0
2	0	2	9	4	3	0
3	0	3	8	11	1	1
4	2	9	10	6	1	0
5	5	6	11	9	0	0
6	6	10	9	1	0	0
7	5	3	4	0	0	0
8	4	2	2	0	0	0
9	2	0	0	0	0	0
Totals	24	36	56	31	5	1
%	157	235	366	203	32	6

TABLE XXXIII

Math 173 Grades and T_2 Scores for Students with Less Than Four Semesters of High School Algebra

Class Interval T_2	Grades					
	A	B	C	D	F	W
1	0	0	0	0	2	0
2	0	0	0	0	1	1
3	1	3	4	0	8	1
4	0	1	3	5	6	2
5	2	7	7	2	4	0
6	3	3	1	1	2	0
7	1	0	2	0	1	0
8	1	0	0	0	1	0
9	2	0	0	0	0	0
Totals	10	14	17	8	25	4
%	128	180	217	102	320	51

TABLE XXXIV

Math 173 Grades and T_3 Scores for Students With Four Semesters of High School Algebra

Class Interval T_3	Grades A	B	C	D	F	W
1	1	0	3	2	0	0
2	0	1	3	3	1	1
3	0	1	7	5	2	0
4	2	8	14	10	2	0
5	1	10	12	6	0	0
6	2	4	12	4	0	0
7	5	3	4	1	0	0
8	8	8	1	0	0	0
9	2	1	0	0	0	0
10	3	0	0	0	0	0
Totals	24	36	56	31	5	1
%	15.7	23.5	36.6	20.3	3.2	.6

TABLE XXXV

Math 173 Grades and T_3 Scores for Students with Less Than Four Semesters of High School Algebra

Class Interval T_3	Grades A	B	C	D	F	W
1	1	2	0	0	2	0
2	0	0	2	0	2	0
3	0	0	0	0	7	0
4	0	2	4	6	3	4
5	4	4	10	1	8	0
6	1	5	1	1	3	0
7	1	1	0	0	0	0
8	2	0	0	0	0	0
9	0	0	0	0	0	0
10	1	0	0	0	0	0
Totals	10	14	17	8	25	4
%	12.8	18.0	21.7	10.2	32.0	5.1

The following facts concerning these tables are noted.

For those students who had four semesters of high school algebra, the only thing the placement tests did was to indicate what grade they would make in the course and was not particularly useful in sectioning those students.

With respect to the four semester algebra group the placement test T_1, for example, does not seem to be a very good criterion for determining whether students will pass Math 173. It may be noted from Table 30 that approximately one fourth of the group made less than the required passing

score on the test, yet passed the course. Notice also that 5 out of 153 students who had four semesters of high school algebra, or 3 per cent, failed Math 173.

In Table 31 notice that 13 out of 21 students who got into the course without the required semesters of algebra or T_1 score failed the course.

Rank Correlation. Math 173 and Math 183

The rank correlation for students who took both Math 173 and Math 183 was computed by using Spearman's formula[6].

$$r = 1 - \frac{6\Sigma(X-Y)^2}{N(N^2-1)}$$

The following is a table giving the rank standing of each student in each course.

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[6] John F. Kenney, op. cit., p. 224.

TABLE XXXVI

Rank of Math 173 and Math 183 Students

Math 173	Math 183	Math 173	Math 183	Math 173	Math 183
1	1	40	80	79	53
2	10	41	56	80	49
3	3	42	26	81	98
4	58	43	94	82	93
5	2	44	52	83	99
6	8	45	60	84	67
7	19	46	34	85	73
8	9	47	35	86	30
9	16	48	68	87	109
10	31	49	18	88	62
11	4	50	27	89	74
12	11	51	69	90	44
13	45	52	92	91	88
14	5	53	57	92	90
15	54	54	101	93	107
16	64	55	70	94	110
17	84	56	71	95	75
18	20	57	39	96	51
19	21	58	36	97	87
20	22	59	37	98	76
21	23	60	61	99	100
22	6	61	48	100	111
23	12	62	72	101	40
24	17	63	38	102	41
25	42	64	95	103	89
26	43	65	102	104	112
27	32	66	96	105	91
28	46	67	81	106	103
29	37	68	105	107	104
30	7	69	33	108	113
31	59	70	78	109	106
32	55	71	28	110	108
33	24	72	29	111	114
34	13	73	85	112	115
35	14	74	86	113	116
36	15	75	82	114	63
37	25	76	97	115	77
38	50	77	66	116	79
39	65	78	83		

$r = .73$

In constructing this rank table, which consists of those students who passed Math 173 and Math 183, there were several students who had the same numerical grade. This made it impossible to differentiate between them according to rank. In order to determine this rank the punch cards were run through the sorting machine and students having the same numerical grade were given ranks according to the position in which their card fell.

By observing Table 36 one will find that the greatest difference in the rank of any student is 67, while the majority of the students have ranks which differ by less than 20. Considering this and the rank correlation ($r = .73$), one may draw the conclusion that, in general, a student who has satisfied the prerequisities for taking Math 173 is as equally qualified to take Math 183.

SUMMARY

Correlation coefficients, regression equations, and standard errors of estimate involving freshman mathematics grades and three placement tests have been computed. The results are stated briefly in Table 37.

The analysis of this study seem to justify the following conclusions:

1. In predicting mathematics grades for students who enrolled in Math 033 and Math 113, none of the placement tests given are of any value.

2. In predicting grades for students who enrolled in Math 143, Math 173, Math 183, and Math 165, each of the three tests is of value, although the grades for students enrolled in Math 143 are not predicted as well by any test as the grades of students enrolled in the more advanced courses.

3. In view of the fact that T_1 and T_3 have higher correlation coefficients and lower standard errors of estimate and that T_2 does not assist in predicting grades above that which can be done by T_1 and T_2, it seems that T_2 can be omitted with no loss of information.

4. By observing the test means it may be noticed that the students who made higher scores on T_1 showed a greater gain in knowledge during the review than those who made the lower scores. (Table 37)

5. Students who have had four semesters of high school algebra can be expected to handle Math 173 and need not be required to take the placement tests.

6. Students who are qualified to take Math 173 are equally qualified to take Math 183.

TABLE XXXVII

Summary of Analysis

Course	T_1			T_2			T_3		
	Corr Coef	Stand Error of Est.	Mean of T_1	Corr Coef	Stand Error of Est.	Mean of T_2	Corr Coef	Stand Error of Est.	Mean of T_3
053	.046	8.25	9.58	.180	8.12	6.74	.314*	7.87	3.37
113	.260*	7.97	19.96	.110	8.10	11.28	.210	7.97	7.83
143	.417**	8.20	20.90	.347**	8.46	11.22	.278**	8.67	10.24
173	.502**	7.75	37.05	.420**	8.10	20.43	.457**	7.81	22.47
183	.637**	6.60	34.60	.559**	7.07	19.60	.524**	6.93	20.80
165	.573**	6.17	46.50	.393*	6.93	27.15	.619**	5.91	33.33

RECOMMENDATIONS FOR FURTHER EXPERIMENTATION

To draw definite conclusions as to what is the best criterion for predicting grades for freshman students, further experimentation is necessary. In conducting such an experiment, the following problems should be considered carefully:

1. The proper choice of criterion to judge whether sectioning of students has been successful. If grades reported by instructors are to be used, then it should be required that all grades be reported according to college standard for determining numerical grades. In this experiment, passing grades ran as low as 55 in one instructor's class, while 68 was failing in other classes. It was necessary to adjust all letter grades to include the same numerical interval before they could be used. In case grades of students who withdraw from class or fail as a result of non-attendance are to be used in the study, and it seems advisable, they may be obtained by requiring instructors to report the grade the student was making at the time he stopped attending class. Instead of using final grades in the course, an achievement test covering the objectives of the course given near the end of the semester may be used as a measure of success. However, the test should be given and graded uniformly.

2. Further experiment of this type is necessary to confirm the results obtained. However, the method of choosing individuals for the experiments and the methods of analysis must remain the same throughout the series of experiments in order to draw comparable conclusions.

It is suggested that Math 113 and Math 183 be omitted in the study, as Math 113 is for commerce students only, requiring no prerequisites or further mathematics, and this report has shown that students qualified to take Math 173 are equally qualified to take Math 183.

3. A further study, involving the same analysis as was made in this study, can be made with the semester grades, the number of semesters of high school algebra, and the number of teachers in high school from which the student graduated. All this data is already on the punch cards and should be considered in any further experimentation until more conclusive evidence is obtained.

4. A study of these same students, or selected groups of them, could be continued by using their achievement in Math courses beyond the first semester. Many of them will continue to take mathematics through the second semester of calculus.

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