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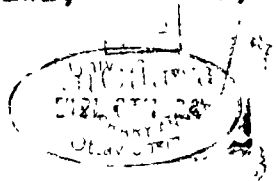
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ACTUARIAL VERSUS CLINICAL METHODS IN
PREDICTING ACHIEVEMENT IN A SCIENCE
FACULTY

by Laurent A. Isabelle

Thesis presented to the School of
Psychology and Education of the
University of Ottawa as partial
fulfilment of the requirements for
the degree of Doctor of Philosophy
in Educational Psychology

Ottawa, Ontario, 1981



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ACKNOWLEDGEMENTS

This thesis was prepared under the supervision of R.-H. Shevenell, O.M.I., Ph.D., director of the School of Psychology and Education of the University of Ottawa.

The writer is indebted to L.-T. Dayhaw, Ph.D., professor of the School of Psychology and Education, for his recommendations on statistical procedures, and to Pierre Gendron, Ph.D., Dean of the Faculty of Pure and Applied Science of the University of Ottawa for his interest in this study and for his cooperation in making it possible to administer tests to the students. The writer is also indebted to Mary Elaine Isabelle whose continued encouragement made the completion of this study possible.

CURRICULUM VITAE

Laurent A. Isabelle was born August 22, 1928, in Lisieux, Saskatchewan. He received the degree of Bachelor of Arts from the University of Ottawa, through its affiliate Le College Mathieu, Gravelbourg, Saskatchewan, in 1950. He received the degree of Bachelor of Education and Master of Education from the University of Ottawa in 1954 and 1956 respectively.

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INTRODUCTION

This dissertation, as the title implies, is another to be added to the already long list of studies in the field of prediction of academic achievement. Prediction is one of its two objectives. The emphasis, however, will be an evaluation of methods of prediction: the actuarial and the clinical, and hence, this study may also be added to those concerned with the controversial issue: the statistician versus the clinician in prediction of human behavior.

The duality of purposes of this project was first prompted by the writer's concern with the high failure rate of the students at the Faculty of Pure and Applied Science at the University of Ottawa, and secondly by the heated discussions on the advantages and shortcomings of the actuarial and the clinical methods in forecasting human behavior, specifically college achievement.

Could it be that, in a setting such as the Faculty of Science, the experience of a counsellor - skilled in the administration and interpretation of current and widely used psychological tests, familiar with the selection and promotion standards of the Faculty, and reasonably well acquainted with the numerous academic and personal problems of students in Science through several hundred interviews over an extended period of time, improve the predictive ability of post-admission psychometrics?

The voluminous literature on prediction of achievement in college, whether it is concerned with the uses of this or that test, or a combination of tests, in forecasting college achievement, or whether it involves an evaluation of primary and secondary school marks relative to success in college, or whether it centers upon the differential characteristics of the students who succeed and of those who fail, or whether it questions and appraises the validity and reliability of the criteria of success as it is determined by professional ratings, brings to the fore the fact that the best predictors - psychometrics, or non-psychometrics, or a combination of the two - seldom explain little more than half of the variance (median multiple r's approximately .6).

Can the clinician predict behavior, and specifically academic achievement? If so, can he do it as well as the statistician? Or, better still, waiving aside professional "jealousies" and lowering the apparent barriers, can they combine their distinctive abilities to arrive at their common objective more efficiently? Could it be that previous studies, emphasizing one or the other method, have overlooked the possibility that, together, some measure of improvement in prediction can be achieved? It seems that this may be the case, and on the strength of his hypothesis, the design and execution of this study was carried out.

The problem, then, is to study the prognostic values of the actuarial and the clinical techniques of group test result interpretation in forecasting the achievement of the students at the Faculty of Science of the University of Ottawa. It is centered on the null hypothesis formulated as follows: There is no significant difference between the actuarial and the clinical methods of interpreting group test results in forecasting the academic achievement of students in First and Second years of Science at the University of Ottawa, and a combination of methods is no more effective than any one used singly.

The review of the literature will be concerned with prediction of college achievement in general, prediction in Science specifically, and with the controversial writings on the predictive supremacies of the statistician and/or the clinician. It will be followed by a description of the four group tests utilized in this experiment, emphasizing their validity and reliability, important characteristics justifying their selection for this study.

In conjunction with this description of tools, and in conformity with scientific expectations, the writer will present the experimental design of this project, including an operational definition of the "clinical" prediction as proposed in this study. In order that misunderstandings, or questions relative to the validity of the clinical

prediction performed in this study, be reduced to a minimum, a description of the experience of the predictor including the data upon which the clinical prediction was founded, will be added.

The results of the two approaches to prediction will be presented and discussed, both in terms of their individual and composite predictive abilities.

The implications for research and for better understanding of the actuarial and clinical methods of group test result interpretation in forecasting college achievement in the Faculty of Science will be set forth in the concluding paragraphs.

CHAPTER I

REVIEW OF THE LITERATURE

1. The Problem of Prediction.

The problem of prediction of achievement in college can be investigated under several headings, some of which are: prediction, measurement in education, academic achievement, college, and educational psychology.

The literature to be reviewed under these many titles is voluminous, and Tyler¹ writes that there are thousands of studies reported. The writer was forcibly selective in his readings, since a good proportion of the material is repetitive and oftentimes not directly related to the topic of prediction of achievement in Science.

The reader might question, at this point, the pertinence of another study in academic prediction, especially since so many such studies have already been published and also because existing psychological tests have seemingly "reached a ceiling" in predictive efficiency.

¹ Tyler, Leona E., The Psychology of Human Differences, New York, Appleton-Century Crofts, Inc., 1956, p. 116.

The writer will first recall a statement made in 1938 by Quaid². The problem of prognosis is difficult, "no universal solution can be proposed, circumstances being specific to each institution, this essentially local problem requires its own individual solution". Has the research of the last two decades invalidated this assertion?

A second argument in favour of such a study as this is found in a recent survey conducted by Black³ of the University of Alberta on the use of tests in thirty-one English speaking Canadian institutions of higher learning. The relevant conclusions drawn from this survey are:

1. A large proportion of the thirty-one institutions report extensive post-admission testing, particularly the use of tests of academic aptitude. Only one institution, and possibly two others, used test scores as part of the data on which admissions are based.
2. In most institutions, little use is made of these data after admission. In many instances it appears that the scores are sent to persons who have little post-admission use for such data. There is sufficient evidence to suggest that in many cases the test scores are simply filed for possible future use, and on the basis of this survey, post-admission testing is usually a waste of time and effort, since little experimental work appears to be going on at these institutions on the differential predictive value and counselling qualities of tests.

² Quaid, T.D.D., "A Study in the Prediction of College Freshman Marks", in the Journal of Experimental Education, Vol. 6, No. 3, issue of March, 1938, p. 350.

³ Black, Donald D., "The Use of Tests in English Speaking Canadian Institutions of Higher Learning", in the School Guidance Worker, Vol. 15, No. 4, issue of January, 1960, p. 2.

Although this may be of only incidental value, the writer quotes this statement:

3. A surprising number of institutions have made no provision for counselling services either on a formal full-time basis or through part-time assignment of staff members to such services.⁴

Black⁵ was equally surprised by the number of counsellors reporting no use of test scores in institutions having "counselling programs", which suggests to this writer the timeliness of a study of this type in a university counselling program as presently organized in this institution.

In view of these statements, the writer will presently single out the conclusions of selected reviews or researches concerning the most effective predictors of college success.

The outstanding findings of the numerous studies, which will in the main serve as the foundation of this study, will be presented in two parts: A. Prediction of achievement in college, without distinction between the various departments or faculties, and B. Prediction of achievement in Science.

A. Prediction of Achievement in College.- In 1949, Garrett surveyed:

...the many studies published during the three decades 1920 to 1950 devoted to the problem of predicting general scholastic achievement in college by intelligence, aptitude and achievement tests, combined in certain cases with other criteria, e.g., the marks in high school.⁶

⁴ Black, Op. Cit., p. 8.

⁵ Black, Op. Cit., p. 8.

⁶ Elagren, John K.G., Annual Review of Psychology, Vol. 3, 1952, p. 399.

It is clearly indicated by Garrett that the high school average "continues to show the highest correlation with later college scholarship average",⁷ regardless of variations in weightings, size of groups, marking systems used, length of college course considered. The coefficients of correlation range from .29 to .83, and the median r .56 is obtained from a review of thirty-two studies.⁸

The second best single index as a basis for predicting scholastic success in college obtained from a review of twenty-four studies was found to be the result of achievement tests, the College Entrance Examination Board Tests,⁹ coefficients of correlation ranging from .23 to .85, median .49.¹⁰

The third most effective predictive index, as determined by a review of ninety-four pertinent studies was found to be the result of an intelligence test, whether it is the American Council on Education Psychological Examination,¹¹

7 Garrett, H.F., "A Review and Interpretation of Investigations of Factors Related to Scholastic Success in Colleges of Arts and Science and Teacher's Colleges", in the Journal of Experimental Education, Vol. 18, No. 2, issue of December, 1949, p. 93.

8 Garrett, Op. Cit., p. 94.

9 Hereafter referred to as the C.E.E.B.

10 Garrett, Op. Cit., p. 99.

11 Hereafter referred to as the A.C.E.

the Ohio State Psychological Examination, the Otis Self-Administering Tests of Mental Ability,¹² coefficients of correlation with the criteria ranging from .17 to .67, the median reported to be .47.¹³

The fourth and fifth best indices of prediction, found on summarizing twenty-eight studies using general aptitude tests on the one hand, and fifteen studies using special aptitude tests on the other, are median r 's .43¹⁴ and .41¹⁵ respectively. The r 's between general aptitude tests and college marks ranged from .12 to .56, while those obtained between special aptitude tests and marks ranged from -.04 to .65.

Other factors, of the non-intellective variety, "fail to show any consistent relationship between their scores and academic success in college", most r 's ranging from .20 to .30.¹⁶

The above indices, when combined to obtain multiple coefficients of correlation of two factors resulted in higher correlations with the criterion than the factors taken

12 Hereafter referred to as the Otis S.-A.

13 Garrett, Op. Cit., p. 109.

14 Garrett, Op. Cit., p. 112.

15 Garrett, Op. Cit., p. 114.

16 Garrett, Op. Cit., p. 114.

singly.

- (1) The most prognostic combinations include:
 - (a) high school marks and intelligence test score
 - (b) high school marks and aptitude test score
 - (c) intelligence test score and achievement test score.

(2) The addition of a third variable adds very little to the predictive value of the combination, and adding a fourth variable has practically no value.¹⁷

Super¹⁸ writes:

Past achievement is often one of the best indices of future accomplishment, so that achievement tests can frequently be used as tests of aptitude for related types of activity.

Further on he states:

In the prediction of educational success, educational achievement tests have been effectively used in the admission programs of colleges and professional schools. In most investigations they have been tried in combination with tests of scholastic aptitude and with high school averages, in order to determine the relative value of each type of predictor. In one such study at the University of Minnesota it was found that high school rank was the best single predictor of sophomore achievement, but that a combination of those three types of indices was better than any single index. ...In brief, experience has shown that achievement tests not only yield predictions of college averages which are about as good as those provided by intelligence tests, but also give better differential predictions of success in specific subjects than do intelligence tests.¹⁹

17 Garrett, Op. Cit., p. 130.

18 Super, Donald E., Appraising Vocational Fitness, New York, Harper & Brothers, 1949, p. 147.

19 Super, Op. Cit., p. 148-149.

Tyler²⁰ writes that,

There is abundant evidence for a consistent dependable relationship between school achievement and intelligence. ...Correlations vary somewhat from study to study but the bulk of them range between .3 and .8. The median would be about .5. This is not pure random variation. High correlations are typically obtained under some circumstances, low ones under others.

On the use of achievement tests in prediction of college success Tyler²¹ states:

The so-called 'prognostic' tests of achievement in various subject matter areas, do seem to produce somewhat higher calculations with grades than intelligence tests do, especially at the college level. They are not, however, outstandingly high, seldom running above .7.

Although Anastasi²² does not discuss under one topic the predictive efficiencies of several predictor variables such as high school marks, results of achievement or intelligence tests, results of interest or personality inventories, or combination of these factors in prediction, she distinguishes between achievement and aptitude tests, a distinction considered important at this point in view of the choice of instruments made in this study:

20 Tyler, Op. Cit., p. 117.

21 Tyler, Op. Cit., p. 120.

22 Anastasi, Anne, Psychological Testing, The MacMillan Co., New York, 1954, p. 1-682.

In differentiating between aptitude and achievement tests, we should especially guard against the naive assumption that achievement tests measure the effects of learning, while aptitude tests measure 'innate capacity' independent of learning. ...It should be obvious that all psychological tests measure the individual's current behavior, which inevitably reflects the influence of prior learning. The fact that every test score has a 'past' does not, however, preclude its having a 'future'. While revealing the effects of past learning, test scores may, under certain conditions, serve as predictors of future learning.²³

Clarke²⁴ reviewed the literature on prediction of college achievement and he reports on studies prior to 1949, research in the 1950's, and pays particular attention to recent Canadian studies. He draws heavily on Garrett²⁵ for that period prior to 1949. He also refers to Travers²⁶ work covering that same span, but he cautions the reader against being hasty in accepting some of Travers' conclusions.

On research in the 1950's, Clarke²⁷ discusses the trend toward differential prediction and that conclusions of recent studies merely confirm those of previous research:

23 Anastasi, Op. Cit., p. 455.

24 Clarke, S.C.T., "Review of Some Previous Studies on Matriculation Problems", in the Alberta Journal of Educational Research, Vol. 4, No. 1, issue of March, 1958, p. 30-39.

25 Garrett, Op. Cit., p. 91-138.

26 Travers, Robert M.W., in Donahue, Wilma T., Clyde H. Coombs, and Robert M.W. Travers, (eds.), The Measurement of Student Adjustment and Achievement, Ann Arbor, Michigan, University of Michigan Press, 1949, p. 1-256.

27 Clarke, Op. Cit., p. 35.

High school marks, achievement tests and mental tests are the best single predictors of success, and more valid predictions are obtained when these prognostic measures are used together or in combination with other measures.

He also points out that some of the reasons for rather low accuracy of prediction can be partly attributed to the low reliability of college marks, partly to the failure of adequate measurement of personality traits that no doubt contribute to success in college, and also to the enormous variations in standards from one college to another.²⁸

The Canadian studies singled out by Clarke are those presently in progress in the Provinces of Alberta and Ontario and these will be reviewed presently.

Acroyd and Roberts²⁹ studied 422 Alberta Grade XII matriculants who represented 60 per cent of the 1949 University of Alberta freshman year. They reported that the students who completed their high school in three years, obtained higher Grade XII averages, repeated fewer Grade XII courses, and were also obtaining better marks than the remaining 40 per cent of that freshman year.

²⁸ Clarke, Op. Cit., p. 35.

²⁹ Acroyd, A.O., and G.O. Roberts, "A Study of the Post School Occupations of Students Who Graduated with University Matriculation from Alberta High Schools in 1949", unpublished M.Ed. Thesis, Faculty of Education, University of Alberta, (no date), reported by Clarke, Op. Cit., p. 35.

Fair³⁰ reported the following coefficients of correlation between (1) A.C.E. test results, (2) Grade XII average and First and Third Year university marks. (The population under study was composed of 100 University of Alberta Arts and Science Freshmen enrolled at the University in 1953-1956.)

A.C.E. and Grade XII average: $r = .56$;

A.C.E. and First and Third Years: $r = .40$ and $r = .31$ respectively;

Grade XII general average and First and Third Years: $r = .64$ and $r = .41$ respectively; and finally,

University First Year average and Third Year average: $r = .69$.

A study published by Evenson and Smith³¹ covering (1) the 1951 University of Alberta freshman class, and (2) the 1956 Grade XII Alberta matriculants indicated that:

1. 1951 Freshman group:³²

A. Highest correlations are to be found between Grade XII average and First Year university marks: $r = .48$.

30 Fair, Donald G., "Predicting Academic Success at the First and Third Year Levels of University", unpublished term project for Psychology 59, Department of Psychology, Faculty of Arts and Sciences, University of Alberta, (no date), reported by Clarke, Op. Cit., p. 37.

31 Evenson, A.B., and D.E. Smith, "A Study of Matriculation in Alberta", in the Alberta Journal of Educational Research, Vol. 4, No. 2, issue of June, 1958, p. 67-83.

32 Evenson and Smith, Op. Cit., p. 70.

- B. A.C.E. score and First Year marks: x .36.
- C. There is no evidence from their results that the A.C.E. might be used as a substitute for present matriculation requirements.
2. The 1956 Grade XII group:³³
- A. The Grade XII examinations of the Province of Alberta are the best single predictors of success at the University of Alberta.
- B. The C.E.E.B. Scholastic Ability Tests,³⁴ coefficients of correlation with First Year university are: Verbal .27, Mathematical .30, whereas the School and College Ability Tests,³⁵ coefficients of correlation with first Year university are: Verbal .21, Quantitative .27, and Total Score .29.
- C. There is yet no evidence that the C.E.E.B. should replace the Grade XII examinations for matriculation purposes.
- D. Senior matriculation at the University of Alberta is at the same level as matriculation based on the C.E.E.B. tests generally in the United States.

Fleming reported the findings of the Atkinson Study of Human Resources investigating personal and academic factors as predictors of success in Ontario universities:

On the whole, this part of the investigation confirms the findings of previous research that the prediction of which students will pass and which will fail is a very difficult problem.³⁶

³³ Evenson and Smith, Op. Cit., p. 82.

³⁴ Hereafter referred to as the S.A.T.

³⁵ Hereafter referred to as the S.C.A.T.

³⁶ Fleming, W.G., "Personal and Academic Factors as Predictors of First Year Success in Ontario Universities", in the report No. 5, Chapter VI, Atkinson Study of Human Resources, Toronto, Department of Educational Research, Ontario College of Education, 1959, p. 18.

The coefficients of correlation between the high school averages from Grade IX to XIII and First Year university marks (all Ontario universities combined) improve progressively from .36 (Grade IX) to .60 (Grade XIII), leading Fleming³⁷ to the conclusion that high school records are of "some" value as predictors.

The results of the S.A.T. Verbal and Mathematical tests correlated with First Year university (all Ontario universities combined) were: .33 and .21.³⁸

The results of the S.C.A.T. Verbal, Quantitative, and Total again correlated with First Year marks were: .29, .16, and .29.³⁹

The Nelson-Denny Reading Test⁴⁰ when correlated with the same criterion, produced an r .29.⁴¹

The summary of the findings of the Ontario study:

1. The aptitude test scores are less effective as predictors of First Year university than the Grade XIII average.

37 Fleming, Op. Cit., Table iv. a. 1.

38 Fleming, Op. Cit., Table iv. c. 1.

39 Fleming, Op. Cit., Table iv. c. 1.

40 Hereafter referred to as N.D.R.T.

41 Fleming, Op. Cit., Table iv. c. 1.

2. The verbal aptitude scores of the S.A.T. are of more value than the mathematical.
3. The use of two predictors is almost always demonstrably superior to the use of a single predictor.
4. The aptitude score should be the verbal for courses emphasizing language, literature, social sciences, philosophy, and others with a strong verbal characteristic, and the mathematical aptitude score should be used for courses emphasizing mathematics and the sciences.

It is of interest to point out that for the thirty-six students of the University of Ottawa included in the Fleming report,⁴² the following coefficients of correlation were obtained between (a) aptitude scores (S.A.T., S.C.A.T., and N.D.R.T.) and Grade XIII average, and (b) First Year university average (all courses):

S.A.T. - V - .19; M - .21;
S.C.A.T. - V - .16; S - .11; T - .17;
N.D.R.T. - .10; Grade XIII average - .61.

The review of studies on prediction of achievement in various college courses will be followed by a review of the studies on prediction of achievement in Science, which is, specifically, the objective of this dissertation.

⁴² Fleming, Op. Cit., Table iv. c.1.

B. Prediction in Science.- In 1937, Bingham⁴³ discussed the predictive efficiency of various tools of measurement and he wrote the following:

The standards of scholarship maintained by most engineering faculties demand of the students superior endowment of intellectual ability or scholastic aptitude...

To anyone familiar with the content of an engineering curriculum it is not surprising that a young man's probability of success in such courses of study is rather closely related to his aptitude for higher mathematics. Indeed a good reliable measure of his mathematical ability is by all odds the best single indicator of his aptitude for pursuing engineering studies.

Stuit⁴⁴ brought together and analyzed the results of the most significant studies pertaining to the prediction of success in several of the professional colleges. He first cautions the reader by writing:

It would be misleading to leave the impression that answers have been found to most of the questions concerning the prediction of success in various professional colleges.⁴⁵

However, some of the conclusions regarding prediction of success in engineering are relevant:

⁴³ Bingham, W., Aptitudes and Aptitude Testing, New York, Harper & Brothers, 12th ed., 1937, p. 170-171.

⁴⁴ Stuit, Dewey B., Predicting Success in Professional Schools, Menasha, Wisconsin, George Banta Publishing Co., 1949, p. i-187.

⁴⁵ Stuit, Op. Cit., p. 17.

1. The quality of an individual's previous academic record either in secondary-school or college-level work appears to be one of the most reliable bases for estimating his chances for doing successful work in a collegiate engineering course.

2. Tests of general scholastic aptitude may also be employed with confidence or additional sources of information regarding an individual's potential capacity for college-level training in the field of engineering.

3. Demonstrated proficiency in mathematics (especially as revealed by high scores on mathematics achievement tests) seems to be the best single indicator of the likelihood that an individual will complete engineering training successfully. Grades received in high school and/or college mathematics courses also constitute an additional source of valuable predictive data.⁴⁶

Other findings singled out by Stuit⁴⁷ are that

(1) English average ability and scientific knowledge correlate significantly with achievement; (2) manipulative skill or dexterity - as reflected by special aptitude tests - seem to be of limited predictive value; and (3) results obtained by interest inventories consistently show little or no correlation with scholastic records made in engineering training.

The most efficient combination of predictive indices to be used in estimating an individual's chances for success in the study of engineering appears to be one comprising (a) previous scholastic records, ... (b) scholastic aptitude test scores, and (c) scores obtained on subject-matter achievement tests in the areas of mathematics, science, and English.⁴⁸

⁴⁶ Stuit, Op. Cit., p. 42-41.

⁴⁷ Stuit, Op. Cit., p. 41.

⁴⁸ Stuit, Op. Cit., p. 40.

Berdie and Sutter⁴⁹ reported in 1950 that the best single predictor of over-all grade average in engineering correlations ranging from .45 to .65 - was found in the high school records, that the scholastic aptitude tests: the Tests of General Educational Development, were the second best single predictor, and that a mathematics aptitude test: the Cooperative General Achievement Test, Part III, Survey in Mathematics, contributed sufficiently to warrant its use as part of a test battery.

Pierson and Jex⁵⁰ found that the best predictor of success in engineering was obtained by using a combination of high school marks with measures of achievement in English and Mathematics.

Cosand⁵¹ concluded from his study of college prediction that intelligence tests plus language skill gave predictors up to .80, though no single test appeared to give more than .50, and that high school marks appeared to be better predictors than any single test.

49 Berdie, R.F., and M.A. Sutter, "Predicting Success of Engineering Students", in the Journal of Educational Psychology, Vol. 41, 1950, p. 190.

50 Pierson, G.A., and F.B. Jex, "Using the Cooperative Achievement Tests to Predict Success in Engineering", in the Journal of Educational and Psychological Measurement, Vol. 11, No. 3, 1951, p. 400.

51 Cosand, J.P., ".....", in the California Journal of Secondary Education, Vol. 28, 1953, reported in the Annual Review of Psychology, Vol. 5, 1954, p. 366.

Garside⁵² indicated in 1957 that high school certificates provided the best measure of prediction of engineering works, conclusion found to be in agreement with those of Hohne⁵³ and Sanders.⁵⁴

Fitzpatrick⁵⁵ studied the problem of failure in engineering at the University of Alberta and it was his finding that the most significant predictors of success in that field were the Grade XII average and the Grade XII mathematic-science average, correlation of .58 and .67 respectively for 253 students. The A.C.E. correlated with marks, r .23.

Evenson and Smith,⁵⁶ who studied the University of Alberta Freshman class and the 1957 Grade XII Alberta matriculants, correlated the Grade XII average and the university marks of the 1951 Freshman class enrolled in

52 Garside, R.F., "The Prediction of Examination Marks in Mechanical Engineering Students at King's College ", Newcastle, in the British Journal of Psychology, Vol. 48, Part 3, issue of August, 1957, p. 220.

53 Hohne, H.H., "Success Over Failure in Scientific Faculties of the University of Melbourne", reported by Garside, Op. Cit., p. 220.

54 Sanders, C., "Student Selection and Academic Success in Australian Universities", Sydney, Commonwealth Office of Education, reported by Garside, Op. Cit., p. 220.

55 Fitzpatrick A.B., "Prediction of Success in First Year Engineering", unpublished M.A. thesis, Department of Psychology, Faculty of Arts and Sciences, University of Alberta, 1955, reported by Clarke, Op. Cit., p. 37.

56 Evenson and Smith, Op. Cit., p. 69.

Engineering, and they reported an r of .59, while the A.C.E. correlated r .26 with the same criterion.

Depending on the setting where studies were made, and on the type of tests used, it seems appropriate to list the predictors which seem to be the most effective predictors in science or engineering.

1. High school average;
2. High school mathematic-science average;
3. Score of scholastic aptitude tests or achievement tests;
4. Score of an intelligence test or of a mathematical aptitude test;
5. The best over-all index seems to comprise the high school general average and any of the remaining variables.

Of course, success in class depends on several factors, such as talent, preparation, motivation, efficiency of study habits, and a host of personal factors such as age, mental and physical health, conclusions of Harris,⁵⁷ Tyler,⁵⁸ Weitz and Wilkinson,⁵⁹ and Fleming.⁶⁰

⁵⁷ Harris, D., "Factors Affecting College Grades: A Review of the Literature, 1930-37", in the Psychological Bulletin, Vol. 37, 1940, p. 125-166.

⁵⁸ Tyler, Op. Cit., p. 86.

⁵⁹ Weitz, Henry, and H. Jean Wilkinson, "The Relationship Between Certain Nonintellective Factors and Academic Success in College", in the Journal of Counselling Psychology, Vol. 4, No. 1, 1957, p. 54-60.

⁶⁰ Fleming, Op. Cit., p. 8.

Nevertheless, the concensus of teachers and psychologists is that talent is of the utmost importance for academic achievement in our system of education. The many other factors like the study habits, the motivation, and the personality traits, do not seem to be as valuable predictors of success in the current literature, although their influence cannot be denied.

2. Actuarial Versus Clinical Prediction.

It is not the purpose of this dissertation to delve into and analyze the several treatments of the logical issues involved in clinical thinking. The analysis of the clinical process has been extensively elaborated by Meehl,⁶¹ McArthur,⁶² Meehl, Tiedeman and McArthur,⁶³ and Holt.⁶⁴

⁶¹ Meehl, P.E., Clinical vs. Statistical Prediction: A Theoretical Analysis and a Review of the Evidence, University of Minnesota Press, 1954, p. 1-149.

⁶² McArthur, Charles, "Analyzing the Clinical Process", in the Journal of Counselling Psychology, Vol. 1, No. 4, 1954, p. 203-208.

⁶³ Meehl, P.E., D. Tiedeman, and C.C. McArthur, "A Symposium on Clinical and Statistical Prediction", in the Journal of Counselling Psychology, Vol. 3, No. 3, 1956, p. 163-173.

⁶⁴ Holt, Robert R., "Clinical and Statistical Prediction: A Reformulation and Some New Data", in the Journal of Abnormal and Social Psychology, Vol. 56, No. 1, 1958, p. 1-12.

The review of the literature on the issue of actuarial versus clinical prediction will be concerned with:

1. Whether or not there are really two approaches to prediction;
2. Definitions of the terms actuarial and clinical;
3. Some of the results of experiments evaluating the two approaches to prediction; and,
4. Suggestions for an experimental design to test the two approaches in predicting success in an academic setting.

"For some time the literature in this field has been concerned with the controversy as to whether there is only one type of prediction or at least two."⁶⁵

The implication that there are at least two kinds of prediction can be seen in this ascertainment made by Viteles⁶⁶ in 1925, "...the statistical point of view must be supplemented by the clinical point of view."

In 1934, Bingham and Moore⁶⁷ pointed out the presence of two kinds of prediction, the statistical prediction

⁶⁵ Dymond, Rosalind, "Can Clinicians Predict Individual Behavior?", in the Journal of Personality, Vol. 22, No. 1, issue of September, 1953, p. 151.

⁶⁶ Viteles, M.S., "The Clinical Viewpoint in Vocational Psychology", in the Journal of Applied Psychology, Vol. 9, 1925, p. 134, reported by Sarbin, T.R., "The Logic of Prediction in Psychology", in the Psychological Review, Vol. 51, 1944, p. 210.

⁶⁷ Bingham, W.V., and B.V. Moore, How to Interview, New York, Harper & Brothers, (rev.ed.), 1934, reported by Sarbin, T.R., "The Logic of Prediction in Psychology", in the Psychological Review, Vol. 51, No. 4, 1944, p. 210.

which is based on regression equations and clinical prediction which is based on statistical prediction, but refined and modified by including the consideration of factors not treated in the regression equation.

Allport⁶⁸ distinguishes between "actuarial" and "individual" prediction, the former suitable for the predictions of group behaviour, the latter for the prediction of the performance of any one particular individual.

Sarbin⁶⁹ refers to both terms "statistical" and "clinical" - and this seems to be a concession to popular usage, because he proposes that the difference between the two kinds of prediction is at best superficial and that, in fact, the two can really be reduced to one - the actuarial.

Truesdell and Bath⁷⁰ consider that the most comprehensive survey of the literature on this topic is that which was done by Meehl⁷¹ who reviewed some twenty-four pieces of research which he considered to be the most pertinent and

68 Allport, G.W., "The Psychologist's Frame of Reference", in the Psychological Bulletin, Vol. 37, No. 1, 1940, p. 16.

69 Sarbin, T.R., "The Logic of Prediction in Psychology", in the Psychological Review, Vol. 51, No. 4, 1944, p. 210-228.

70 Truesdell, Albert B., and John A. Bath, "Clinical and Actuarial Predictions of Academic Survival and Attrition", in the Journal of Counselling Psychology, Vol. 4, No. 1, 1957, p. 50.

71 Meehl, Op. Cit., p. 1-149.

about which he points out in great detail their advantages and their shortcomings. He also offers suggestions as to the caution to be exercised in using each kind of approach to prediction.

In this monograph, Meehl⁷² considers that there are two approaches to prediction: the actuarial and the clinical. The former is often described as the formal, statistical or empirical method; it is a mechanical combination of data from which predictions can be made. The latter, on the other hand, is the informal, judgmental or impressionistic approach; it consists of a subjective analysis of data from which inferences can be made.

Meehl⁷³ distinguishes between two different applications of statistics: discriminative (or validating) and structural (or analytic), the first usually consisting of correct matchings, of simple significance tests, or of prediction systems; the second usually consisting of factor analysis, of analysis of co-variance, or of applications of partial correlations. He also distinguishes between the two types of data upon which both the actuarial and the clinical approaches to prediction can be applied: psychometrics and non-psychometrics.⁷⁴

72 Meehl, Op. Cit., p. 15.

73 Meehl, Op. Cit., p. 11.

74 Meehl, Op. Cit., p. 15.

In a more recent paper, Meehl⁷⁵ writes that of the twenty-seven empirical and pertinent studies in the literature:

...which make some meaningful comparison between the predictive success of the clinician and the statistician ...17 show a definite superiority for the statistical method; 10 show the methods to be of about equal efficiency; none of them show the clinician predicting better.

The thesis upheld in these two publications is that the clinician is not as good at predicting behavior as he thinks he is and that the statistician is by far more effective.

He goes on to say:

I have some reservations about some of these studies; I do not believe that they are optimally designed to exhibit the clinician at his best, but I submit that it is high time that those who are so sure that the 'right kind of study' will exhibit the clinician's prowess, should do this right kind of study and back up their claim with evidence.⁷⁶

Most of the shortcomings of the studies singled out by Meehl can be reduced to the following: little is known about the clinician(s) making predictions; some do not really compare the two methods of prediction, but rather compare clinical predictions; little is known about the kind and

75 Meehl, Paul E., "When Shall We Use our Heads Instead of the Formula", in the Journal of Counseling Psychology, Vol. 4, No. 4, 1957, p. 272.

76 Meehl, Op. Cit., p. 272.

amount of clinical study that is competing with the actuarial method; predictions are made on different sets of data; little is known about the amount of information the clinician is using to make his predictions; the weights employed by some were not optimally derived, but were "crude quantifications"; and in others, some clinicians did not predict for all the cases whereas the statistician predicted for all subjects in the group.

The experimental design he suggests can probably be summarized by the following statements:

1. Any empirical study of actuarial versus non-actuarial techniques should involve the making of predictions from similar or identical sets of information by the two methods, and the comparison of the success frequency arrived at in these two ways.^{76a}

2. The ideal design is one in which the same basic facts is subjected on the one hand to the skilled analysis of a trained clinician, and on the other hand is subjected to mechanical operations (tally entry, multiplication by weights, or the like). The predictions arrived at by these two methods are then compared with respect to their success.⁷⁷

Holt⁷⁸ claims that none of the studies cited by Meehl made pertinent comparisons between the two methods of prediction because the statistician had the distinct

^{76a}Meehl, Op. Cit., p. 84.

⁷⁷ Meehl, Op. Cit., p. 90.

⁷⁸ Holt, Op. Cit., p. 3.

advantage of having previously studied the way their predictive data were related to the criterion, whereas the clinician had not.

He proceeds to define the terms "actuarial" and "clinical". Pure actuarial prediction uses only objective data to predict a clear-cut criterion by the means of statistical processes.⁷⁹ The clinical approach is defined in the following manner: "Naive clinical" prediction uses data which is primarily qualitative,

...with no attempt at objectification, their processing is entirely a clinical and intuitive matter and there is no prior study of the criterion or the possible relation of the predictive data to it. Clinical judgment is at every step relied on not only as a way of integrating data to produce predictions, but also as an alternative to acquaintance with the facts.⁸⁰

The "sophisticated clinical" approach uses,

...qualitative data as well as objective facts and scores, ...but as much as possible of objectivity, organization, and scientific method are introduced into the planning, the gathering of data, and their analysis.⁸¹

Holt⁸² concludes that most of the studies singled out by Meehl "pitted" pure actuarial predictive designs against essentially "naive clinical" approaches. He also

79 Holt, Op. Cit., p. 4.

80 Holt, Op. Cit., p. 4.

81 Holt, Op. Cit., p. 4.

82 Holt, Op. Cit., p. 4.

recommends:

One kind of comparative study might teach us something even though it would be hard to do it properly; simultaneous attempts to predict the same criterion from the same data by clinicians and statisticians who have gone through the same preliminary steps.⁸³

Holt later questions whether or not this type of design makes sense and he offers two alternatives, one of which is:

A second possibility would be for two otherwise equally sophisticated methods to predict the same criterion, each using the kind of data most appropriate to it.⁸⁴

As long as the clinician and the statistician are trying to predict the same criterion, the clinician is likely to be working under a severe, though concealed handicap. ...The clinician ends up trying to predict grade-point average in the freshman year by a 'clinical synthesis' of high school grades and an intelligence test. This is a manifest absurdity; under the circumstances, how could the clinician do other than operate like a second rate Hollerith machine? If clinical judgment is really to be tested, it must operate on data that are capable of yielding insights. Moreover, it makes hardly any more sense to expect it to grind out numerical averages than to expect an actuarial table to interpret dreams.⁸⁵

Need we go as far as to predict grade-point average? If it is absurd for a clinical approach to predict grade-point average, is it also absurd for it to predict simply pass or fail? If so, are not most college admission officers

⁸³ Holt, Op. Cit., p. 5.

⁸⁴ Holt, Op. Cit., p. 5.

⁸⁵ Holt, Op. Cit., p. 6.

making absurd decisions (hence predictions) since they inevitably predict a pass upon admission of a candidate? Does not a merchant inevitably predict he will sell the product he purchases? The student counsellor directly or indirectly, consciously or unconsciously, predicts - and more often than not from purely objective test data! Many, if not most, situations where prediction is involved cannot draw upon a fund of statistical weights or formulae - and the clinical, intuitive, or impressionistic approach is the only acceptable alternative. Refusal to predict is very much akin to inactivity.

Holt⁸⁶ describes and discusses the results of a study conducted at the Menninger School of Psychiatry, where the "naive clinical" predictions are "pitted" against the "sophisticated clinical", in the selection of medical men for training in Psychiatry.

The results of the "naive clinical" prediction seem to be summarized in this statement.

The naive clinical method depends a good deal on the particular clinician doing the predicting and that - at least in this study - a pooling of judgments helped make up for the deficiencies of individuals.⁸⁷

⁸⁶ Holt, Op. Cit., p. 5.

⁸⁷ Holt, Op. Cit., p. 7.

The results of the "sophisticated clinical" predictions are:

...barely significant validity coefficients, about the same size as those from the naive clinical approach, despite the attempt to create a sophisticated clinical predictive system that involved many actuarial elements. I believe that the lesson of our findings up to this point is simple: with an adequate sample of information about a person, no matter how sophisticated the technique of prediction, there is a low ceiling on the predictive validity that can be obtained.⁸⁸

Some of the implications of this study are:

1. Clinical methods are more flexible than their actuarial counterparts;
2. Valid clinical impressions can be attained from an intensive study of a few cases, while it takes large samples to set up or revise an actuarial system;
3. If the pure actuarial approach were to be seriously applied to psychiatry, it would be necessary to develop a formula for each of many different types of practice and to revise it constantly as new developments created needs for new types of practitioners;
4. The important issue is the relative inertia of actuarial predictive systems and the maneuverability introduced when the generating prediction is done by clinical judgment - freedom which is a source of weakness as well as strength; and
5. When clinical methods are given a chance - when skilled clinicians use methods with which they are familiar, predicting a performance about which they know something - and especially when the clinician has a rich body of data and has made the fullest use of systematic procedures developed by actuarial workers,

⁸⁸ Holt, Op. Cit., p. 7.

including a prior study of the bearing of the predictive data on the criterion performance, then sophisticated clinical prediction can achieve quite respectable results.⁸⁹

In another paper, Meehl and Rosen⁹⁰ claim that it is difficult or impossible to determine the efficiency of most psychometric devices used in clinical psychology because base rates are seldom provided in the literature, samples are usually too small and there is insufficient data given on the distribution, cross-validation data are lacking, and results are reported in terms of the numbers of correct predictions only resulting for individuals within the group studied.

Also of interest is a study published in 1957 by Truesdell and Bath,⁹¹ and judged as pertinent in this controversy, was designed to determine the accuracy of clinical judgment of academic attrition and survival in the Division of Engineering at Iowa State College. The study also compared this clinical judgment to actuarial predictions. Of secondary interest, they compared the predictive skill of the nine judges who made the clinical predictions.

⁸⁹ Holt, Op. Cit., p. 11-12.

⁹⁰ Meehl, Paul E., and Albert Rosen, "Antecedent Probability and the Efficiency of Psychometric Signs, Patterns, or Cutting Scores", in the Psychological Bulletin, Vol. 52, No. 3, p. 194-216.

⁹¹ Truesdell and Bath, Op. Cit., p. 50-53.

The population consisted of one hundred male freshmen in the various engineering curricula at Iowa State. All entrants were submitted to entrance tests, but in addition they were given the Kuder Preference Record, form OH, Guilford's Inventory of Factors STDCR, and the Guilford-Martin Inventory of Factors GAMIN. These tests contributed twenty of the twenty-one variables, the remaining variable being the first quarter grade point average.

This group of one hundred was randomly selected from an initial group of 314 enrollees - forty-eight from the 48 per cent who had survived three academic years, and fifty-two from the 52 percent who had not.

For each of the 100, a profile was prepared utilizing the 21 variables, and nine male judges - all on the academic staff of Iowa State and all familiar with the instruments used - were required to predict attrition or survival. The actuarial prediction was based on a previously determined discriminant function of six of the twenty-one variables. The judges were divided into groups A, B, and C, depending on their counselling experience. They did not know the precise attrition rate of the students but they probably did have some conception about the attrition rates of the Engineering Division.

The results of this experiment are:

1. Considered separately, the judges differed significantly in their ability to predict attrition or survival (1% level), but when they are compared in groups, groups did not differ significantly. Reservations were made about the lack of difference between groups because there were only three judges per group and because their assignment to a group was somewhat arbitrary.
2. The judges revealed that they attached considerably more importance to the grade-point average than to any other factor. The discriminant function also gave more weight to this variable - more than the other five variables combined.
3. The data suggest approximate equivalence of the clinical and the actuarial methods of prediction under the conditions of the study. The number of correct predictions ranged from 56 to 78 and four judges "equaled or exceeded" the prediction made by the discriminant function, while five did not predict as well. The mean number of correct predictions for the groups were: A - 61/100; B - 71/100; and, C - 73/100.

The only Canadian study which can properly belong to this discussion is that conducted by the Student Advisory Services of the University of Alberta and which was the subject of a paper presented by Hough.⁹²

The purpose of this experiment was to predict success in First-Year Engineering. At the time the paper was read, only the results of the predictive efficiency of three experienced counsellors were available. The prediction

⁹² Hough, A.J.B., "An Experiment in Predicting Success in First Year Engineering", reported in the Annual Conference Report, University Counselling and Placement Association, Edmonton, Alberta, June, 1958, p. 31-34.

potential of the ten predictor variables were yet to be statistically determined, so strictly speaking, this particular study does not compare the efficiencies of the two approaches. However, in the opinion of the writer, the first part of this experiment is concerned with the "clinical" approach to prediction and consequently valued as relevant.

The data available to the three counsellors who were required to rate Pass, fail, or No Prediction for each of the 313 Freshmen under study were: Grade XII average; marks in Grade XII Algebra - Analytical Geometry and Trigonometry - and Physics; Grade XII mathematics-science average; English-Social Studies average in Grade XII; number of supplementals in Grade XII; the year Grade XII was completed; the A.C.F. score; and finally, the age of the student. It was recognized that an eleventh variable was operative; namely, the skill and training of the counsellors, all of whom were experienced.

Each of the counsellors rated the various students as Pass, Fail, or No Prediction possible, defined as follows: Pass, those who would be promotable, (this includes, from a survey of the tables presented - "clear pass" to "pass with up to and including three subject failures"); Fail, those who would be required to withdraw or would be in serious academic difficulty; No Prediction, those for whom there was a lack of data, or for whom the data available were conflicting, prediction was questionable.

The corporate ratings produced the following results:

Number predicted as Pass	- 182
Number predicted as Fail	- 54
Number of No Prediction	- 77
Total	- 313

The actual outcome was:

Pass	- 246
Fail	- 67
Total	- 313

Hough⁹³ reports that 91.2 per cent of those predicted as failing were promoted and 55.5 per cent of those predicted as failing were either required to withdraw from the University or advised to repeat.

These percentages were obtained by first excluding the seventy-seven in the No Prediction group and using the following results:

Pass	- 190
Fail	- 46
Total	- 236

In a 2 x 3 table, these are the total results:

Prediction	<u>Pass</u>	<u>Fail</u>	<u>Total</u>
Pass	166	16	182
Fail	24	30	54
No Prediction	<u>56</u>	<u>21</u>	<u>77</u>
Totals	246	67	313

93 Hough, Op. Cit., p. 32.

In a 2 x 2 table, these are the remaining results:

Prediction	<u>Pass</u>	<u>Fail</u>	<u>Total</u>
Pass	166	16	182
Fail	<u>24</u>	<u>30</u>	<u>54</u>
Totals	190	46	236

The 91.2 per cent correct pass prediction was arrived at by $\frac{182}{190} \times 100 = 91.2$ and the fail prediction was similarly calculated by $\frac{30}{54} \times 100 = 55.5$. These are meaningless. The important result is the number of correctly identified Pass which is arrived at by $\frac{166}{190} \times 100 = 87.3\%$ and similarly the correct number of Fail identified by $\frac{30}{46} \times 100 = 65.2\%$.

It is of interest also to point out that predictions were not made for 24.5 per cent (77/313) of the group, and that 72.7 per cent (56/77) of these rejects were, on their definition of terms, promotable. The proportion of Pass-Fail in this rejected group is very close to the actual proportion of Pass-Fail of the whole 313: $\frac{246}{313}$ and $\frac{67}{313}$, or 78.5 per cent and 21.5 per cent respectively.

Since the characteristics of the No Prediction group were such that prediction was not attempted, it is unlikely that had predictions been made for that group, they would have been done with the accuracy of the remaining group, especially in the light of the Pass-Fail proportion of this rejected group.

Finally, in the opinion of this writer, the predictive efficiency of these counsellors cannot really be determined because 25 per cent of the group was rejected. What really counts is the accuracy of prediction for the whole group under study. Hough⁹⁴ writes:

While the results of the experiment indicate that it is possible to predict academic success in first year engineering with considerable accuracy, although it appears less possible to accurately predict failure, (this follows the 91.2% versus 55.5% calculations!), it remains that, had this procedure been used for admission selections, 24 students who were promoted, or 10.2% (24/236) of the students for whom pass-fail predictions were made, would not have been admitted.

The writer wonders what would have been decided for the seventy-seven "No Prediction" had this procedure been used on selection. Administrative policy would very likely consider them quite risky, and likely not admissible. In that case, not 24 would not have been admitted (who eventually passed), but 101, out of which a total of 80 would have eventually passed - 25.5 per cent (80/313).

In a setting similar to that of the previous two studies, and where high school marks cannot be used as one of the predictor variables because they originate from most provinces in Canada and many foreign countries - hence not equatable - can one experienced counsellor predict attrition or survival for each student, using only post-admission,

94 Hough, Op. Cit., p. 33.

simple and objective group test data?

With the review of the literature in the background, it is fitting to present the means of prediction in the next chapter.

CHAPTER II

THE MEANS OF PREDICTION

To pursue our objective, we will now describe and evaluate the four paper-and-pencil groups tests that were chosen for this experiment.

There are, first of all, two tests of general mental ability: the Otis Self-Administering Tests of Mental Ability¹ - Higher Form, or its French equivalent l'Ottawa d'Habileté Mentale, and the Abstract Reasoning² subtest of the Differential Aptitude Tests.³ Then there are two tests of mathematical aptitude: the Amoss Mathematical Ability Test,⁴ and the Numerical Ability⁵ subtest of the D.A.T.

These instruments were selected primarily because they are known to be useful predictors of academic achievement; secondarily, because these tests are currently widely used and they are part of the usual battery of tests utilized by the Guidance Centre of the University of Ottawa; thirdly, because the Faculty of Science does not employ

1 Hereafter referred to as the Otis S.A.

2 Hereafter referred to as the D.A.T. Abstract.

3 Hereafter referred to as the D.A.T.

4 Hereafter referred to as the Amoss.

5 Hereafter referred to as the D.A.T. Numerical.

tests in its admission practices which are based on the high school record and letters of recommendation; and lastly, because they are economical in terms of time and money as compared to some more sophisticated batteries.

1. The Otis S.-A.

The Otis S.-A. has gained and still holds reputed value in the prediction of college success, as indicated by Kuder,⁶ Super,⁷ Garrett,⁸ Seashore,⁹ and Vaillancourt.¹⁰

⁶ Kuder, Frederick, "A Review of the Otis S.-A. Tests", quoted by C.K. Bureau, (ed.), The Third Mental Measurement Yearbook, Highland Park, New Jersey, the Gryphon Press, 1941, p. 248.

⁷ Super, Donald E., Appraising Vocational Fitness, New York, Harper & Brothers, 1949, p. 109.

⁸ Garrett, H.F., "A Review and Interpretation of Investigations of Factors Related to Scholastic Success in Colleges of Arts and Science, and Teachers' Colleges", in the Journal of Experimental Education, Vol. 18, No. 2, issue of December, 1949, p. 110.

⁹ Seashore, H., "Tenth Grade Tests as Predictors of Twelfth Grade Scholarship and College Entrance Status", in the Journal of Counselling Psychology, Vol. 1, No. 2, 1954, p. 110.

¹⁰ Vaillancourt, Raymond, "Local College Predictions with the Otis and Otis-Ottawa", unpublished M.A. thesis, School of Psychology and Education, University of Ottawa, 1955, p. vii.

It is a seventy-five item, paper-and-pencil, self-administering group test of general mental ability. The items are placed in a spiral omnibus arrangement, where items of different types: verbal, arithmetical, spatial - involving vocabulary, sentence meaning, proverbs, number series, analogies, etc. ... are combined into a single test, the easier items of all types appearing early in the test and the more difficult ones later, preceded by four practice problems. There are four forms: A, B, C, and D, in both the higher and intermediate levels. Both time limits of twenty or thirty minutes may be used and when it is administered in the shorter time limit, the scores must first be connected to the thirty minutes time limit before interpretation. The French equivalent Otis-Ottawa differs only in the number of forms, i.e., A and B in both the higher and the intermediate levels.¹¹

The manual¹² of the Otis S.-A. and the manual¹³ of the Otis-Ottawa both claim high reliability, coefficients reported in the .90's. According to Otis¹⁴ the test's validity lies in the method of standardization and the coefficients of correlation between the Otis S.-A. and

11 Isabelle, Laurent A., "Prediction of Academic Success at the Faculty of Pure and Applied Science of the University of Ottawa", unpublished M.Ed. paper, School of Psychology and Education, University of Ottawa, 1960, p. 9-10.

12. Otis, Arthur S., Manual, The Otis Self-Administering Tests of Mental Ability, Yonkers-on-Hudson, World Book, 1928, p. 12.

13 Shevenell, Raymond H., Manuel, Les Examens Otis-Ottawa d'Habileté Mentale, Ottawa, Edition de l'Université, 1948, p. 19.

14 Otis, Op. Cit., p. 12.

other tests of mental ability vary from a high of .88 to a low of .59. Two selected reviews, Traxler¹⁵ and Kuder¹⁶ also support that claim.

When we remember that talent is not the only condition of success, it is not surprising to find some investigations reporting rather low coefficients of correlation between the Otis and the academic criteria.¹⁷

One such study, reported in 1932, found the predictive value of the Otis S.-A. to be relatively low and discouraging, the coefficient obtained .40.¹⁸ In view of the fact that predictor variables chosen from past or present school achievement are known to be about the best single indices (Stuit, Garrett), median r 's around .6, it is more easily understood why Wilson and Hodges¹⁹ found the Otis S.-A. to be "discouraging".

A pilot study conducted by Isabelle²⁰ at the Faculty of Science maintains that the Otis S.-A. has some predictive

¹⁵ Traxler, Arthur E., "Reliability, Consistency, and Validity of the Otis I.Q.", in the Journal of Applied Psychology, Vol. 18, No. 2, issue of April, 1934, p. 244.

¹⁶ Kuder, Op. Cit., p. 109.

¹⁷ Isabelle, Op. Cit., p. 12.

¹⁸ Wilson, M.O., and J.H. Hodges, "Predicting Success in the Engineering College", in the Journal of Applied Psychology, Vol. 16, No. 14, issue of August, 1932, p. 350.

¹⁹ Wilson and Hodges, Op. Cit., p. 350.

²⁰ Isabelle, Op. Cit., p. 42.

value in that setting; r 's between the Otis S.-A. and the Final Average, .23, in two academic sessions; and Mathematics, .09 and .15; and Physics, .35 and .46; and Chemistry, .28 and .16.^{20a} In second year, for two academic sessions, the results were much lower and it was suggested that further research be conducted under improved conditions.

2. The D.A.T. Abstract Reasoning.

The D.A.T. Abstract test is

...intended as a non-verbal measure of the student's reasoning ability. The series presented in each problem requires the perception of an operating principle in the changing diagrams. In each instance, the student must discover the principle or principles governing the change of the figures and give evidence of his understanding by designating the diagram which should logically follow.²¹

The test is a series completion type, composed of fifty items employing abstract patterns or figures and the time limit for use in Grades VIII to XII is twenty-five minutes.

Super²² describes this test as attempting

... to measure reasoning without the use of words (Thurstone's R). Problems are of a spatial type made familiar by the A.C.E. Psychological Examination, and require finding the principle underlying a series of changing geometric figures.

^{20a} Isabelle, Op. Cit., p. 27-29.

²¹ Bennett, George K., Harold G. Seashore, and Alexander G. Wesman, Manual, (2nd ed.), Differential Aptitude Tests, New York, The Psychological Corporation, 1952, p. 6.

²² Super, Op. Cit., p. 370.

The D.A.T. Abstract was intended, in this study, as a supplement to the Otis S.-A. which would favor the foreign students who have language difficulties and who are, as a result, penalized by such a test as the Otis S.-A. or the Otis-Ottawa. The result on this test also serves as a check on the result of the Otis S.-A., thus favoring Canadian or non-Canadian students alike.

This procedure parallels that intended by the authors of the D.A.T. battery.

The Abstract Reasoning test supplements the general intelligence aspect of the Verbal and Numerical tests. It involves the ability to perceive relationship in abstract figure patterns - generalization and education of principles from non-language designs. ... Since the ability to reason with words is not the same as the ability to reason with abstract figures, the Abstract Reasoning cannot substitute for the Verbal Reasoning test. However, it may be valuable as a check on the Verbal score in some cases of known or suspected language handicap. For example, if a student with a foreign background scores low on the Verbal Reasoning test but relatively high when dealing with the abstract figure, the counsellor would have good reason to question the validity of the Verbal score for that student.²³

A reader might ask at this point, "Why not use the Verbal Reasoning instead of the Otis S.-A.?" The choice of the Otis S.-A. was prompted by the fact that a large number of the students in Science are French-speaking, thus raising very high the proportion of students with known or suspected language handicaps. The Verbal Reasoning, not yet

²³ Bennett, et.al., Op. Cit., p. 7.

available in French, it was thought that the Otis S.-A. and the Otis-Ottawa would serve better under these conditions. The D.A.T. Abstract which apparently can serve as a check on the Verbal Reasoning and Numerical Ability of the battery, can also probably serve as a suitable check on the Otis S.-A.

Although the D.A.T. battery was developed principally for use in vocational and educational guidance of high school students, the subtests have "a sufficient range of item difficulty to be used with most adult groups".²⁴ This statement supports the claims of the authors of the D.A.T. battery:

Since the D.A.T. have been effective at the twelfth grade level, it was perhaps inevitable that some colleges would experiment with their use at the college freshman level. ...In three of the four colleges (who reported their results) the tests all have adequate ceilings, no mean score is disturbingly close to the maximum possible score. The standard deviations, though on the whole a little smaller than those for twelfth graders, are nonetheless large enough to indicate that the spread of scores is adequate.²⁵

That the use of this subtest can be questioned for students in Science can be partly defended by the authors'

²⁴ Hunally, Jan C. Jr., Tests and Measurements, New York, McGraw-Hill, 1959, p. 183.

²⁵ Bennett, et.al., Op. Cit., p. 58.

statement:

The test of Abstract Reasoning predicts best the subsequent performance of pupils in Science courses, although in some schools it also predicts moderately well such diverse courses as office practice and industrial arts.²⁶

In support of this claim, they report coefficients of correlation between this subtest and grades in Algebra, obtained at Kansas State College, Pittsburg, Kansas, r .43; Physics and Mathematics obtained at State Teacher's College, Oswego, New York, r 's ranging from .51 to .34.²⁷

The validity of the D.A.T. battery can be demonstrated by a survey of Tables 17 and 18 of the manual.²⁸ The authors also remind the reader that validity is specific to the college and to the course and tests which have proved effective for one course might not predict equally well for another. The same applies from one school to another, or again for the same course in two different institutions.

Validity can also be determined by correlating test results with scores obtained on appropriate standardized tests, and again reference can be made to the voluminous statistical data included in the manual where such information

26 Bennett, et.al., Op. Cit., p. 38.

27 Bennett, et.al., Op. Cit., p. 54.

28 Bennett, et.al., Op. Cit., p. 58.

is provided: "...it is clear that the D.A.T. are valid for predicting school success as measured by standard achievement tests".²⁹

Anastasi³⁰ critically reviewed the D.A.T. and she wrote: "Extensive data are available on the empirical validity of the D.A.T., several thousand validity coefficients having been reported to date". Further she commented as follows:

The statistical procedures followed in finding norms, reliability, and validity, as well as the fullness and clarity with which the relevant data are reported in the manual, are especially commendable.³¹

This viewpoint is supported by Bechtoldt, Berdie, and Humphreys.³²

The equally numerous data on the reliability of the D.A.T. can best be summarized by Nunally's³³ statement: "The reliabilities of the tests are generally high, coefficients ranging from .65 to .93 for all except the mechanical comprehension test".

29 Bennett, et.al., Op. Cit., p. 59.

30 Anastasi, Anne, Psychological Testing, New York, MacMillan, 1954, p. 375.

31 Anastasi, Op. Cit., p. 376.

32 Bechtoldt, Harold, Ralph Berdie, and Lloyd G. Humphreys, three reviews, quoted by C.K. Buros, The Fourth Mental Measurement Yearbook, New Jersey, The Gryphon Press, 1953, p. 676-681.

33 Nunally, Op. Cit., p. 187.

3. The Amoss M.A.T.

The third instrument utilized in this experiment is

...a test of mathematical ability, comprising twenty-four items of the numerical series variety, arranged in increasing order of difficulty and preceded by two practice problems. It requires little verbal explanations and is administered in a twenty-minute time interval.³⁴

This test is set forth by the author as valid and reliable in the Province of Ontario, and probably in other similar areas, and according to the reverse side of the scoring key, which serves also as the manual, he considers it an adequate measure of mathematical ability:

It is not a test of mathematical attainment but of mathematical ability and aptitude, based on the thesis that a test of mathematical intelligence is best obtained by confronting the candidate with a sequence or sequences of situations involving complex and increasingly disparate relationships of the same kind as determined by usage rather than with an array of widely selected samplings arranged in order of difficulty only by trial and error standardization and inevitably subject to the influence of local learning.³⁵

Several studies utilizing a variety of tests of mathematical ability were reviewed by Isabelle³⁶ who wrote:

All have concluded from their research with these various tests of mathematical aptitude that they are useful predictors in virtually any subject area, and particularly in technical courses.

³⁴ Isabelle, Op. Cit., p. 14.

³⁵ Amoss, Harry, Manual, Mathematical Ability Test, Toronto, The Ryerson Press, 1937, p. 2.

³⁶ Isabelle, Op. Cit., p. 15-16.

On the strength of these results, the Amoss was selected for a pilot study conducted at the Faculty of Science and the following results were obtained in First Year in two academic sessions: Amoss and Final Average, r 's .30 and .43; and Mathematics, .30 and .38; and Physics, .32 and .81; and Chemistry, .35 and .20.³⁷

These results were again not supported in Second Year and further research was recommended under improved conditions.³⁸

4. The D.A.T. Numerical.

The manual of the D.A.T. describes this subtest as follows:

The Numerical Ability Items are designed to test understanding of numerical relationships and facility in handling numerical concepts. The problems are framed in the item type usually called "arithmetic computation" rather than in what is usually called "arithmetic reasoning". This was prompted by the desire to avoid the language elements of the usual arithmetic reasoning problem, in which reading ability may play a significant role. The computation form has the advantage of not being thus contaminated as a measure of numerical ability.³⁹

³⁷ Isabelle, Op. Cit., p. 35-37.

³⁸ Isabelle, Op. Cit., p. 48.

³⁹ Bennett, et.al., Op. Cit., p. 6.

The authors claim that the arithmetic computation type of item does not sacrifice reasoning ability and that they are sufficiently complex to challenge students in all high school grades.⁴⁰

The test consists of forty problems and the time allotted is thirty minutes. It is a multiple choice arithmetic test covering a wide variety of operations, from simple additions to the extraction of cube root.

It teams with the Verbal Reasoning test as a measure of general learning ability. Educationally it is important for prediction in such fields as mathematics, physics, chemistry, engineering and other curricula in which quantitative thinking is essential.⁴¹

Super⁴² relates this test to another of Thurstone's factors - N.

What has been written concerning the reliability and validity of the D.A.T., in the presentation of the D.A.T. Abstract, need not be repeated here. However, it may be worthwhile to mention the following coefficients of correlation between the results of this test with the marks obtained by some college students at Kansas State College referred to earlier. The r between the D.A.T. Numerical

40 Bennett, et.al., Op. Cit., p. 6.

41 Bennett, et.al., Op. Cit., p. 6.

42 Super, Op. Cit., p. 370.

and Algebra is reported at .67. The r 's between the D.A.T. Numerical and Physics and Mathematics at State Teacher's College, Oswego, New York, are reported as follows: .84 and .14, .41 and .49 respectively.⁴³

Berdie⁴⁴ examined the D.A.T., form A, as a predictor of engineering training by administering the battery to 472 entering Freshmen at the Institute of Technology at the University of Minnesota, in 1948. With the exception of the Numerical Ability, the tests did not contribute significantly to the prediction of academic achievement. He also suggests that a more difficult version of the Numerical may prove to be more effective at prediction in a setting such as the Institute of Technology.

5. The "Clinical" Appraisal and Prediction.

Finally, to comply with a "suggestion" made by Meehl⁴⁵ when he discusses some of the complicating factors met when interpreting the studies cited: "we know too little about the skill and qualifications of the clinicians who

43 Bennett, et.al., Op. Cit., p. 54.

44 Berdie, Ralph, "The Differential Aptitude Tests in Prediction of Engineering", in the Journal of Educational Psychology, Vol. 42, 1951, p. 120.

45 Meehl, P.E., Clinical vs Statistical Prediction: A Theoretical Analysis and a Review of the Evidence, Minnesota, University of Minnesota Press, 1954, p. 114.

were making the predictions", it was considered appropriate to briefly mention the writer's experience relative to the type of "clinical" prediction that was made in this experiment.

As a staff member of the Guidance Centre of the University of Ottawa since 1955, the writer was responsible for the post-admission group testing and counselling of the students of First and Second years at the Faculty of Science. This testing and counselling of the students promoted close association with some members of that Faculty - heads of departments and professors, not only concerned with the high failure rate in the first two years of the Science course, but who also became interested in the tests and the accuracy of the predictions being made. This association with the Faculty produced a greater and greater familiarity with the admission and promotion practices, as well as the academic standards of the Faculty, and the general trends in attrition and survival.

The term "general trends" reflects the fact that the pass-fail ratios have changed from year to year since 1955, and also that the so-called "base rates" have as yet not crystallized. Faculty policies seem not to have been permanently defined and the fluctuations in pass-fail ratios may be attributed, at least in part, to the many changes that are bound to occur in a still very young department.

With these instruments in hand, it will now be possible to present the experimental design of this project.

CHAPTER III

EXPERIMENTAL DESIGN

The design of this experiment will be presented in five parts: 1. The Testing Procedure; 2. The Criteria Chosen; 3. The Clinical Prediction; 4. The Statistical Predictions; and, 5. The Combination of the Techniques of Prediction.

1. The Testing Procedure.

The tests were administered by the writer, with the assistance of several proctors, at the end of October of each academic year under study: 1959-60, and 1960-61. The timing was planned to comply with the recommendations of the pilot study conducted by the writer in 1955-56 and 1956-57, and reported in an unpublished paper in 1960.¹ The end of October, six weeks after admission and three to four weeks prior to first-term examinations, was considered to be appropriate.

The testing was conducted in a large study hall where the lighting, the seating facilities, the freedom

¹ Isabelle, Laurent A., "Prediction of Academic Success at the Faculty of Pure and Applied Science of the University of Ottawa", unpublished M.Ed. paper, School of Psychology and Education, University of Ottawa, 1960, p. 17-19.

from distractions of all types, and the atmosphere were as conducive to suitable attitudes as possible. These prerequisites for optimal performance in mental tasks, and especially on timed psychological tests, corresponded to recommendations such as those outlined by Super.²

The testing is compulsory for all students of First and Second years, as it is stipulated in the Calendar,³ and this ensured the presence of all the students in those groups. This measure was adopted by the Faculty on the recommendation of the writer following the completion of the pilot study.⁴

A short introductory explanation of the reasons for the experiment was given, and it would seem that the students were adequately motivated to give their best performance on the tests. As an additional incentive, all the students were invited to consult the writer in order to discuss their test results. This particular incentive, although it is very time consuming, "pays off" handsomely in terms of eagerness and cooperativeness. Needless to say that it pays off equally well in terms of insights into

² Super, Donald E., Appraising Vocational Fitness, New York, Harper and Brothers, 1949, p. 109.

³ University of Ottawa, Calendar, Faculty of Science, 1960-61, p. 2.

⁴ Isabelle, Op. Cit., p. 48.

student problems, student attitudes towards studies, the Faculty policies, etc. The writer has been conducting testing in that Department since the spring of 1956 and the number of students visiting the writer to discuss their results - and subsequently, academic and personal problems as well - has increased steadily. During the 1959-60 academic year approximately 180 students (83%) were interviewed by the writer; interview time ranging from a minimum of twenty minutes to as much as twelve hours extended over a period of several weeks. The number of hours interviewing time was estimated at ninety hours, one half day per student on the average.

The student population includes English and French speaking Canadians, and several students from many foreign countries: Hong Kong, Formosa, India, Ceylon, Africa, South America, etc. The French speaking students were tested with the Otis-Ottawa, a French equivalent of the Otis S.-A.

The time limits decided upon for this experiment were: Otis S.-A. - twenty minutes; Amoss - 10 minutes; both the D.A.T. Numerical and Abstract - 15 minutes each. The decision for cutting the time limits was mostly arbitrary; observation of the performance of many students at the Guidance Centre prompted the writer to reduce time for this select population.

8. The Criteria Chosen.

For the two groups, Science I and Science II, of the academic year under study - 1959-60 - predictions of achievement were made for two sets of examinations which are:

1) the first term examinations, on full year courses, held in December; and, 2) the final examinations held in April. Partial cross-validation was attempted by predicting achievement for similar groups of the 1960-61 academic year. In this instance, however, only first term (December) examinations will serve as criteria of success and failure.

Clinical and statistical prediction of the general average is the main objective of this study, and according to the Calendar of the Faculty of Science,⁵ a mark of 60% is required for a pass. However, for the 1959-60 groups, since predictions are also made for final (April) marks, it is necessary to examine the policy of the Faculty in determining that final, second term average.

As stated in the Calendar,⁶ the aggregate of the year is considered in determining the final general average. In full year courses the combined weight of the two mid-term (November and February) tests equals that of the term test. This weighted average is called the aggregate of the

⁵ University of Ottawa, Op. Cit., p. 41.

⁶ University of Ottawa, Op. Cit., p. 41.

year and the calculation of the final mark is made according to a similar scheme as follows:

If the mark obtained in the final examination is between:	The weight of the final examination in the final mark is:	And the weight of the aggregate mark in the final mark is:
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90-100%	90%	10%
80-89%	80%	20%
70-79%	70%	30%
-- 69%	60%	40%

In this study, a pass on the first term general average will be simply 60%. A pass on the final, second term general average will be 60% and will include:

- 1) "clear" pass, i.e. no failures in any subjects; and,
- 2) "conditional" pass, i.e. when a student maintains the required 60% but fails in one, two or three subjects and when the Faculty allows that student to write supplemental examinations in these subjects.

The secondary objective of this study is to predict achievement in the three following subjects: Mathematics, Physics, and Chemistry. A pass mark in any given subject is 50%.⁷ In the Science courses, the Faculty awards two marks, one for knowledge of the theory, and one for the laboratory applications. Only the mark on the theory will be considered in this experiment.

⁷ University of Ottawa, Op. Cit., p. 41.

Even though the writer agrees with Guilford,⁸ Clarke,⁹ and Fleming,¹⁰ that class marks are of questionable reliability and validity, and that they are contaminated with irrelevant factors, we have no choice but to consider them for their probable value in studying the results.

Before proceeding to the next section the reader might want to know why prediction in Mathematics, Physics, and Chemistry, is included in this study, and secondly, what is the content of each of these subjects. Firstly, the Faculty considers that these subjects are of major importance. In fact, to be promoted from First year Science, not only must the student have a general average of 60%, but he must also have a 60% average on the mathematics courses in the program.¹¹ Secondly, for a student in Pure or Applied Science there is little doubt that success in the remaining two, Physics and Chemistry, is essential.

⁸ Guilford, J.P., Fundamental Statistics in Psychology and Education, New York, McGraw-Hill, 1950, p. 352.

⁹ Clarke, S.C.T., "Review of Some Previous Studies on Matriculation Problems", in the Alberta Journal of Educational Research, Vol. 4, No. 1, issue of March, 1958, p. 33.

¹⁰ Fleming, W.G., "Personal and Academic Factors as Predictors of First Year Success in Ontario Universities", Report No. 5, Chapter V, Atkinson Study of Human Resources, Department of Educational Research, Ontario College of Education, Toronto, 1959, p. 17.

¹¹ University of Ottawa, Op. Cit., p. 41.

The First year Mathematics courses bearing the codes MA 110, 120, and 130, are Analytic Geometry, Algebra, and Plane Trigonometry and Statics, respectively. The student's marks obtained on these examinations were combined to arrive at one mark in Mathematics. In Second year, the Mathematics courses are MA 210 and 220, Analytic Geometry, and Algebra - Differential and Integral Calculus.

The First year course in Physics, coded PY 100, is concerned with General Physics. In Second year, PY 204 and 230, correspond to Principles of Physics, and Principles of Mechanics.

The First year and Second year courses in Chemistry are CH 110 and 210 respectively, that is, General Chemistry and Principles of Chemistry.

3. The Clinical Prediction.

Before proceeding to the modus operandi of the clinical prediction made in this study, a definition of the term clinical is in order.

Referring to the various descriptions and definitions of the word "clinical", presented in the review of the literature, the reader will recall that clinical may be used in a restricted sense, and may also be used in a wider, more general sense.

In this dissertation, the term clinical is taken in the wide meaning, and it means nothing more than the subjective interpretation of the group test results, taken singly and/or in profile. In Holt's¹² analysis and definition of terms, the meaning attached to the term clinical in this study is probably partly "naive" and partly "sophisticated".

To the statistically oriented reader, this clinical prediction is nothing other than an unrefined actuarial prediction. The clinician, in the broad interpretation of his role, is in fact making use of a formula even though it may not be fully structured.

To the clinically inclined reader, clinical - in the restricted interpretation, the type of prediction made in this study may be an over simplification. Be that as it may, there must be room for the middle-of-the-road interpretation, the type of group test result interpretation made by the vast majority of counsellors and clinicians involved in educational and vocational counselling. And on this assumption, the "clinical" prediction in this context rests.

A few words of caution may be added. The clinician or the predictor in this experiment had access to other information about the students. Included with group test

¹² Holt, Robert R., "Clinical and Statistical Prediction: A Reformulation and Some New Data", in the Journal of Abnormal and Social Psychology, Vol. 56, No. 1, 1958, p. 1-12.

results were the name and age of the student, the date the tests were administered (the same for all students in Science I and similarly in Science II), the sex of the student, and finally, the year in which he or she was enrolled, i.e. Science I or II. This sketchy information, may, in the case of foreign students especially, have influenced the writer in some manner; however, this may be part of the clinical process which differentiated it from the actuarial. In any event, the possible biasing this information may have caused is mentioned here for the sake of clarity and "scientific" method.

Other information about the students was available in the records, such as the high school performance, letters of recommendation, personal history as determined by the registration form, etc. This material was not used because a meaningful comparison of the clinical and the actuarial methods can only be made if both approaches predict from the same data. It should also be mentioned that two of the tests upon which predictions were based, the Otis S.-A. and the Amoss, had been used in a pilot study,¹³ and the point-biserial coefficients of correlation between these instruments and the criteria were known. Due to the fact that these coefficients were quite low, or that there was

¹³ Isabelle, Op. Cit., p. 1-54.

considerable overlapping, cut-off scores, multiple r 's, or discriminant functions, were not established. These rather low r 's were attributed to such observations as poor testing conditions, inadequate representation of the groups tested, questionable marks, etc., and it was suggested that further experimentation with these tools and others was advisable. The other data referred to had not been previously evaluated as predictors of success in Science at this University. With these delineations in mind, a description of the clinical prediction will presently be given. The test scores were first converted to stanines, in other words, tentative local norms. In the case of the Otis S.-A., the I.Q. (or better, the educational quotient E.Q.) was also determined.

These stanines, taken singly, or in profile, were subjectively interpreted to arrive at predictions of the First term and final general averages for each student.

These predictions were:

- G : Good chances of success, or success very likely;
- P - G : Probable success, leaning towards G;
- P - D : Probable success, leaning towards D;
- D : Doubtful chances of success, or success very unlikely.

These predictions apply to the first term and final general averages for the academic year 1959-60, while they only apply to the first term general average of the 1960-61 academic year.

Further refinement was considered to be inappropriate, especially in the light of Sarbin's¹⁴ experience. He reported that in his study, some of the clinicians predicting academic success felt that there was no practical value in the refined eight point prediction and that they would do better merely to predict success versus failure.

Observation shows that there is a fairly large group whose results are conflicting and for whom predictions may be questionable. The writer felt that rejecting these cases is simply an avoidance of the task and that an evaluation of the predictive efficiency of the clinician becomes nearly meaningless if such a group is rejected. Prediction, using only extreme scores, may not be putting the clinician to the test. Furthermore, a significant comparison of the actuarial and clinical approaches to prediction, requires that prediction be made for all cases, or, at least, on identical groups, by the two methods.

The Probable category in this experiment comprises the cases where the test results are in conflict, i.e., a high score on the Otis S.-A. and a relatively low score on one or more of the remaining tests. However, throwing these cases into a Probable group was viewed as a near or "subtle"

¹⁴ Sarbin, T.R., "A Contribution to the Study of Actuarial and Individual Methods of Prediction", in the American Journal of Sociology, Vol. 48, No. 5, 1942, p. 597.

reject. The division of this shapeless category into two parts forced the clinician to further commit himself. These were not entirely chance predictions. Depending on which of the tests were high or low in relation to the profile, and/or depending on which subjects it was suspected the student would encounter difficulty, he was placed in the Probable to Good or the Probable to Doubtful. This may be thought of as crystal gazing by some, or pure guessing by others. This "impressionistic" hunch, however, is one of the descriptions made of the clinical predictive process. It is entirely subjective and the experiment is designed to test its hit accuracy.

The test of accuracy will be expressed in a frequency distribution of hits and misses, and its significance will be evaluated by an actuarial technique, the Chi-square. For this purpose, the G and P-G categories were combined to form a Pass group, and the P-D and D categories were combined as Fail. Since the predictions are thus reduced to a prediction of Pass or Fail, the reader might wonder why the Probable category was used at all. The underlying motives were to facilitate decision-making in the cases where there were conflicting results and also to facilitate the task of test results interpretation in the counselling situation. A reader who has experienced a task of predicting achievement will readily appreciate the inclusion of a Probable category.

4. The Statistical Predictions.

The statistical techniques appropriate to this material are now discussed. Reliability being the first concern of statisticians, it was considered likely useful to test the reliability of the marks in Mathematics, Physics, and Chemistry, as well as the general average, obtained by the students in First and Second year of the 1959-60 academic session. This was achieved by correlating the marks obtained at the end of the first term (December) and those obtained at the end of the second term (April). Making use of appropriate standardized achievement tests would probably be a better method, but this could not be realized, for two major reasons. Firstly, achievement tests developed in other areas may not be suitable in this setting for reasons of content in subject matter and standards. Secondly, an experimenter has often to contend with administrative policies, and in the light of the expenses to be incurred and testing time to be allotted, this measure had to be dropped.

Subsequently, given sets of serial results for the chosen tests, and a pass or fail dichotomy for the criteria, it was believed appropriate to use the point-biserial coefficient of correlation between:

1. The Otis S.-A. and the general average of all subjects;
2. The Otis S.-A. and marks in Mathematics;
3. The Otis S.-A. and marks in Physics;
4. The Otis S.-A. and marks in Chemistry;
5. The D.A.T. Abstract and the same four criteria;
6. The Amoss and the same four criteria;
7. The D.A.T. Numerical and the same criteria.

This was done for the first term and final marks for both Science I and II of the 1959-60 academic year, but only for the first term marks of the following 1960-61 session. To make sure that these coefficients of correlation thus obtained were not due to chance alone, the t test of significance was applied.

It was then possible to derive the multiple r 's and the Beta weights. The multiple regression equation prediction was made and its results evaluated by the Chi-square method.

Of secondary interest was the prediction of achievement in Mathematics, Physics, and Chemistry. The multiple regression equation predictions in these subjects were also evaluated by the Chi-square method. These predictions will not serve any further purpose, since they do not strictly form part of the study of the clinical and actuarial predictive efficiencies which are confined to the general average only.

The second actuarial predictive technique utilized is that proposed by Lykken,¹⁵ a profile analysis which allows for the assessment of similarity and dissimilarity of profiles with respect to the criterion dimension.

In the application of this method, the stanine scores 1 to 5 inclusive were assigned a value of 0, and the stanines 6 to 9 a value of 1. Using the binary system, where the values for the four predictor variables, in the order used: Otis S.-A., Amoss, D.A.T. Numerical, and D.A.T. Abstract, are 1, 2, 4, and 8, a student's stanine scores on the four tests, each reduced to 1 or 0, and multiplied by the corresponding weight of 1, 2, 4, and 8, become cell numbers when summed. In the binary system, the cells range from 0 to 16, and in this experiment they were arranged in four rows of four, proceeding from top left corner down to bottom right corner, from left to right for each row.

The students' cell numbers were then tallied in their respective cells, and in each cell they were divided into two groups - pass or fail - as determined by the criterion, in this case the general average. Then a decision of pass or fail was made for each student depending upon the ratio of pass to fail in that cell to which he was

¹⁵ Lykken, D.T., "A Method of Actuarial Pattern Analysis", in the Psychological Bulletin, Vol. 53, 1956, p. 102-107.

assigned, and in the case of a ratio of 1:1, the pass or fail was decided by the pass to fail ratio of that row of cells to which that student belonged. An illustration of the process might be in order at this point. Given stanines of 6, 5, 7, 7 for the four tests in the order given above, a student's cell number becomes 13, that is 1 times 1, plus 0 times 2, plus 1 times 4, plus 1 times 6, equals 13. All cell numbers of 13 are tallied in cell number 13, in the pass or fail group, depending on the average obtained on the examinations. Once all tallies are made, and pass-fail ratios determined for each cell and each row of cells, then it is an easy matter to decide a pass or fail for each cell number. The results of this prediction were also evaluated by the Chi-square method.

5. The Combination of Methods.

In combining the predictions made by the clinical technique and the two statistical techniques, the decision of pass or fail for each student was arrived at by the agreement of any two of the three techniques. The resulting combined predictions were also evaluated by the Chi-square method.

The evaluation of the predictive efficiencies of the four predictions: clinical, multiple regression equation, profile analysis, and the combination of the three, was then

made by a comparison of the proportion of accuracy each technique achieved in predicting the pass, the fail, and the total over-all prediction.

This design will serve as our plan for the subsequent presentation and discussion of results.

CHAPTER IV

PRESENTATION OF RESULTS

The presentation and discussion of the results will follow the plan set out in the preceding chapter. They will be handled in eleven consecutive sections:

1. Reliability of the criteria and of the tools of measurement, Tables I and II;
2. Clinical and Profile Analysis predictions of the first term and final general averages, Science I, 1959-60, their frequency distributions and significance, Tables III and IV;
3. Clinical and Profile Analysis Techniques in predicting the first term and final general averages, Science I, 1959-60, their significant differences, Tables V and VI;
4. Clinical prediction of the first term general average, Science I, 1960-61, its frequency distribution and significance, Table VIII;
5. Clinical, Multiple Regression Equation, Profile Analysis, and Combination of the three techniques in predicting the first term and final general averages, Science II, 1959-60, their frequency distributions and significance, Tables VIII, IX, X, and XI;
6. Clinical, Multiple Regression Equation, Profile Analysis, and Combination of the three techniques in predicting the first term general average, Science II, 1959-60, their significant differences, Tables XII, XIII, XIV, XV, XVI, and XVII;
7. Clinical, Multiple Regression Equation, Profile Analysis, and Combination of the three techniques in predicting the final general average, Science II, 1959-60, their significant differences, Tables XVIII, XIX, XX, XXI, XXII, and XXIII;

8. Clinical, Multiple Regression Equation, Profile Analysis, and Combination of the three techniques in predicting the first term general average, Science II, 1960-61, their frequency distributions and significance, Tables XXIV, XXV, XXVI, and XXVII;

9. Clinical, Multiple Regression Equation, Profile Analysis, and Combination of the three techniques in predicting the first term general average, Science II, 1960-61, their significant differences, Tables XXVIII, XXIX, XXX, XXXI, XXXII, and XXXIII;

10. Multiple Regression Equation prediction of the first term and final marks in Mathematics and Physics, and final marks in Chemistry, Science II, 1959-60, its frequency distribution and significance, Tables XXXIV, XXXV, and XXXVI;

11. Discussion of the results, Table XXXVII.

1. Reliability of the Criteria and of the Tools of Measurement.

The reliability of the marks obtained by the students of First and Second years in Mathematics, Physics, and Chemistry, and, the reliability of the general average, was calculated by correlating the marks of the first term with those obtained at the end of the second (or final) term. The weights that the mid-term (November and February) and the first term (December) marks hold in the final mark, as explained earlier, probably account for much of the correlation. These coefficients are presented in Table I. The reader is referred to Tables XLII and XLIII of the Appendix for additional information, such as the means and standard deviations of the marks in question.

Table I.-

Reliability Coefficients of the Four Criteria, Yielded by the First Term and Final Examinations, Science I and II, 1959-60.

Criterion	Science I			Science II		
	N	r	SE	N	r	SE
Mathematics	106	.849	±.027	87	.793	±.040
Physics	102	.696	±.051	86	.657	±.062
Chemistry	104	.778	±.039	86	.715	±.054
General Average	106	.879	±.022	86	.823	±.034

The reliability of the four tests, the Otis S.-A., the Amoss, the D.A.T. Numerical, and the D.A.T. Abstract, was obtained by correlating the test-retest results. The students in Science I and Science II of the 1959-60 academic year who failed, and the students in Science I, 1959-60, who were promoted to Science II, 1960-61, were retested with the same instruments under similar conditions. The scores obtained by these students in the 1959-60 testing session were correlated with those they obtained in the 1960-61 session. The total number of students who were retested is sixty-one, and this relatively small N may account in part for the fact that the coefficients of correlation presented in Table II are not impressive. The writer points out that the relatively short time-limits established for the testing in this situation may also play a part in the restriction of range. Tables XLVI, XLVII, and XLVIII of the Appendix will provide the reader with additional information regarding the test results, such as the means and standard deviations of all the test results, as well as those obtained by the sixty-one students in both testing sessions, presented separately.

Table II.-

Test - Retest Reliability^a of the Four Predictor Variables,
N:61^b.

Predictor	r	SE
Otis S.-A.	.843	± .037
Amoss	.854	± .073
D.A.T. Numerical	.785	± .049
D.A.T. Abstract	.792	± .048

a Corrected for restriction of range.

b Population includes those who failed Science I and Science II, in 1959-60, and who are repeating their year in 1960-61, and, those who were promoted from Science I, 1959-60, to Science II, 1960-61.

2. **Clinical and Profile Analysis Prediction of the First Term and Final General Averages, Science I, 1959-60, Their Frequency Distributions and Significance.**

The pattern for all the subsequent tables pertaining to the frequency distributions and the Chi-square significance of these distributions will be set by Table III, a standard 2 x 2 table, containing as it does: the type of prediction made, that is Clinical, Multiple Regression Equation, Profile Analysis, or the Combination of the three; the number of predicted pass; the number of predicted fail; the total of the predictions. All of these frequencies are compared to the actual outcome and the results are evaluated by the Chi-square method.

A study of Table III, where the frequency distribution of the Clinical prediction is compared to the actual outcome, in both the first term and final examinations, reveals that the Clinical prediction is significant at the .02 level in forecasting the first term general average, and at the .05 level in forecasting the final general average. Closer scrutiny of the First term predictions shows the number of accurate and inaccurate individual predictions as:

	<u>Accurate</u>		<u>Inaccurate</u>
Pass	26 on 45, or 58%	Pass	25 on 51, or 49%
Fail	47 on 72, or 65%	Fail	19 on 66, or 29%
Total	77 on 117, or 62%	Total	44 on 117, or 38%

Table III.-

Clinical Prediction of the First Term and Final General Average, Science I, 1959-60: Its Frequency Distribution and Significance^a.

Clinical Prediction	Actual Outcome		
	Pass	Fail	Totals
Pass			
First Term	26	25	51
Final	25	26	51
Fail			
First Term	19	47	66
Final	22	44	66
Totals			
First Term	45	72	117
Final	47	70	117

^a First Term, Chi-square - 5.98, P less than .02.
 Final, Chi-square - 3.24, P less than .05.

Similarly, the number of accurate and inaccurate predictions of individual success or failure, of the Science I, 1959-60 final general average is:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	25 on 47, or 53%	Pass	26 on 51, or 51%
Fail	44 on 70, or 63%	Fail	22 on 66, or 33%
Total	69 on 117, or 59%	Total	48 on 117, or 41%

The Profile Analysis predictions for the same group: Science I, 1959-60, of the same criterion - the general average of the first term and that of the final term, will be found in Table IV, where the level of significance of this actuarial prediction is at .001 in both instances. A breakdown of this table will show that the number and percentage of accurate and inaccurate predictions of the first term general average by this technique is as follows:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	21 on 45, or 47%	Pass	11 on 32, or 34%
Fail	61 on 72, or 85%	Fail	24 on 85, or 28%
Total	82 on 117, or 71%	Total	35 on 117, or 29%

Similarly, the number of predictions of the final general average that is accurate and inaccurate.

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	23 on 47, or 49%	Pass	13 on 36, or 36%
Fail	61 on 72, or 81%	Fail	24 on 81, or 29%
Total	84 on 117, or 68%	Total	37 on 117, or 32%

Table IV.-

Profile Analysis Prediction of the First Term and Final
General Average, Science I, 1959-60: Its Frequency
Distribution and Significance^a.

Profile Analysis Prediction	Actual Outcome		
	Pass	Fail	Totals
Pass			
First Term	21	11	32
Final	23	13	36
Fail			
First Term	24	61	85
Final	24	57	81
Totals			
First Term	45	72	117
Final	47	70	117

^a First Term, Chi-square - 13.73, P less than .001.
Final, Chi-square - 12.17, P less than .001.

3. Clinical and Profile Analysis Techniques in Predicting the First Term and Final General Averages, Science I, 1959-60, Their Significant Differences.

The pattern for all the subsequent tables that are concerned with significant differences between predictive techniques will be set by Table V, containing as it does: a comparison of the proportions of accuracy of prediction by two methods, for pass, fail and total; the differences in proportions; the standard error of these differences; the respective t ratios; and the level or levels of significance between predictive efficiencies.

The significant difference between the Clinical and the Profile Analysis techniques in predicting the first term general average of the Science I group, 1959-60, is presented in Table V. We note that the Profile Analysis technique is significantly more efficient, .01 level, than the Clinical in predicting the fail group. On the other hand, in prediction of the pass group, although the Clinical technique is not significantly better than the Profile Analysis technique, it is worthy of note that the Clinical method tends to be superior in accuracy, t ratio 1.71, when it is known that the .05 level requires 1.96. The two techniques are equally efficient when total predictions are considered, t ratio only .15.

Table V.-

Clinical and Profile Analysis Techniques in Predicting the
First Term General Average, Science I, 1959-60: Their
Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Clinical Prediction	.5778	.6528	.6239
Profile Analysis Prediction	.4667	.8472	.7009
Differences	.1111	.1944	.0770
SE of the Diff.	.0648	.0548	.0616
t Ratios	1.71	<u>3.55^a</u>	.13

^a P less than .01.

In forecasting the final general average, Science I, 1959-60, we see in Table VI, that the Profile Analysis technique is again more efficient than the Clinical in the identification of the fail group, a difference significant at the .01 level. The techniques do not differ, at the accepted levels of significance, in predicting the pass group, nor do they differ on the total accurate predictions, $\frac{t}{n}$ ratios .66 and .15 respectively.

The Multiple Regression Equation was not derived for prediction in Science I, 1959-60, because the point-biserial coefficients of correlation between the tests and the criteria were too low. The experimental data in Table XLIX of the Appendix bears this out.

Since the Combination prediction requires the results of three predictive techniques, it was not possible to perform this operation for this group of Science I, the results of only two methods being available. As previously explained the Combination prediction consists of the agreement of at least two techniques on a pass or a fail.

4. Clinical Prediction of the First Term General Average, Science I, 1960-61, Its Frequency Distribution and Significance.

The frequency distribution of the Clinical prediction of the first term general average in terms of pass or fail, Science I, 1960-61, is presented in Table VII. The

Table VI.-

Clinical and Profile Analysis Techniques in Predicting the Final General Average, Science I, 1959-60: Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Clinical Prediction	.5319	.6286	.5897
Profile Analysis Prediction	.4893	.6143	.6838
Differences	.0426	.1857	.0941
SE of the Diff.	.0648	.0574	.0632
t Ratios	.66	<u>3.24^a</u>	.15

^a P less than .01.

Table VII.-

Clinical Prediction of the First Term General Average,
Science I, 1960-61: Its Frequency Distribution and
Significance^a.

Clinical Prediction	Actual Outcome		Totals
	Pass	Fail	
Pass	15	47	62
Fail	8	51	59
Totals	23	98	121

^a Chi-square - 2.22, P less than .20.

number and percentage of accurate and inaccurate predictions is readily determined as follows:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	15 on 23, or 65%	Pass	47 on 62, or 76%
Fail	51 on 98, or 52%	Fail	8 on 59, or 14%
Total	66 on 121, or 55%	Total	55 on 121, or 45%

The Chi-square is significant at the .20 level only. This is not surprising in view of the pass-fail ratio of this group on first term examinations: 19% of the group passed, 81% failed.

Needless to point out that the Multiple Regression Equation could not be derived for this group. Table XVI of the Appendix, containing the point-biserial coefficients between the tests and the criteria will bear this out. The Profile Analysis technique, as it is applied in this experiment, could not differentiate between the pass and the fail, and consequently, no other results will be presented for this group.

5. Clinical, Multiple Regression Equation, Profile Analysis, and Combination of the Three Techniques in Predicting the First Term and Final General Averages, Science II, 1959-60, Their Frequency Distributions and Significance.

Following the same pattern of presentation of results, and beginning with Table VIII which contains those obtained by the Clinical prediction, we note that it differs

Table VIII.-

Clinical Prediction of the First Term and Final General Average, Science II, 1959-60: Its Frequency Distribution and Significance^a.

Clinical Prediction	Actual Outcome		
	Pass	Fail	Totals
Pass			
First Term	29	21	50
Final	39	11	50
Fail			
First Term	7	42	49
Final	19	30	49
Totals			
First Term	36	63	99
Final	58	41	99

^a First Term, Chi-square - 20.43, P less than .001.
 Final, Chi-square - 15.69, P less than .001.

significantly from chance, .001 level, in both instances - first term and final.

The accurate and the inaccurate identifications of the pass and fail on the first term examinations are as follows:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	29 on 36, or 81%	Pass	21 on 50, or 42%
Fail	42 on 63, or 67%	Fail	7 on 49, or 14%
Total	71 on 99, or 72%	Total	28 on 99, or 28%

Similarly, the accuracy and inaccuracy of the Clinical technique in forecasting pass or fail on the final general average, Science II, 1959-60, are:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	39 on 58, or 67%	Pass	11 on 50, or 22%
Fail	30 on 41, or 73%	Fail	19 on 49, or 39%
Total	69 on 99, or 70%	Total	30 on 99, or 30%

The Multiple Regression Equation prediction of the first term and final general averages, Science II, 1959-60, is also significant at the .001 level in both instances. A breakdown of Table IX will show that the percentages of hits and misses are for the first term:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	18 on 36, or 50%	Pass	9 on 27, or 33%
Fail	54 on 63, or 86%	Fail	18 on 72, or 25%
Total	72 on 99, or 73%	Total	27 on 99, or 27%

Table IX.-

Multiple Regression Equation Prediction of the First Term and Final General Average, Science II, 1959-60: Its Frequency Distribution and Significance^a.

Multiple Regression Prediction	Actual Outcome		Totals
	Pass	Fail	
Pass			
First Term	18	9	27
Final	48	23	71
Fail			
First Term	18	54	72
Final	10	18	28
Totals			
First Term	36	63	99
Final	58	41	99

^a First Term, Chi-square - 14.73, P less than .001.
 Final, Chi-square - 8.42, P less than .001.

In predicting for the final term, the results are:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	48 on 58, or 83%	Pass	23 on 71, or 32%
Fail	18 on 41, or 44%	Fail	10 on 28, or 36%
Total	66 on 99, or 67%	Total	33 on 99, or 33%

The frequency distributions yielded by the Profile Analysis technique in predicting pass or fail, Science II, 1959-60, on both first term and final examinations, are again significant at the .001 level. Breaking down Table X in the usual manner, we obtain the following results for the first term set:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	22 on 36, or 61%	Pass	7 on 29, or 24%
Fail	56 on 63, or 86%	Fail	14 on 70, or 20%
Total	78 on 99, or 77%	Total	21 on 99, or 21%

The results of the prediction for the final term are:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	45 on 58, or 78%	Pass	15 on 60, or 25%
Fail	26 on 41, or 63%	Fail	13 on 39, or 33%
Total	71 on 99, or 72%	Total	28 on 99, or 28%

The three techniques in combination identify the pass and the fail, on both the first term and final examinations of the Science II group, 1959-60, at the .001 level, as did each one separately. The results presented in Table XI, beginning with the first term distribution are:

Table X.-

Profile Analysis Prediction of the First Term and Final
General Average, Science II, 1959-60: Its Frequency
Distribution and Significance^a.

Profile Analysis Prediction	Actual Outcome		
	Pass	Fail	Totals
Pass			
First Term	22	7	29
Final	45	15	60
Fail			
First Term	14	56	70
Final	13	26	39
Totals			
First Term	36	63	99
Final	58	41	99

^a First Term, Chi-square - 27.65, P less than .001.
Final, Chi-square - 16.91, P less than .001.

Table XI.-

A Combination^a of the Clinical, Multiple Regression Equation, and Profile Analysis Techniques, in Predicting the First Term and Final Average, Science II, 1959-60: Its Frequency Distribution and Significance^b.

Combination Prediction	Actual Outcome		Totals
	Pass	Fail	
Pass			
First Term	25	9	34
Final	47	17	64
Fail			
First Term	11	54	65
Final	11	24	35
Totals			
First Term	36	63	99
Final	58	41	99

a The pass or Fail decision was arrived at by the agreement of at least two of the three techniques.

b First Term, Chi-square - 30.47, P less than .001.
Final, Chi-square - 16.45, P less than .001.

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	25 on 36, or 69%	Pass	9 on 34, or 21%
Fail	54 on 63, or 86%	Fail	11 on 65, or 17%
Total	79 on 99, or 80%	Total	20 on 99, or 20%

The number and percentages of accurate and inaccurate predictions, final term, are:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	47 on 58, or 81%	Pass	17 on 64, or 27%
Fail	24 on 41, or 59%	Fail	11 on 35, or 31%
Total	71 on 99, or 72%	Total	28 on 99, or 28%

6. Clinical, Multiple Regression Equation, Profile Analysis, and Combination of the Three Techniques in Predicting the First Term General Average, Science II, 1959-60, Their Significant Differences.

The differences between the predictive efficiencies of the Clinical and Multiple Regression Equation techniques are presented in Table XII. In identifying the pass group, the Clinical prediction is significantly superior to the Multiple Regression equation, t ratio 4.78, P less than .01. Whereas in identifying the fail group, the inverse is true, that is, the Multiple Regression Equation is significantly better, t ratio 3.32, also significant at the .01 level. It can readily be seen that the two techniques, on total predictions, are of equal efficiency, t ratio .16.

The comparison of the Clinical and Profile Analysis techniques, Table XIII, reveals an identical pattern: in

Table XII.-

Clinical and Multiple Regression Equation Techniques in Predicting the First Term General Average, Science II, 1959-60: Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Clinical Prediction	.8056	.6667	.7172
Multiple Regression Prediction	.5000	.8571	.7273
Differences	.3056	.1904	.0101
SE of Diff.	.0640	.0574	.0632
t Ratios	<u>4.78^a</u>	<u>3.38^b</u>	.16

a P less than .01.

b P less than .01.

Table XIII.-

Clinical and Profile Analysis Techniques in Predicting the
First Term General Average, Science II, 1939-60: Their
Significant Differences.

	Proportion of Accuracy		Total
	Pass	Fail	
Clinical Prediction	.8056	.6667	.7172
Profile Analysis Prediction	.6111	.8571	.7677
Differences	.1945	.1904	.0505
SE of Diff.	.0632	.0574	.0632
t Ratios	<u>3.08^a</u>	<u>3.32^b</u>	.80

a P less than .01.

b P less than .01.

predicting the pass, Science II, 1959-60, first term, the Clinical method is significantly more efficient than the Profile Analysis, t ratio 3.08, P less than .01; and in predicting the fail, the Profile Analysis technique is more efficient, t ratio 3.32, P less than .01; and finally, on the whole, the techniques are nearly equal in efficiency.

When the two actuarial techniques are compared to each other, Table XIV, we note that none of the differences between the Multiple Regression Equation and Profile Analysis predictions are significant. It may be useful to point out that the Profile Analysis technique, when considering prediction of the pass group, tends to be better than the Regression Equation, t 1.59, approaching the .05 level of significance requiring 1.96.

The comparison of each technique, one clinical, two actuarial, with the three in combination, Tables XV, XVI, and XVII, will presently be undertaken.

The Combination prediction differs significantly from the Clinical in identifying the fail group, t ratio 3.27, P less than .01. On the other hand, for the pass group, the inverse tends to be true; although the t ratio 1.81 is not significant, it is quite close to the level required for .05. On the total accuracy of prediction, the Combination prediction is only somewhat better than the Clinical, t ratio 1.35.

Table XIV.-

**Multiple Regression Equation and Profile Analysis Techniques
in Predicting the First Term General Average, Science II,
1959-60: Their Significant Differences.**

	Proportion of Accuracy		Total
	Pass	Fail	
Multiple Regression Prediction	.5000	.8571	.7273
Profile Analysis Prediction	.6111	.8571	.7677
Differences	.1111	.0000	.0404
SE of the Diff.	.0700	.0663	.0616
t Ratios	1.59	.00	.66

Table XV.-

Clinical Technique and the Combination^a of Techniques in Predicting the First Term General Average, Science II, 1959-60: Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Clinical Prediction	.8056	.6667	.7172
Combination Prediction	.6944	.8571	.7980
Differences	.1112	.1904	.0808
SE of the Diff.	.0616	.0583	.0600
t Ratios	1.81	<u>3.27^b</u>	1.35

^a The Pass or Fail decision was arrived at by the agreement of at least two of the three techniques.

^b P less than .01.

Table XVI.-

Multiple Regression Equation Technique and the Combination^a of Techniques in Predicting the First Term General Average, Science II, 1959-60: Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Multiple Regression Prediction	.5000	.8571	.7273
Combination Prediction	.6944	.8571	.7980
Differences	.1944	.0000	.0707
SE of the Diff.	.0666	.0663	.0600
t Ratios	<u>2.83</u> ^b	.00	1.18

^a The Pass or Fail decision was arrived at by the agreement of at least two of the three techniques.

^b P less than .01.

Table XVII.-

Profile Analysis Technique and the Combination^a of Techniques
in Predicting the First Term General Average, Science II,
1959-60: Their Significant Differences.

	Proportion of Accuracy		Total
	Pass	Fail	
Profile Analysis Prediction	.6111	.8571	.7677
Combination Prediction	.6944	.8571	.7980
Differences	.0833	.0000	.0303
SE of the Diff.	.0678	.0663	.0583
t Ratios	1.23	.00	.52

a The Pass or Fail decision was arrived at by the agreement of at least two of the three techniques.

The Combination prediction is significantly better than the Multiple Regression Equation, .01 level, in identifying the pass group - Table XVI. It is only slightly better than the Regression Equation when considering the total accurate predictions, t ratio 1.18, which is not sufficient to attain accepted levels of significance. The two predictions are equal in identifying the fail group.

Finally, when comparing the Combination prediction and the Profile Analysis prediction, Table XVII, we note that none of the differences are significant, and if we may single out trends, it seems that the Combination prediction is slightly better than the Profile Analysis method in selecting pass, t 1.23.

7. Clinical, Multiple Regression Equation, Profile Analysis, and Combination of the Three Techniques in Predicting the Final General Average, Science II, 1959-60, Their Significant Differences.

The differences between the predictive efficiencies of the Clinical and Multiple Regression Equation techniques, in identifying the pass and the fail of the final general average, Science II, 1959-60, are presented in Table XVIII, and two of the three are significant at the .01 level.

In this situation, the Multiple Regression Equation is clearly superior in identifying the pass group, t ratio 2.59, whereas the Clinical method is clearly superior in

Table XVIII.-

Clinical and Multiple Regression Equation Techniques in
Predicting the Final General Average, Science II,
1959-60: Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Clinical Prediction	.6724	.7317	.6970
Multiple Regression Prediction	.6276	.4390	.6667
Differences	.1552	.2927	.0303
SE of Diff.	.0600	.0671	.0656
t Ratios	<u>2.59^a</u>	<u>4.36^b</u>	.46

a P less than .01.

b P less than .01.

distinguishing the fail group, t ratio 4.36. It is also shown that on the total accurate prediction the techniques are equally effective, t .46.

These findings, compared to those shown in Table XII, are interesting. As it was pointed out, the Clinical method was definitely superior to the Multiple Regression Equation in predicting the first term general average; and the inverse was true in predicting the fail group. In other words, in predicting the first term general average, the Clinical method is more accurate in the pass group, while in predicting the final general average in the pass group the Multiple Regression Equation is superior. The same reversal occurs in predicting the fail group; here, the Multiple Regression is more accurate than the Clinical for the first term, less accurate for the final.

In Table XIX, the Clinical method is compared to the Profile Analysis technique in predicting the pass and fail of the final general average, Science II, 1959-60. In this situation, none of the differences between the techniques are significant. However, it may be useful to point out that the Profile Analysis technique tends to be better than the Clinical in predicting the pass, t ratio 1.66, while the Clinical tends to be better than the Profile Analysis in predicting the fail. Although these differences are not significant, the trend is very similar to the previous, that

Table XIX.-

Clinical and Profile Analysis Techniques in Predicting the
Final General Average, Science II, 1959-60: Their
Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Clinical Prediction	.6724	.7317	.6970
Profile Analysis Prediction	.7759	.6341	.7172
Differences	.1035	.0976	.0202
SE of the Diff.	.0625	.0663	.0640
t Ratios	1.66	1.47	.32

is, when predicting for the first term general average, the Clinical is a better technique, while for the fail group the Profile Analysis is the more efficient. Reference to Table XIII discussed previously will bear this out. This is, then, another instance where the findings in prediction of the final general average is a reversal trend.

When the two actuarial techniques are compared to determine the differential predictive abilities of each, for the same group: final general average, Science II, 1959-60, presented in Table XX, we note that the only significant difference occurs in predicting the fail group. The Profile Analysis technique is clearly superior than the Multiple Regression Equation, t 2.78, P less than .01. These two techniques are nearly equal in predicting the pass, t .93, and also nearly equal on the total prediction.

When the same two techniques predict for the first term general average, Table XIV, we noted that no significant differences were found. May we again point out a partial reversal in trend? In predicting the pass group, first term, the Multiple Regression Equation tends to be superior to the Profile Analysis, while the reverse tends to occur in the final term, t ratios 1.59 and .93 respectively. This is not the case for the fail groups, first and final terms. In the first term, both techniques are equally efficient; in the final term, the Profile Analysis is clearly more efficient.

Table IX.-

Multiple Regression Equation and Profile Analysis Techniques
in Predicting the Final General Average, Science II, 1959-60:
Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Multiple Regression Prediction	.8276	.4390	.6667
Profile Analysis Prediction	.7759	.6341	.7172
Differences	.0517	.1951	.0505
SE of the Diff.	.0557	.0700	.0648
t Ratios	.93	<u>2.78^a</u>	.78

^a P less than .01.

Following the same pattern of presentation, we will again present the comparison of each technique with the three techniques in combination, Tables XXI, XXII, and XXIII, final term, Science II, 1959-60.

The Combination of techniques in predicting the pass group (Table XXI) is clearly superior to the Clinical alone, t ratio 2.84, P less than .05, approaching .01. In predicting the fail group, the Clinical method is more efficient than the Combination, t ratio 2.21, P less than .05, also approaching .01. No significant difference is found on the total prediction: t ratio .32. When comparison is made between the same two methods in predicting the first term general average, Table XV, we note the same reversal in trend as was pointed out earlier.

The Combination prediction in predicting the fail group, Table XII, is more efficient than the Multiple Regression Equation alone, t 2.09, P less than .05. No significant differences are found in predicting the pass, and similarly on the total prediction. To compare these findings with those presented in Table XVI where the same two techniques are pitted against each other - first term prediction, we discover that in this case, the Combination prediction is better at predicting the pass group. A trend towards reversal is still at play.

Table XXI.-

Clinical Technique and the Combination^a of Techniques in Predicting the Final General Average, Science II, 1959-60: Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Clinical Prediction	.6724	.7317	.6970
Combination Prediction	.8103	.5854	.7172
Differences	.1379	.1463	.0202
SE of the Diff.	.0616	.0663	.0640
t Ratios	<u>2.24</u> ^b	<u>2.21</u> ^c	.32

a The Pass or Fail decision was arrived at by the agreement of at least two of the three techniques.

b P less than .05.

c P less than .05.

Table XXII.-

Multiple Regression Equation Technique and the Combination^a
of Techniques in Predicting the Final General Average,
Science II, 1959-60: Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Multiple Regression Prediction	.8276	.4390	.6667
Combination Prediction	.8103	.5854	.7172
Differences	.0175	.1464	.0505
SE of the Diff.	.0548	.0700	.0648
t Ratios	.32	<u>2.09</u> ^b	.78

^a The Pass or Fail decision was arrived at by the agreement of at least two of the three techniques.

^b P less than .05.

Table XXIII.-

Profile Analysis Technique and the Combination^a of Techniques
in Predicting the Final General Average, Science II, 1959-60:
Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Profile Analysis Prediction	.7759	.6341	.7172
Combination Prediction	.8103	.5854	.7172
Differences	.0344	.0487	.0000
SE of the Diff.	.0574	.0693	.0632
t Ratios	.60	.70	.00

^a The Pass or Fail decision was arrived at by the agreement of at least two of the three techniques.

Finally, when comparing the Combination prediction and the Profile Analysis prediction, for the same group, Table XXIII, we note that none of the differences are significant. The same conclusion was made when these two techniques were compared in Table XVII, concerned with prediction of the first term general average, and no reversal in trends seems to be at play in this comparison.

8. Clinical, Multiple Regression Equation, Profile Analysis, and Combination of the Three Techniques in Predicting the First Term General Average, Science II, 1960-61, Their Frequency Distributions and Significance.

The presentation and discussion of results of the same techniques, applied in a similar situation of another academic year, Science II, 1960-61, will now be done in the same fashion.

The frequency distribution of the Clinical prediction of the first term general average is found in Table XXIV. A breakdown of this table in terms of percentage of accuracy and inaccuracy of prediction will demonstrate that:

	<u>Accurate</u>		<u>Inaccurate</u>
Pass	32 on 44, or 73%	Pass	25 on 57, or 44%
Fail	27 on 52, or 51%	Fail	12 on 39, or 31%
Total	59 on 96, or 60%	Total	37 on 96, or 40%

This frequency distribution is significant at the .05 level, Chi-square 4.83.

TableXXIV.-

Clinical Prediction of the First Term General Average,
 Science II, 1960-61: Its Frequency Distribution and
 Significance^a.

Clinical Prediction	Actual Outcome		Totals
	Pass	Fail	
Pass	32	25	57
Fail	12	27	39
Totals	44	52	96

^a Chi-Square - 4.63, P less than .05.

The frequency distribution of the Multiple Regression Equation Prediction, presented in Table XXV, is significant at the .05 level of confidence, Chi-square 3.87.

A close study of this table, in terms of accurate and inaccurate predictions, shows the following:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	12 on 44, or 27%	Pass	6 on 18, or 33%
Fail	46 on 52, or 88%	Fail	32 on 78, or 41%
Total	58 on 96, or 60%	Total	38 on 96, or 40%

The prediction of pass and fail on first term examinations, Science II, 1960-61, by the Profile Analysis technique, is significant at the .001 level of confidence, Table XXVI.

In terms of hits and misses, this distribution shows:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	32 on 44, or 73%	Pass	22 on 54, or 41%
Fail	30 on 52, or 58%	Fail	12 on 42, or 29%
Total	62 on 96, or 65%	Total	34 on 96, or 35%

Finally, a study of the predictive accuracy of the three techniques in combination, Table XXVII, The distribution is significant at the .001 level, Chi-square 24.50.

Again in terms of accuracy and inaccuracy, the predictions are:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	28 on 44, or 64%	Pass	16 on 46, or 35%
Fail	36 on 52, or 69%	Fail	16 on 50, or 32%
Total	44 on 96, or 67%	Total	32 on 96, or 33%

Table XV.-

Multiple Regression Equation Prediction of the First Term
General Average, Science II, 1960-61: Its Frequency
Distribution and Significance^a.

Multiple Regression Prediction	Actual Outcome		Totals
	Pass	Fail	
Pass	12	6	18
Fail	32	46	78
Totals	44	52	96

^a Chi-square - 3.87, P less than .05.

TableXXVI.-

Profile Analysis Prediction of the First Term General average, Science II, 1960-61: Its Frequency Distribution and Significance^a.

Profile Analysis Prediction	Actual Outcome		Totals
	Pass	Fail	
Pass	32	22	54
Fail	12	30	42
Totals	44	52	96

^a Chi-square - 8.96, P less than .001.

Table XXVII.-

A Combination^a of the Clinical, Multiple Regression Equation, and Profile Analysis Techniques, in Predicting the First Term General Average, Science II, 1960-61: Its Frequency Distribution and Significance^b.

Combination Prediction	Actual Outcome		Totals
	Pass	Fail	
Pass	28	16	46
Fail	16	36	50
Totals	44	52	96

a The Pass or Fail decision was arrived at by the agreement of at least two of the three techniques.

b Chi-square - 24.50, P less than .001.

9. Clinical, Multiple Regression Equation, Profile Analysis, and Combination of the Three Techniques in Predicting the First Term General Average, Science II, 1960-61, Their Significant Differences.

Beginning with the study of the differences in predictive ability between the Clinical and the Multiple Regression Equation methods, Table XXVIII.

In this situation, the Clinical prediction is significantly more efficient than the Multiple Regression Equation prediction, in identifying the pass group, t ratio 7.10, P less than .01. The reverse is true when predicting the fail group; in this case the Multiple Regression Equation is far better, t ratio 6.16, also P less than .01.

When compared to the predictions made for Science II first term examinations of the previous year, Table XII, we note identical results.

On the total of the predictions, these two techniques do not differ, t ratio .00. For the 1959-60 group, we note a close relationship, t .16.

Table XXIX pertains to the differences between the Clinical and Profile Analysis techniques in prediction of the first term general average, Science II, 1960-61. It is observed that none of the differences are significant, t ratios .00, .94, and .39, for the pass, fail, and total groups respectively.

Table XXVIII.-

Clinical and Multiple Regression Equation Techniques in
Predicting the First Term General Average, Science II,
1960-61: Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Clinical Prediction	.7273	.5098	.6042
Multiple Regression Prediction	.2727	.8846	.6042
Differences	.4546	.3748	.0000
SE of the Diff.	.0640	.0608	.0707
t Ratios	<u>7.10^a</u>	<u>6.16^b</u>	.00

a P less than .01.

b P less than .01.

Table XXIX.-

Clinical and Profile Analysis Techniques in Predicting the First Term General Average, Science II, 1960-61: Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Clinical Prediction	.7273	.5098	.6042
Profile Analysis Prediction	.7273	.5770	.6458
Differences	.0000	.0672	.0416
SE of the Diff.	.0648	.0714	.0700
t Ratios	.00	.94	.59

For purposes of comparison, we recall the predictions made by the same two techniques for the first term 1959-60, Table XIII. In this situation, significant differences were found between the methods of prediction. There is some resemblance in the trends for predicting fail. In 1959-60, the Profile Analysis method predicted fail more accurately than did the Clinical. In 1960-61, there is a tendency for the Profile Analysis to predict the fail group more accurately than the Clinical method, t .94. It is definitely not significant, but it seems that some consistency exists, moderate as it is.

In Table XXX we will find the proportions of accurate predictions obtained by the Multiple Regression Equation and the Profile Analysis methods. There are significant differences: the Profile Analysis method better at predicting pass, t ratio 7.02, P less than .01; and the Multiple Regression Equation better at predicting fail, t 5.12, again at the .01 level of confidence. The techniques balance out on the total number of accurate predictions, t only .59.

Differences are found also when we compare the predictive accuracies of the same techniques in the first term group, Science II, 1959-60, Table XIV. In this case, none of the differences are significant. If it is permitted to single out trends, we note that the Profile Analysis technique tends to be a better predictor of the pass, in 1959-60,

Table XXX.-

Multiple Regression Equation and Profile Analysis Techniques
In Predicting the First Term General Average: Science II,
1960-61: Their Significant Differences.

	Proportion of Accuracy		Total
	Pass	Fail	
Multiple Regression Prediction	.2727	.8846	.6042
Profile Analysis Prediction	.7273	.5770	.6458
Differences	.4546	.3076	.0416
SE of the Diff.	.0648	.0600	.0700
t Ratios	<u>7.02^a</u>	<u>5.12^b</u>	.59

a P less than .01.

b P less than .01.

t 1.59, and for the 1960-61 group the trend is more significant, t 7.02.

The comparison of each technique, one clinical, two actuarial, with the three in combination, Tables XXXI, XXXII, and XXXIII, for the first term, Science II, 1960-61, will be presented and discussed.

Table XXXI emphasizes the differences between the Combination technique and the Clinical. The Combination method predicts the fail group with greater accuracy than the Clinical, t ratio 2.63, P less than .01. This was also the case with the same comparison for the 1959-60 group, Table XV. For the prediction of pass, the Clinical method tends to be better than the Combination, t ratio 1.35. The same findings are observed for the 1959-60 group, Table XV. On the total accurate predictions, the techniques balance out in the 1959-60 group and also in the 1960-61 group.

When comparing the Multiple Regression Equation prediction with that of the Combination, Table XXXII, first term 1960-61, the Combination prediction identifies the pass group with more accuracy, t ratio 5.42, P less than .01. The same observation was made for the 1959-60 comparable group, Table XVI. On predicting the fail group, the Multiple Regression Equation is more effective than the Combination, t ratio 3.35, P less than .01, while for the 1959-60 group, Table XVI, no difference was found. Both

Table XXXI.-

Clinical Technique and the Combination^a of Techniques in Predicting the First Term General Average, Science II 1960-61: Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Clinical Prediction	.7273	.5098	.6042
Combination Prediction	.6364	.6925	.6667
Differences	.0909	.1825	.0625
SE of the Diff.	.0671	.0695	.0695
t Ratios	1.35	<u>2.65</u> ^b	.90

^a The Pass or Fail decision was arrived at by the agreement of at least two of the three techniques.

^b P less than .01.

Table XXXII.-

Multiple Regression Equation Technique and the Combination^a of Techniques in Predicting the First Term General Average, Science II, 1960-61: Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Multiple Regression Prediction	.2727	.8846	.6042
Combination Prediction	.6364	.6923	.6667
Differences	.3637	.1923	.0625
SE of the Diff.	.0671	.0574	.0693
t Ratios	<u>5.42^b</u>	<u>3.35^c</u>	.90

a The Pass or Fail decision was arrived at by the agreement of at least two of the three techniques.

b P less than .01.

c P less than .01.

Table XXXIII.-

Profile Analysis Technique and the Combination^a of Techniques
in Predicting the First Term General Average, Science II,
1960-61: Their Significant Differences.

	Proportion of Accuracy		
	Pass	Fail	Total
Profile Analysis Prediction	.7273	.5770	.6458
Combination Prediction	.6364	.6923	.6667
Differences	.0909	.1153	.0209
SE of the Diff.	.0671	.0686	.0686
t Ratios	1.35	1.68	.30

^a The Pass or Fail decision was arrived at by the agreement of at least two of the three techniques.

techniques are equally effective on total predictions, and this was also the case in the 1959-60 academic session.

Finally, to compare the Combination technique with the Combination, we refer to Table XXXIII, where no significant differences occur in all predictions. The same conclusions were made for the comparable group in 1959-60, Table XVII.

It may be useful to point out the trends in both situations. In the 1960-61 group, the Profile Analysis technique tends to predict pass more accurately than does the Combination, while the reverse seems to be true in 1959-60.

10. Multiple Regression Equation Prediction of the First Term and Final Marks in Mathematics and Physics, and Final Marks in Chemistry, Science II, 1959-60, its Frequency Distribution and Significance.

The results of the Multiple Regression Equation prediction of the first term and final marks in Mathematics, Table XXXIV, will first be studied. The distributions presented are significant at the .01 and .02 levels of confidence. Broken down into accurate and inaccurate predictions, the first term results are:

Table XXXIV.-

Multiple Regression Equation Prediction of the First Term and Final Marks in Mathematics, Science II, 1959-60: Its Frequency Distribution and Significance^a.

	Actual Outcome		Totals
	Pass	Fail	
Pass			
First Term	13	9	22
Final	49	27	76
Fail			
First Term	20	57	77
Final	8	15	23
Totals			
First Term	33	66	99
Final	57	42	99

^a First Term, Chi-square - 8.44, P less than .01.
Final, Chi-square - 6.37, P less than .02.

<u>Accurate</u>	<u>Inaccurate</u>
Pass 13 on 33, or 39%	Pass 9 on 22, or 41%
Fail 57 on 66, or 86%	Fail 20 on 77, or 26%
Total 70 on 99, or 71%	Total 29 on 99, or 29%

The accurate and inaccurate predictions in Mathematics, final marks, are:

<u>Accurate</u>	<u>Inaccurate</u>
Pass 49 on 57, or 86%	Pass 27 on 76, or 36%
Fail 15 on 42, or 36%	Fail 8 on 23, or 35%
Total 64 on 99, or 65%	Total 35 on 99, or 35%

The Multiple Regression Equation predictions of pass and fail in Physics, on both first term and final marks, are presented in Table XXIV, where the first term predictions are significant at the .001 level, and those of the final term marks are significant at the .05 level, Chi-squares 18.75 and 5.16 respectively.

Presented in terms of accurate and inaccurate predictions, the results of the first term predictions are:

<u>Accurate</u>	<u>Inaccurate</u>
Pass 57 on 57, or 100%	Pass 29 on 86, or 34%
Fail 13 on 42, or 31%	Fail 00 on 00,
Total 70 on 99, or 71%	Total 29 on 99, or 29%

The same breakdown for the final term predictions

shows:

<u>Accurate</u>	<u>Inaccurate</u>
Pass 34 on 47, or 72%	Pass 26 on 60, or 43%
Fail 26 on 52, or 50%	Fail 13 on 39, or 33%
Total 60 on 99, or 61%	Total 39 on 99, or 39%

Table XXXV.-

Multiple Regression Equation Prediction of the First Term
and Final Marks in Physics, Science II, 1959-60: Its
Frequency Distribution and Significance^a.

	Actual Outcome		Totals
	Pass	Fail	
Pass			
First Term	57	29	86
Final	54	26	80
Fail			
First Term	0	13	13
Final	13	26	39
Totals			
First Term	57	42	99
Final	47	52	99

^a First Term, Chi-square - 18.75, P less than .001.
Final, Chi-square - 5.16, P less than .05.

The Multiple Regression Equation was derived for prediction of the final marks in Chemistry, and not for the first term marks, because the coefficients of correlation between the tests and the criteria were too low to warrant this calculation. The reader will note that the derivation of the Regression Equation was hardly worth while for the prediction of the final marks in Chemistry, Chi-square .47, not significantly different from chance.

To follow the pattern set for all other presentations of results, in terms of accurate and inaccurate predictions, we obtain:

<u>Accurate</u>		<u>Inaccurate</u>	
Pass	70 on 71, or 99%	Pass	27 on 97, or 28%
Fail	1 on 28, or 4%	Fail	1 on 2, or 50%
Total	71 on 99, or 72%	Total	28 on 99, or 28%

Multiple Regression Equations to predict Mathematics, Physics, and Chemistry, for Science I, 1959-60, and Science I and II, 1960-61, were not derived because the point-biserial r 's were too low in all cases. Reference is made to Tables XLIX, LIII, and LIV of the Appendix to support this statement.

Table XXIV.-

Multiple Regression Equation Prediction of the Final Marks
in Chemistry, Science II, 1959-60: Its Frequency
Distribution and Significance^a.

	Actual Outcome		Totals
	Pass	Fail	
Pass	70	27	97
Fail	1	1	2
Totals	71	28	99

^a Chi-square - .47.

11. Discussion of Results.

A tabulation of the number of times each technique is successful in being more efficient than, or equal to, the other techniques in predicting pass or fail has been prepared. Table XXXVII contains the following information: proceeding from top left to top right, the techniques are enumerated: Clinical (CL), Multiple Regression Equation (MR), Profile Analysis (PA), Combination of the three techniques (CO), and Total, each section divided into two parts Pass (P) or Fail (F). The last column Totals includes the addition of the Pass and Fail columns that are separately added in the column immediately preceding it. Proceeding from top left to bottom left, we note the same listing of techniques under given codes, and each category is divided into Better than (B) and Equal to (E).

The frequencies in these "cells" are to be understood in the following manner. Beginning with the Clinical technique, on the Y axis, we note that this technique, on row B, was successful five times in predicting pass, four times in predicting fail, when it was compared to the Multiple Regression Equation; we also note that the Clinical method was more efficient two times in predicting pass, and once in predicting fail, than was the Profile Analysis method; and finally, that in comparison to the Combination

Table XXXVII.-

Comparison of the Clinical, Multiple Regression Equation, Profile Analysis, and the Combination of the Three Techniques in Over-all Predictions: Their Respective Numbers of Successes.

		Methods of Prediction								Totals ^a			
		Clinical		Multiple		Profile		Combined		Total		P & F -Del. & E	
		P	F	P	F	P	F	P	F	P	F		
CL	B			5(2)	4(1)	2(1)	1(0)	3(0)	4(1)	10(3)	9(2)	19	(5)
	E					4	2	2		6	2	8	
MR	B	1	2				1		1	1	4	5	
	E					2	1	1		3	1	5	
PA	B		3	3(1)	3(1)			2(0)	2(0)	5(1)	8(4)	13	(5)
	E							3	3	3	3	6	
CO	B	1	2	2	1					3	3	6	
	E				1						1	1	
T ^b	B	2	7	10(5)	8(3)	2(1)	2(1)	5(0)	7(2)	19(4)	24(6)	43	(10)
	E				1	6	3	6	3	12	7	<u>38</u>	
											81		

a This column contains the total number of Pass-Fail "victories" for each technique, row B, and the total number that remain after deletions are made. The number of Pass-Fail "equals" in this column have to be added to the number of "equals" in the T row at the bottom in order to obtain a total number of "equals" for each technique.

b This Totals row, B & E is a check row. However, to count the number of "equals" on Pass-Fail the E totals for each technique have to include those in this row plus those in the Totals^a column. Therefore total of equals - 38, and not 19.

prediction, the Clinical was more successful in predicting pass three times, fail four times. In the total column, the Clinical technique predicted pass ten times, fail nine times, a total of nineteen "victories". The numbers in parentheses, row B - Clinical, and row B - Profile Analysis, will be explained later. On row E, the Clinical was equal to the Profile Analysis technique in predicting pass efficiently - four times, and in predicting fail - two times; and in comparison to the Combination prediction, it was equally effective on two occasions in predicting pass. The Clinical method was then equally effective in predicting pass six times, in predicting fail two times, in comparison to other techniques, a total of eight "equals". Therefore, to read "victories", the reader will proceed from the Y axis, and along row B for each technique. To read "equals" the reader must again proceed from the Y axis, this time row E, for each technique. He must also add vertically the results in row E for each technique, to arrive at a total of "equals". For example, selecting the Multiple Regression Equation, row E, we note that it was equal to the Profile Analysis on two occasions in predicting pass, and once on fail. However, these are also "equals" for the Profile Analysis technique. Therefore to obtain the number of times the Profile Analysis was equal to others in predicting pass or fail, add three on pass, three on fail, total column, to six on pass, three on

fail, Total (bottom) row E. Sum total of equals for the Profile Analysis technique is then: nine plus six, equals fifteen.

The number of "victories" each technique has to its credit in the total 81 comparisons is:

Clinical	19
Multiple R	5
Profile Analysis	13
Combination	<u>6</u>
	43

The number of ties is:

Clinical	8
Multiple R	5
Profile Analysis	15
Combination	<u>10</u>
	38

Some additional explanations are necessary at this point. Firstly, all the predictions of Pass or Fail that were made in this study were tallied. Secondly, the Clinical and the Profile Analysis techniques were victorious by default in the following instances, and this will explain the numbers in the parentheses, row B of the Clinical and Profile Analysis sections.

1. Science I, 1959-60, both first term and final term: the clinical technique could not be compared to the Multiple Regression Equation - the reader will remember that the Multiple Regression could not be calculated - and, as a result, the Clinical technique is victorious by default in predicting Pass and Fail on the first term, and also on the

final term. It might be argued that this is not fair. In concession, subtract 2 from Total column Pass, leaving a total of 6, and similarly subtract 2 from the Fail column, 9 minus 2, leaving 7.

Similarly for the Profile Analysis technique. Subtract 2 from Pass, 5 minus 2 leaving 3, and 2 from Fail, 8 minus 2, leaving 6.

2. Science I, 1959-60, both first and final terms: subtract 2 from the total column Pass, and 2 from Fail, for the Clinical and the Profile Analysis, because the comparisons between these two techniques and the Combination of techniques could not be done for obvious reasons. This second subtraction, Clinical, leaves a total of 6 in Pass, 5 in Fail (8 minus 2, and 7 minus 2, respectively). The totals that remain in the Profile Analysis category, Pass 1, (3 minus 2) and Fail 4 (8 minus 2).

3. Science I, 1960-61, first term: only the Clinical prediction was made, and then, not significantly different from chance. In this case, strike off 3 more from Pass, leaving 3, 3 from Fail, leaving 2. The numbers in parentheses are then the number of successful competitions with the other techniques that remain after the subtractions referred to above were made.

As a result of a scrupulous deletion, the Clinical method obtains the following results:

	<u>Before Deletions</u>	<u>After Deletions</u>
Pass	10	3
Fail	9	2
Total	19	5

Similarly, these are the comparative results obtained by the Profile Analysis technique:

	<u>Before Deletions</u>	<u>After Deletions</u>
Pass	5	1
Fail	8	4
Total	13	5

But, is this fair? Is not a victory by default, a victory? On the one hand, then, the Clinical prediction is as efficient as the Multiple Regression Equation, ratio 5:5, and as the Profile Analysis, ratio 5:5, but not quite as efficient as the Combination, ratio 5:6. On the other hand, it is strikingly superior, ratios of 19:5, 19:13, and 19:6, respectively.

A comparative study of the two actuarial techniques pitted against each other is easily done. Considering "victories":

Multiple R vs Profile	ratio 5:13, or 5:5 after deletions;
Multiple R vs Combination	ratio 5:6;
Profile vs Combination	ratio 13:6, or 5:6 after deletions.

Considering next the "equals":

Multiple R vs Profile	ratio 5:15;
Multiple R vs Combination	ratio 5:10;
Profile vs Combination	ratio 15:10.

A detailed analysis of this table might be in order.

In prediction of Pass, taken alone:

- 1) Clinical vs Multiple R, ratio 10:1,
or 3:1, after deletions;
- 2) Clinical vs Profile, ratio 10:5,
or 3:1, after deletions;
- 3) Clinical vs Combination, ratio 10:3,
or 3:3, after deletions.

In prediction of Fail, taken alone:

- 1) Clinical vs Multiple R, ratio 9:4,
or 2:4, after deletions;
- 2) Clinical vs Profile, ratio 9:8,
or 2:4, after deletions;
- 3) Clinical vs Combination, ratio 9:3,
or 3:3, after deletions.

The writer concludes, from this experimental data, that the Clinical technique of appraising group test data, in an academic setting such as the Faculty of Science at this institution, is, a more flexible and more effective predictor of achievement than are the more complicated and sophisticated actuarial techniques. Holt¹ arrived at a similar conclusion in his study.

The "clinical" evaluation of group test results, as is very likely done by a great number of counsellors, makes prediction available early in the academic year, a prediction that is very useful in academic counselling. The

¹ Holt, Robert R., "Clinical and Statistical Prediction: A Reformulation and Some New Data", in the Journal of Abnormal and Social Psychology, Vol. 56, No. 1, 1956, p. 7.

actuarial prediction, in this study - postdiction - can only become available after examinations are held, and after time-consuming and costly statistical analysis. It may be argued that cut-off scores, Multiple R 's or discriminant functions need only be prepared once, on an adequate group, and then applied to new situations. In the writer's experience, at this point, this method would likely prove disappointing. Admission policies, academic standards, and marking systems seem to be in a state of flux.

From an administrative point of view, is it more practical to predict successes, or is it more practical to predict failures? It is not the purpose of this dissertation to argue this contentious question, however, in the light of the data from this experiment, if emphasis is placed on prediction of the pass group, the Clinical technique seems to be more effective than are the other techniques. If emphasis is placed on predicting the fail group, the Clinical method is still better, with possibly one exception, where the Clinical and Profile Analysis techniques are nearly equal in predicting this group, ratio 9:8. However, if one takes into account the results of the Clinical prediction, and those of the Profile Analysis prediction - after deletions are made - the Clinical no longer leads in predicting the fail group. In this situation, the Multiple Regression and the Profile Analysis are superior in efficiency.

Would we arrive at similar conclusions if the pass-fail ratios on examinations, on both first and final terms, more "reasonable"? The writer is tempted to conclude with Hohne,² that "rigorous selection based upon refined techniques will not materially decrease university failure without fundamental changes in the policies and practices of university examiners."

Finally, in studying the Multiple Regression Equation as a predictor of success in Mathematics, Physics, and Chemistry, Tables XXXIV, XXXV, and XXXVI, it is evident that the prediction was significant in predicting success or failure in Mathematics, Chi-square 8.44, P less than .01 - first term marks, and Chi-square 6.37, P less than .02 - final term marks. Prediction in Physics was also possible for that group of students under study, Science II, 1959-60, Table XXXV. There is some doubt about prediction in Chemistry, Table XXXVI. It was not possible to calculate the Multiple Regression Equation for the prediction of the first term set of marks, and although a Multiple Regression Equation was calculated in predicting final marks, the results were disappointing.

² Hohne, H.H., Success and Failure in Scientific Faculties of the University of Melbourne, Melbourne, Australian Council for Educational Research, 1955, reported by Garside, R.F., "The Prediction of Examination Marks in Mechanical Engineering Students at King's College, Newcastle, in the British Journal of Psychology, Vol. 48, Part 3, issue of August, 1957, p. 220.

SUMMARY AND CONCLUSIONS

Four paper-and-pencil group tests, two measuring general mental ability: the Otis S.-A. and the D.A.T. Abstract (verbal and non-verbal respectively), and two measuring mathematical ability; the Amoss, and the D.A.T. Numerical (number series and arithmetic fundamentals respectively) were administered to all the students in First and Second years Science, academic sessions 1959-60 and 1960-61.

The results of these tests, expressed in stanine scores, were evaluated subjectively to yield a clinical prediction of pass or fail of students on the general average obtained on first term examinations and on final term examinations. The same results were analyzed by a pattern or profile analysis technique to yield one type of actuarial prediction of success and failure of the same criterion. Point-biserial r 's and multiple regression equations were also derived to yield a third prediction, also actuarial, of the same criterion. Of secondary interest was the prediction of achievement in Mathematics, Physics, and Chemistry by the Multiple Regression Equation derived for each of these criteria.

The purpose of this dissertation was to compare the predictive efficiencies of the Clinical method to the

predictive efficiencies of the two Actuarial techniques, and also to compare the actuarial methods to each other. The study of the predictive efficiency of each technique in comparison to the results of predictions made by all these techniques in combination was also realized.

The predictions by means of all four techniques were only possible in Science II, 1959-60, first and final terms, and in Science II, 1960-61, first term. The Clinical and Profile analysis techniques were applied to the Science I, 1959-60 group, while only the Clinical prediction was performed for Science I, 1960-61.

The results of the predictive efficiency of each method were first presented, in terms of percentages of hits and misses, or accurate versus inaccurate predictions. These results, expressed in proportions, were then compared to each other.

Considering the total number of predictions made, the Clinical method of group test appraisal and resulting predictions was strikingly "victorious" in terms of the number of times it "defeated" the other techniques in the competitive task of forecasting pass or fail for each student.

When the study of the results is limited to those instances where all the techniques could be applied to the data, that is, Science II, 1959-60, general average of the

first and final terms, and Science II, 1960-61, first term, the Clinical technique's "victories" were not so impressive. It equalled the Multiple Regression Equation and the Profile Analysis methods, but it was slightly inferior to the Combination of techniques.

When comparisons are made to determine which techniques are more effective in predicting the pass group, first considering all the predictions that were made, in all situations, the Clinical by far outstrips the others. When restricting the comparison to those situations where all techniques were operative, the Clinical method is ahead of the Multiple Regression Equation and the Profile Analysis techniques, but is equalled by the Combination.

In predictions of the fail group, again considering all predictions made, in all situations, the Clinical method is more successful than are the others, with possibly one exception, where the Clinical and Profile Analysis techniques are nearly equal, ratio 9.5. When restricted to those instances where all the techniques are used, the actuarial techniques outstrip the Clinical.

It seems that in such a setting as the Science Faculty, under the present admission and academic practices or policies, that the Clinical appraisal of post-admission group test results is a useful method, due to its flexibility, its adaptability, its economy, and its predictive accuracy.

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APPENDIX 1

ADDITIONAL DATA

Table XXXVIII.-

Science I, 1959-60: Results on Four Tests and the Clinical (CL) and Profile Analysis (PA) in Predicting First Term and Final General Averages.

Name Code	Tests ^a				Predictions				Outcome	
	O	A	DN	DA	CL		PA		X	A
					X ^b	A ^c	X	A		
1.	58	28	34	34	PG	PG	P	P	P	P
2.	51	30	22	41	PD	PD	F	F	F	F
3.	64	31	28	38	G	G	P	P	F	F
4.	62	29	26	36	G	G	P	F	F	F
5.	67	27	14	30	PD	PD	F	F	F	F
6.	72	38	36	40	G	G	P	P	F	P
7.	60	31	24	34	PG	PG	F	F	F	F
8.	48	36	17	29	D	D	F	F	F	F
9.	39	29	25	33	D	D	F	F	F	F
10.	62	29	29	26	PG	PG	P	P	P	P
11.	33	30	30	40	PD	PD	F	F	P	P
12.	50	34	30	44	PG	PG	F	F	F	F
13.	60	37	29	38	G	G	P	P	F	F
14.	60	32	34	38	G	G	P	P	F	P
15.	61	28	30	40	G	G	P	F	P	P
16.	43	28	24	32	D	D	F	F	F	F
17.	64	35	37	38	G	G	F	F	P	F
18.	45	29	28	27	PG	PG	F	F	P	P
19.	48	26	7	33	D	D	F	F	F	P
20.	49	24	16	28	D	D	F	F	F	F
21.	40	34	23	27	PD	PD	F	P	F	P
22.	20	34	17	30	D	D	F	P	P	P

a Otis S.-A. - O; Amoss - A; D.A.T.Numerical - DN; D.A.T. Abstract - DA.

b First Term (December) - X.

c Final (April) - A.

Table XXXVIII.- (Cont'd.)

Science I, 1959-60: Results on Four Tests and the Clinical (CL) and Profile Analysis (PA) in Predicting First Term and Final General Averages.

Name Code	Tests				Predictions				Outcome	
	O	A	DN	DA	CL		PA		F	A
					X	A	X	A		
23.	43	30	22	14	D	D	F	F	P	P
24.	43	29	24	40	PD	PD	F	F	F	F
25.	51	28	22	43	PD	PD	F	F	F	F
26.	46	30	23	30	D	D	F	F	F	F
27.	49	30	27	39	PD	PD	F	F	F	F
28.	68	32	35	39	G	G	P	P	P	P
29.	49	29	20	32	D	D	F	F	F	F
30.	58	36	31	37	G	G	P	P	P	P
31.	58	32	24	42	G	G	P	P	F	F
32.	64	28	19	32	PD	PL	F	F	F	F
33.	31	31	31	5	D	D	F	F	F	F
34.	51	36	30	38	PG	PG	F	F	P	P
35.	32	26	5	26	D	D	F	F	F	F
36.	48	35	19	29	PD	PD	F	F	F	F
37.	63	33	29	26	G	G	F	F	F	F
38.	60	36	21	41	PG	PG	F	F	F	F
39.	62	30	25	21	PG	PG	P	P	P	P
40.	23	23	11	17	D	D	F	F	P	P
41.	64	30	24	39	G	G	P	P	P	P
42.	58	31	16	34	PG	PG	F	F	F	F
43.	50	34	34	28	PG	PG	F	P	F	F
44.	55	26	15	29	D	D	F	F	F	F
45.	45	29	1	0	D	D	F	F	F	F
46.	68	34	23	39	G	G	F	F	F	F
47.	51	30	29	26	PG	PG	F	F	P	P
48.	70	31	22	36	G	G	F	F	P	P
49.	60	32	31	41	G	G	P	P	P	P
50.	68	38	32	45	G	G	P	P	F	F
51.	51	28	23	24	PD	PD	F	F	F	F
52.	64	32	33	43	G	G	P	P	P	P
53.	43	26	19	36	D	D	F	F	F	F
54.	60	35	24	42	D	D	F	P	P	P
55.	43	31	30	25	D	D	F	P	P	P
56.	43	25	10	29	D	D	F	F	F	F
57.	51	25	13	26	D	D	F	F	F	F
58.	67	36	38	41	G	G	F	P	P	P
59.	62	29	21	36	PG	PG	F	F	F	F

Table XXXVIII.- (Cont'd.)

Science I, 1959-60: Results on Four Tests and the Clinical (CL) and Profile Analysis (PA) in Predicting First Term and Final General Averages.

Name Code	Tests				Predictions				Outcome	
	O	A	DN	DA	CL		PA		X	A
					X	A	X	A		
60.	41	32	22	30	D	D	F	P	P	P
61.	58	25	32	25	PD	PD	P	P	P	P
62.	46	30	24	32	PD	PD	F	F	F	F
63.	53	28	31	34	PD	PD	F	F	F	F
64.	65	30	24	40	G	G	P	F	F	F
65.	63	29	29	36	G	G	P	F	P	F
66.	49	26	21	29	D	D	F	F	F	F
67.	62	30	15	38	PD	PD	F	F	F	F
68.	64	28	31	34	PG	PG	P	P	F	F
69.	39	26	14	24	D	D	F	F	F	F
70.	56	26	19	35	PD	PD	F	F	P	P
71.	51	31	22	43	PG	PG	F	F	P	P
72.	30	25	15	28	D	D	F	F	F	F
73.	41	27	21	33	D	D	F	F	P	P
74.	39	27	21	12	D	D	F	F	P	P
75.	68	34	21	25	G	G	F	F	F	F
76.	67	30	31	38	G	G	P	F	F	F
77.	39	28	7	26	D	D	F	F	F	F
78.	55	32	26	32	PG	PG	F	F	P	P
79.	31	30	29	40	PD	PD	P	F	P	P
80.	68	29	28	35	G	G	F	F	F	P
81.	36	30	24	24	D	D	F	F	F	F
82.	58	36	36	38	G	G	F	F	F	P
83.	39	27	10	41	D	D	F	F	F	F
84.	55	34	20	35	PD	PD	F	F	F	F
85.	39	29	25	24	PD	PD	F	F	P	P
86.	50	31	19	34	PD	PD	F	P	P	P
87.	36	28	21	33	D	D	F	F	P	P
88.	48	32	22	31	PD	PD	F	P	F	F
89.	70	35	34	36	G	G	P	P	F	F
90.	51	33	18	36	PD	PD	F	F	F	F
91.	56	32	24	41	G	G	P	P	F	P
92.	37	32	23	27	D	D	F	P	F	F
93.	59	29	25	18	PG	PG	P	P	P	P
94.	45	31	23	39	PD	PD	F	F	P	P
95.	46	30	19	39	PD	PD	F	F	P	P
96.	53	34	35	40	G	G	F	F	F	F

Table XXXVIII.- (Cont'd.)

Science I, 1959-60: Results on Four Tests and the Clinical (CL) and Profile Analysis (PA) in Predicting First Term and Final General Averages.

Name Code	Tests				Predictions				Outcome	
	O	A	DN	DA	CL		PA		X	A
					X	A	X	A		
97.	40	30	18	25	D	D	F	F	P	P
98.	27	28	19	25	D	D	F	F	P	P
99.	48	34	30	28	PG	PG	F	F	P	P
100.	40	32	27	41	PD	PD	F	F	F	F
101.	41	28	19	39	D	D	F	F	F	F
102.	26	26	19	11	D	D	F	F	F	F
103.	54	28	32	31	PG	PG	F	F	F	F
104.	45	30	21	44	PD	PD	F	F	F	F
105.	66	30	21	42	G	G	F	F	F	F
106.	40	22	13	25	D	D	F	F	F	F
107.	51	28	23	29	PD	PD	F	F	F	F
108.	62	31	18	40	PG	PG	F	F	F	F
109.	58	33	28	37	G	G	F	F	P	P
110.	48	29	20	30	D	D	F	F	F	F
111.	31	28	24	19	D	D	F	F	F	F
112.	33	29	16	26	D	D	F	F	P	P
113.	51	32	19	24	PD	PD	F	F	F	F
114.	54	37	35	40	G	G	F	F	P	P
115.	28	30	17	26	D	D	F	F	F	F
116.	10	20	5	1	D	D	F	F	F	F
117.	65	30	25	37	G	G	F	F	F	F

Table XXXIX.-

Science II, 1959-60: Results on Four Tests and the Clinical (CL), Multiple Regression Equation (MR), Profile Analysis (PA), and the Combination (CO) of the Three Techniques, in Predicting Their First Term and Final General Averages

Name Code	Tests ^a				Predictions								Outcome	
	O	A	DN	DA	CL		MR		PA		CO		X	A
					X ^b	A ^c	X	A	X	A	X	A		
1.	46	26	22	17	D	D	F	F	F	F	F	F	F	F
2.	62	31	24	36	PG	PG	F	P	F	F	F	P	F	P
3.	70	37	38	36	PG	PG	P	P	P	P	P	P	P	P
4.	54	34	34	36	G	G	P	P	F	P	P	P	P	P
5.	74	33	37	41	G	G	P	P	P	P	P	P	P	P
6.	54	30	26	33	PG	PG	F	P	F	F	F	P	F	F
7.	44	28	20	20	D	D	F	F	F	F	F	F	F	F
8.	58	30	29	33	PD	PD	F	P	F	P	F	P	P	P
9.	55	33	35	33	PG	PG	P	P	P	P	P	P	P	P
10.	31	24	21	0	D	D	F	F	F	F	F	F	F	F
11.	20	21	9	25	D	D	F	F	F	F	F	F	F	F
12.	64	32	33	35	G	G	F	P	P	P	P	P	F	F
13.	62	33	24	41	G	G	F	P	F	P	F	P	F	F
14.	53	33	22	41	PD	PD	F	P	F	P	F	P	F	F
15.	50	29	15	25	D	D	F	F	F	F	F	F	F	F
16.	46	26	20	30	D	D	F	F	F	F	F	F	F	P
17.	20	33	13	26	D	D	F	F	F	F	F	F	F	F
18.	59	27	23	32	PD	PD	F	P	F	F	F	F	F	F
19.	62	30	28	27	PG	PG	F	P	P	P	P	P	P	P
20.	64	38	36	38	G	G	P	P	P	P	P	P	P	P
21.	59	31	23	35	PD	PD	F	P	F	F	F	F	F	P
22.	61	32	19	35	PD	PD	F	P	F	F	F	F	F	F
23.	64	26	19	32	PD	PF	F	F	F	F	F	F	F	P
24.	66	33	16	49	G	G	F	P	F	P	F	P	F	P
25.	61	34	24	28	PG	PG	F	F	F	P	F	P	P	P
26.	71	38	30	41	G	G	P	P	P	P	P	P	P	P

a. Otis S.-A. - O; Amoss - A; D.A.T.Numerical - DN;
D.A.T. Abstract - DA.

b First Term (December) - X.

c Final (April) - A.

Table XXXIX.- (Cont'd.)

Science II, 1959-60: Results on Four Tests and the Clinical (CL), Multiple Regression Equation(MR), Profile Analysis(PA), and the Combination(CO)of the Three Techniques,in Predicting Their First Term and Final General Averages.

Name Code	Tests				Predictions								Outcome	
	O	A	DN	DA	CL		MR		PA		CO		X	A
					X	A	X	A	X	A	X	A		
27.	54	26	19	23	D	D	F	F	F	F	F	F	P	P
28.	56	33	27	28	PD	PD	F	P	F	F	F	F	F	F
29.	55	34	29	37	PG	PG	F	P	F	P	F	P	F	F
30.	71	34	37	35	G	G	F	P	P	P	P	P	P	P
31.	63	34	29	34	G	G	F	P	P	P	P	P	P	P
32.	54	32	27	6	D	D	F	F	F	F	F	F	F	F
33.	63	35	32	38	G	G	P	P	P	P	P	P	P	P
34.	33	26	12	23	D	D	F	F	F	F	F	F	F	F
35.	53	32	21	36	PD	PD	F	P	P	F	F	F	F	F
36.	65	29	25	40	PG	PG	F	P	F	F	F	P	F	P
37.	48	34	26	37	D	D	F	P	F	P	F	P	F	P
38.	41	32	30	36	PD	PD	F	P	F	P	F	P	F	F
39.	49	30	21	16	D	D	F	F	F	F	F	F	F	P
40.	64	34	37	34	G	G	P	P	P	P	P	P	P	P
41.	55	33	35	44	G	G	P	P	F	P	P	P	F	P
42.	67	34	28	32	G	G	F	P	P	P	P	P	P	P
43.	17	21	21	15	D	D	F	F	F	F	F	F	F	F
44.	49	28	22	31	D	D	F	P	F	F	F	F	P	P
45.	45	33	20	31	D	D	F	F	F	F	F	F	F	F
46.	54	32	28	41	PG	PG	F	P	F	P	F	P	P	P
47.	39	28	24	20	D	D	F	F	F	F	F	F	F	F
48.	63	32	35	30	PG	PG	P	P	P	P	P	P	F	F
49.	67	37	35	33	G	G	P	P	P	P	P	P	P	P
50.	50	28	25	19	D	D	F	F	F	F	F	F	F	F
51.	56	37	34	36	G	G	P	P	P	P	P	P	P	P
52.	72	36	30	38	G	G	P	P	P	P	P	P	F	P
53.	46	36	31	34	PD	PD	P	P	P	P	P	P	F	F
54.	33	26	13	17	D	D	F	F	F	F	F	F	F	F
55.	30	29	22	25	D	D	F	F	F	F	F	F	P	P
56.	68	39	39	33	G	G	P	P	P	P	P	P	P	P
57.	65	35	27	39	G	G	F	P	F	P	F	P	F	P
58.	63	35	34	44	G	G	P	P	P	P	P	P	P	P
59.	40	26	15	9	D	D	F	F	F	F	F	F	F	P
60.	68	34	36	46	G	G	P	P	P	P	P	P	P	P
61.	48	37	30	38	PD	PD	P	P	F	P	F	P	F	P
62.	54	32	26	33	PD	PD	F	P	F	F	F	F	F	F

APPENDIX 1

Table XXXIX.- (Cont'd.)

Science II, 1959-60: Results on Four Tests and the Clinical (CL), Multiple Regression Equation (MR), Profile Analysis (PA), and the Combination (CO) of the Three Techniques, in Predicting Their First Term and Final General Averages.

Name Code	Tests				Predictions								Outcome	
	O	A	DN	DA	CL		MR		PA		CO		X	A
					X	A	X	A	X	A	X	A		
63.	61	28	8	16	PD	PD	F	F	F	F	F	F	F	F
64.	64	34	26	26	PG	PG	F	F	F	F	F	F	F	F
65.	64	32	39	43	G	G	P	P	F	F	F	F	F	F
66.	53	28	15	35	D	D	F	F	F	F	F	F	F	F
67.	55	32	23	35	PD	PD	F	P	F	F	F	F	F	F
68.	35	34	18	37	PD	PD	F	P	F	P	F	P	F	P
69.	61	39	20	44	G	G	F	P	F	P	F	P	F	P
70.	64	34	24	42	G	G	F	P	F	P	F	P	F	P
71.	46	32	19	30	D	D	F	F	F	F	F	F	F	F
72.	61	32	36	35	G	G	P	P	P	P	P	P	F	F
73.	59	31	30	29	PG	PG	F	P	F	P	F	P	F	P
74.	66	35	31	43	G	G	P	P	P	P	P	P	F	P
75.	65	37	33	43	G	G	P	P	P	P	P	P	F	P
76.	71	35	22	46	G	G	F	F	F	P	F	P	F	F
77.	62	28	18	28	PD	PD	F	F	F	F	F	F	F	F
78.	65	35	36	38	G	G	P	P	P	P	P	P	F	P
79.	43	35	26	36	PD	PD	F	P	F	P	F	P	F	P
80.	62	33	0	28	PD	PD	F	F	F	P	F	F	F	P
81.	55	34	31	32	PG	PG	F	P	P	P	P	P	F	P
82.	46	30	29	28	D	D	F	P	F	P	F	P	F	P
83.	65	34	24	25	PD	PF	F	F	F	P	F	F	F	F
84.	56	30	19	33	PD	PF	F	F	F	F	F	F	F	F
85.	50	27	29	31	D	D	F	P	F	P	F	P	F	F
86.	41	31	32	31	PD	PD	F	P	F	P	F	P	F	P
87.	53	27	29	37	PG	PG	F	P	F	P	F	P	F	P
88.	54	34	23	36	PG	PG	F	P	F	P	F	P	F	P
89.	55	32	26	40	PG	PG	F	P	F	P	F	P	F	P
90.	67	35	23	37	PG	PG	F	P	F	P	F	P	F	P
91.	54	36	34	42	G	G	P	P	F	P	F	P	F	P
92.	40	31	28	29	D	D	F	P	F	P	F	P	F	P
93.	68	36	33	41	G	G	P	P	F	P	F	P	F	P
94.	54	29	30	31	PD	PD	F	P	F	P	F	P	F	P
95.	59	31	26	38	PG	PG	F	P	F	P	F	P	F	P
96.	70	33	34	44	G	G	P	P	F	P	F	P	F	P
97.	40	24	32	35	D	D	F	P	F	P	F	P	F	P
98.	62	32	29	29	PG	PG	F	P	F	P	F	P	F	P
99.	51	33	25	35	PD	PD	F	P	F	P	F	P	F	P

Table XL.-

Science I, 1960-61: Results on Four Tests and the Clinical (CL) Technique in Predicting Their First Term General Average.

Name Code	Tests ^a				Prediction	Outcome
	O	A	DN	DA		
1.	56	31	15	33	PD	F
2.	19	28	15	33	D	F
3.	49	21	14	24	D	F
4.	41	19	24	23	D	F
5.	49	30	18	38	PD	F
6.	50	31	25	32	PD	F
7.	44	31	21	34	PD	P
8.	48	22	8	27	D	F
9.	63	29	27	32	G	F
10.	45	27	23	30	PD	F
11.	67	32	22	34	G	F
12.	60	31	35	32	G	F
13.	64	35	36	35	G	F
14.	68	37	29	33	G	P
15.	35	28	15	35	D	P
16.	67	32	30	26	G	P
17.	56	29	22	33	PG	F
18.	59	28	18	37	PG	P
19.	70	29	28	30	G	F
20.	56	28	22	29	PG	F
21.	59	29	18	35	PG	F
22.	55	32	22	29	PG	F
23.	62	31	23	24	PG	F
24.	48	34	30	29	PD	P
25.	56	24	12	26	PD	F
26.	45	27	18	31	D	F
27.	44	26	15	27	D	P
28.	61	26	28	24	PG	F
29.	69	37	29	44	G	F
30.	62	30	15	32	PG	F
31.	46	33	14	27	D	F
32.	53	29	21	29	PD	F

^a Otis S.-A. - O; Amoss - A; D.A.T. Numerical - DN;
D.A.T. Abstract - DA.

Table XL.- (Cont'd.)

Science I, 1960-61: Results on Four Tests and the Clinical
(CL) Technique in Predicting Their First Term General Average.

Name Code	Tests				Prediction	Outcome
	O	A	DN	DA		
33.	56	31	27	29	PG	P
34.	50	28	22	32	PD	F
35.	65	34	28	35	G	F
36.	61	27	16	27	PD	F
37.	55	37	30	36	G	F
38.	27	18	20	16	D	F
39.	62	30	19	38	PG	F
40.	53	23	12	26	PD	F
41.	62	36	38	46	G	P
42.	50	28	21	36	PD	P
43.	61	33	21	40	G	F
44.	61	32	20	28	PG	F
45.	39	31	27	23	PD	F
46.	66	32	15	33	PG	F
47.	49	36	17	14	D	F
48.	51	26	15	30	D	F
49.	49	31	19	28	D	F
50.	66	31	17	33	G	F
51.	58	31	16	26	PD	F
52.	63	27	21	39	PG	F
53.	33	26	12	26	D	F
54.	59	35	34	39	G	F
55.	65	30	27	26	G	F
56.	53	26	9	26	D	F
57.	68	35	27	34	G	F
58.	49	33	18	29	PD	F
59.	64	28	25	20	PG	F
60.	50	29	17	31	PD	F
61.	61	30	29	39	G	F
62.	61	36	25	36	G	F
63.	59	30	22	36	PG	P
64.	65	34	31	39	G	P
65.	68	34	17	40	PG	F
66.	75	38	39	48	G	F
67.	63	27	17	29	PG	F
68.	40	28	16	22	D	F
69.	51	30	31	0	PD	F
70.	50	34	24	19	PD	F
71.	48	34	22	32	PD	F

Table XL.- (Cont'd.)

Science I, 1960-61: Results on Four Tests and the Clinical (CL) Technique in Predicting Their First Term General Average.

<u>Name</u> Code	<u>Tests</u>				<u>Prediction</u>	<u>Outcome</u>
	O	A	DN	DA		
72.	64	32	29	44	G	F
73.	32	32	30	37	PG	F
74.	33	24	28	13	D	F
75.	64	29	23	31	PG	F
76.	66	33	30	38	G	P
77.	46	35	32	25	PD	F
78.	33	23	14	23	D	F
79.	63	33	31	39	G	P
80.	55	30	23	39	PG	F
81.	56	28	31	34	PG	F
82.	48	26	17	23	D	F
83.	63	31	18	27	PG	P
84.	59	27	17	22	D	F
85.	72	36	33	46	G	P
86.	41	22	15	22	D	F
87.	66	35	29	39	G	F
88.	41	29	25	35	PD	F
89.	39	26	13	13	D	F
90.	71	31	22	28	PG	F
91.	24	27	6	3	D	F
92.	61	19	15	28	PD	P
93.	50	33	13	20	D	F
94.	63	32	31	35	PG	F
95.	63	36	30	38	G	F
96.	62	31	30	39	G	P
97.	58	37	31	34	G	P
98.	50	30	22	32	PD	F
99.	43	27	21	16	D	F
100.	51	28	30	33	PD	F
101.	64	34	32	35	G	F
102.	49	26	23	26	D	F
103.	51	28	23	40	PD	P
104.	33	26	10	23	D	F
105.	61	32	26	32	G	F
106.	69	26	19	31	PD	F
107.	71	38	36	38	G	F
108.	19	30	26	27	D	F
109.	41	31	9	15	D	F

Table XL.- (Cont'd.)

Science I, 1960-61: Results on Four Tests and the Clinical
(CL) Technique in Predicting Their First Term General Average.

Name Code	Tests				Prediction	Outcome
	A	O	DM	DA		
110.	55	32	13	32	PD	P
111.	58	30	20	30	PD	F
112.	30	32	20	18	D	F
113.	55	34	26	38	PG	F
114.	63	35	28	34	G	F
115.	63	35	26	33	G	F
116.	68	35	25	35	G	F
117.	63	36	30	34	G	P
118.	37	34	21	33	PD	F
119.	53	32	25	33	PG	P
120.	62	29	24	36	PG	F
121.	59	26	22	26	PD	F

Table XLI.-

Science II, 1960-61: Results on Four Tests and the Clinical (CL), Multiple Regression Equation (MR), Profile Analysis (PA), and the Combination (CO) of the Three Techniques in Predicting Their First Term General Average.

Name Code	Tests ^a				Predictions				Outcome
	O	A	DN	DA	CL	MR	PA	CO	
1.	50	30	17	33	D	F	F	F	F
2.	66	34	16	30	PD	F	F	F	P
3.	55	32	32	25	PD	F	F	F	P
4.	66	32	20	36	PG	F	P	P	F
5.	69	30	35	40	G	F	F	F	F
6.	60	33	30	32	G	F	P	P	P
7.	73	32	23	35	G	F	F	P	P
8.	65	32	30	36	G	F	F	F	F
9.	44	24	20	35	D	F	P	F	P
10.	68	28	26	36	PG	F	P	P	P
11.	55	26	19	26	D	F	F	F	F
12.	51	27	13	25	D	F	F	F	F
13.	67	30	25	29	PG	F	F	F	F
14.	43	26	25	31	D	F	F	F	F
15.	45	29	19	31	D	F	F	F	F
16.	40	28	22	29	D	F	F	F	P
17.	67	31	26	36	G	F	P	P	P
18.	61	27	21	27	PD	F	F	F	F
19.	50	28	21	25	D	F	F	F	F
20.	41	31	22	24	D	F	F	F	F
21.	66	34	39	28	G	P	P	P	F
22.	60	33	26	34	PG	F	P	P	P
23.	71	34	35	35	G	P	P	P	P
24.	64	33	29	37	G	F	P	P	P
25.	63	35	28	33	G	F	F	F	F
26.	69	29	21	33	PG	F	F	F	F
27.	66	32	26	34	PG	F	P	P	F
28.	61	36	33	33	G	P	P	P	P
29.	61	29	17	32	PD	F	F	F	F
30.	45	35	35	21	D	P	P	P	P
31.	70	31	26	40	PG	F	P	P	F
32.	30	22	19	18	D	F	F	F	F
33.	70	36	37	36	G	P	P	P	F

^a Otis S.-A. - O; Amoss - A; D.A.T. Numerical - DN; D.A.T. Abstract - DA.

Table XLI.- (Cont'd.)

Science II, 1960-61: Results on Four Tests and the Clinical (CL), Multiple Regression Equation(MR), Profile Analysis(PA), and the Combination(CO)of the Three Techniques in Predicting Their First Term General Average.

Name Code	Tests				Predictions				Outcome
	O	A	DM	DA	CL	MR	PA	CO	
34.	53	28	20	32	PD	F	F	F	F
35.	64	31	32	31	G	F	P	P	P
36.	71	35	19	40	G	F	P	P	F
37.	67	30	29	27	PG	F	F	F	P
38.	23	26	10	18	D	F	F	F	F
39.	62	28	25	42	PD	F	P	F	F
40.	54	38	30	30	PD	F	P	F	F
41.	62	31	27	27	PG	F	F	F	P
42.	64	34	37	30	G	F	P	P	P
43.	63	31	34	39	G	F	P	P	P
44.	72	35	31	36	G	F	P	P	F
45.	67	38	36	29	G	F	P	P	P
46.	63	32	35	41	G	F	F	F	F
47.	59	37	28	40	PG	F	P	P	F
48.	26	28	21	15	D	F	F	F	F
49.	22	28	13	11	D	F	F	F	F
50.	71	30	34	37	G	F	F	F	F
51.	70	37	36	45	G	F	P	P	P
52.	60	35	30	25	PD	F	P	F	F
53.	60	30	35	32	PG	F	F	F	F
54.	64	30	21	35	PD	F	P	F	F
55.	54	25	31	37	PG	F	P	P	P
56.	72	34	32	20	G	F	P	P	P
57.	58	34	29	36	PG	F	P	P	P
58.	62	30	27	40	PD	F	P	F	P
59.	46	28	25	29	D	F	F	F	P
60.	50	31	26	30	D	F	F	F	F
61.	33	24	4	18	D	F	F	F	F
62.	61	32	31	33	G	F	F	F	P
63.	64	31	23	33	PG	F	F	F	P
64.	50	26	22	39	PD	F	P	F	F
65.	64	33	38	38	G	F	P	P	F
66.	68	34	31	31	G	F	P	P	F
67.	62	30	25	38	PG	F	P	P	P
68.	64	36	32	31	G	F	P	P	F
69.	45	29	34	26	PD	F	F	F	F
70.	70	32	23	42	PG	F	P	P	F

Table XLI.- (Cont'd.)

Science II, 1960-61: Results on Four Tests and the Clinical (CL), Multiple Regression Equation(MR), Profile Analysis(PA), and the Combination(CO)of the Three Techniques in Predicting Their First Term General Average.

Name Code	Tests				Predictions				Outcome
	O	A	DM	DA	CL	MR	PA	CO	
71.	71	35	31	40	G	F	P	P	P
72.	49	28	28	27	D	F	F	F	F
73.	53	28	22	35	PD	F	P	F	F
74.	71	34	30	37	G	F	P	P	F
75.	61	28	30	29	PG	F	F	F	F
76.	68	33	38	39	G	P	P	P	F
77.	61	36	30	32	G	P	P	P	P
78.	49	34	25	34	PD	F	P	F	P
79.	51	34	23	35	PD	F	P	F	P
80.	64	40	32	33	G	P	P	P	P
81.	49	29	34	32	PD	F	F	F	F
82.	73	32	32	41	G	F	F	F	F
83.	50	35	39	26	PD	P	P	P	P
84.	66	32	23	40	PG	F	P	P	P
85.	64	27	33	35	PG	F	F	F	P
86.	64	36	38	33	G	P	P	P	F
87.	43	34	24	27	PD	F	F	F	F
88.	63	30	28	38	PG	F	P	P	P
89.	45	33	10	38	PD	F	P	F	F
90.	70	35	38	43	G	P	P	P	P
91.	59	34	28	29	PG	F	F	F	F
92.	58	32	33	30	PD	F	F	F	F
93.	73	37	39	43	G	P	P	P	P
94.	58	32	31	35	PG	F	P	P	P
95.	71	32	35	30	G	F	P	P	F
96.	45	27	15	16	D	F	F	F	F

Table XLII.-

Science I, 1959-60, First Term and Final Term
Examinations: Their Means and Standard Deviations.

Criteria	N	Term	Means	SD's
M A T H	115	First	49.53	19.41
	104	Final	52.36	21.35
P H Y S	114	First	51.96	17.70
	102	Final	54.12	17.03
C H E M	114	First	50.77	15.98
	104	Final	53.27	16.29
A V E R	115	First	56.04	11.84
	106	Final	57.92	13.19

Table XLIII.-

Science II, 1959-60, First Term and Final Term
Examinations: Their Means and Standard Deviations.

Criteria	N	Term	Means	SD's
M	92	First	43.96	16.20
A				
T	87	Final	54.39	16.93
H				
P	92	First	58.20	15.59
H				
Y	86	Final	50.66	15.00
S				
C	92	First	59.88	11.66
H				
E	86	Final	61.66	12.09
M				
A	92	First	56.50	9.89
V				
E	88	Final	61.89	9.77
R				

Table XLIV.-

Science I, 1960-61, First Term Examinations:
Their Means and Standard Deviations.

Criteria	N	Means	SD's
MATH.	113	45.03	19.53
PHYS.	112	42.62	18.69
CHEM.	113	40.34	17.16
AVER.	113	49.01	12.58

Table XLV.-

Science II, 1960-61, First Term Examinations:
Their Means and Standard Deviations.

Criteria	N	Means	SD's
MATH.	86	54.03	19.25
PHYS.	86	56.94	17.86
CHEM.	86	51.24	15.19
AVER.	86	57.30	12.05

Table XLVI.-

Science I and II, 1959-60, Test Results: Their Means and Standard Deviations, N 117 and 99 Respectively.

Groups	Tests				
	Otis	Amoss	DAT M.	DAT A.	
Sc. I	M	50.55	30.29	23.11	32.15
	SD	12.50	3.40	7.30	8.70
Sc. II	M	55.00	31.88	26.00	32.80
	SD	11.60	3.60	7.50	7.50

Table XLVII.-

Science I and II, 1960-61, Test Results: Their Means and Standard Deviations, N 121 and 96 respectively.

Groups	Tests				
	Otis	Amoss	DAT N.	DAT A.	
So. I					
	M	54.00	30.27	22.66	30.23
	SD	11.72	4.28	7.04	7.80
So. II					
	M	58.60	31.56	27.50	32.55
	SD	11.34	3.51	7.28	6.79

Table XLVIII.-

Test-Retest Group, Test Results: Their Means and Standard Deviations, N 61.

Years		Tests			
		Otis	Amoss	DAT N.	DAT A.
1959-60	M	52.32	30.86	22.17	32.78
	SD	11.50	3.20	6.90	7.80
1960-61	M	53.41	31.34	23.44	33.79
	SD	9.60	3.10	6.40	6.00

Table XLIX.-

Science I, 1959-60, First Term, Point-Biserial
Coefficients of Correlation and Their Signifi-
cance, N 117.

Criteria	Tests			
	Otis	Amoss	DAT N.	DAT A.
MATH.	-.106	.103	<u>.230</u> ^b	-.065
PHYS.	.110	.182	<u>.371</u>	-.017
CHEM.	<u>.266</u> ^a	.114	<u>.301</u>	.128
AVER.	.036	.092	<u>.363</u>	.023

a P less than .01.

b P less than .05.

Table I.-

Science I, 1959-60, Final Term: Point-Biserial
Coefficients of Correlation and Their Signifi-
cance, N 117.

Criteria	Tests			
	Otis	Amoss	DAT N.	DAT A.
MATH.	-.104	.040	.149	-.117
PHYS.	-.016	-.085	-.092	-.137
CHEM.	-.004	.092	<u>.251</u> ^a	.073
AVER.	.069	-.012	<u>.270</u> ^b	.015

a P less than .05.

b P less than .01.

Table LL-

Science II, 1959-60, First Term: Point-Biserial
Coefficients of Correlation and Their Signifi-
cance, N 99.

Criteria	Tests			
	Otis	Amoss	DAT N.	DAT A.
MATH.	<u>.391^a</u>	<u>.312</u>	<u>.315</u>	<u>.270</u>
PHYS.	<u>.343</u>	<u>.251^b</u>	<u>.312</u>	<u>.307</u>
CHEM.	<u>.257</u>	<u>.210</u>	<u>.379</u>	.128
AVER.	<u>.334</u>	<u>.391</u>	<u>.409</u>	<u>.250</u>

a P less than .01.

b P less than .05.

Table LII.-

Science II, 1959-60, Final Term: Point-Biserial
Coefficients of Correlation and Their Signifi-
cance, N 99.

Criteria	Tests			
	Otis	Amoss	DAT N.	DAT A.
MATH.	<u>.318^a</u>	<u>.262^b</u>	<u>.353</u>	.112
PHYS.	<u>.369</u>	<u>.266</u>	<u>.260</u>	<u>.253</u>
CHEM.	<u>.272</u>	.090	<u>.251</u>	.117
AVER.	<u>.276</u>	<u>.292</u>	<u>.297</u>	<u>.310</u>

a P less than .01.

b P less than .05.

Table LIII.-

Science I, 1960-61, First Term: Point-Biserial Coefficients of Correlation and Their Significance, N 121.

Criteria	Tests			
	Otis	Amoss	DAT N.	DAT A.
MATH.	.109	<u>.263^a</u>	<u>.262</u>	<u>.321</u>
PHYS.	.093	.142	<u>.296</u>	<u>.264^b</u>
CHEM.	.118	.092	<u>.183</u>	.163
AVTR.	.133	.162	.177	<u>.259</u>

a P less than .01.

b P less than .05.

Table LIV.--

Science II, 1960-61, First Term: Point-Biserial Coefficients of Correlation, and Their Significance, N 96.

Criteria	Tests			
	Otis	Amoss	DAT N.	DAT A.
MATH.	.115	<u>.280^a</u>	<u>.368</u>	.180
PHYS.	.105	.164	.156	<u>.247^b</u>
CHEM.	-.029	.032	.154	-.071
AVER.	.113	<u>.228</u>	<u>.242</u>	.135

a P less than .01.

b P less than .05.

APPENDIX 2

ABSTRACT OF

Actuarial Versus Clinical Methods in Predicting Achievement in a Science Faculty¹

The duality of purpose of this project was first prompted by the writer's concern with the high failure rate of the students at the Faculty of Pure and Applied Science at the University of Ottawa and, secondly, by the heated discussions on the advantages and shortcomings of the actuarial and the clinical methods in forecasting human behavior, specifically college achievement.

Four paper-and-pencil group tests, two measuring general mental ability: the Otis S.-A or its French equivalent the Otis-Ottawa and the D.A.T. Abstract Reasoning, and two measuring mathematical ability: the Amoss Mathematical Ability Test and the D.A.T. Numerical Ability, were administered to all the students in First and Second years at the Faculty of Science, of the University of Ottawa, in two consecutive academic sessions 1959-60 and 1960-61.

The results of these tests, expressed in stanine scores, were evaluated subjectively to yield a clinical

¹ Laurent A. Isabelle, doctoral thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, May, 1961, xi-176 p.

prediction of pass or fail on the general average obtained by the students on first term and on final term examinations. The same test results were analyzed by a pattern or profile analysis technique to yield one type of actuarial prediction of success or failure on the same criterion. Point-biserial coefficients of correlation and multiple regression equations were also derived to yield a third prediction, also actuarial. Of secondary interest was the prediction of achievement in Mathematics, Physics, and Chemistry, by the multiple regression equation calculated for each of these criteria.

A comparative study of the predictive efficiencies of the three techniques and their combination prediction, when considering all the predictions of the general average that were made, has shown that the Clinical method of group test appraisal and resulting predictions was strikingly "victorious" in terms of the number of times it defeated the other techniques in the competitive task of forecasting pass or fail for each student. When the study of the results is limited to those instances where all techniques could be applied to the data, the Clinical technique's efficiency was not as impressive, although it still led the Multiple Regression Equation and the Profile Analysis in the prediction of the pass group; it was defeated by these two methods on identification of the fail group. The Clinical method equalled the Combination prediction of both pass and fail.

It seems that in such a setting as the Faculty of Science, under the present admission and academic practices or policies, that the Clinical appraisal of post-admission group test results is a useful method, due to its flexibility, its adaptability, its economy, and its predictive accuracy.

