Factors affecting the success of transfer students at Drake University

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FACTORS AFFECTING THE SUCCESS OF TRANSFER STUDENTS AT

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by

John Allen Ingram

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Major Subject: Education

Approved:

Signature was redacted for privacy.

In Charge of Major Work

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Head of Major Department

Signature was redacted for privacy.

Dean of Graduate College

Iowa State University
Of Science and Technology
Ames, Iowa

1967
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INTRODUCTION

A most prominent trend in American higher education has been the increase in the number of students who begin their collegiate degree programs in a junior or community college. It seems realistic that in the future much if not most of the lower division college work will be done at junior colleges while senior institutions will concentrate on upper division and graduate level programs. At present several states including California, New York, Florida and others have systems wherein the junior colleges serve as feeder institutions to the larger state universities.

This year thousands of students will start to college, many of whom probably would not have gone beyond high school if a junior or community college had not been locally available. Many of these students enter college with the intent to later transfer to a four-year institution.

Frederick deW. Bolman stated that (7),

Today approximately five and one half million students are enrolled in our colleges and universities -- about one-fifth of whom are in junior or community colleges. Eight years from now we expect over eight million enrollment in higher education and the proportion which must attend a junior college may increase significantly.

...Meanwhile the demands for educated manpower are increasing as work in our society requires more and better training. The need for unskilled labor is decreasing. The explosion of knowledge through vastly stepped-up research soon finds its way into the work of America for, as Whitehead once remarked 'Knowledge does not keep any better than fish'.

In recent years, growth of junior and community colleges has been so rapid that there has scarcely been time to develop satisfactory programs or patterns of cooperation with senior institutions. However, nationwide meetings were held in 1965 in which the American Association of Junior
Colleges sponsored fifteen state and regional conferences toward facilitating and systematizing the transfer of college students. The specific goal of this project was to set guidelines which might improve articulation, coordination and planning among the sending and receiving institutions.

The growth in number of students attending Iowa junior-community colleges has increased by nearly 500 per cent in the past thirteen years. Enrollment figures were published by the State Department of Public Instruction (21, 22). Their findings appear in Table 1.

There has been a marked increase in enrollment in Iowa junior colleges. The trend toward increased enrollment may necessitate major changes in the programs of Iowa's four-year colleges.

The present study was of transfer students to Drake University, Des Moines, Iowa. Drake is a private university which supports colleges of business administration, education, fine arts, liberal arts, professional schools -- law, journalism, divinity -- and a graduate college. The regular day enrollment at Drake in fall 1965 was 5,313 (12).

Indeed transfers have become a sizeable portion of the Drake student body. Annual reports by the Registrar at Drake (10, 12) indicated that there were 993 new freshmen and 353 new transfer entrants in fall 1961; in 1965 one thousand two hundred fifty two new freshmen and 404 new transfer students came to Drake.

The purpose of this research was to study the achievement of transfer students at Drake University. More specifically the purposes were to (1) analyze the academic records of transfer students, for the purpose of predicting achievement in work taken at Drake, (2) to study the relation of
Table 1. Iowa public junior college beginning of the year enrollments for 1953 through 1965

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Enrollment</th>
<th>Per centage increase Over previous year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1953-1954</td>
<td>1,457</td>
<td></td>
</tr>
<tr>
<td>1954-1955</td>
<td>1,777</td>
<td>21.9</td>
</tr>
<tr>
<td>1955-1956</td>
<td>2,332</td>
<td>31.2</td>
</tr>
<tr>
<td>1956-1957</td>
<td>2,596</td>
<td>11.3</td>
</tr>
<tr>
<td>1957-1958</td>
<td>2,677</td>
<td>3.1</td>
</tr>
<tr>
<td>1958-1959</td>
<td>2,783</td>
<td>4.0</td>
</tr>
<tr>
<td>1959-1960</td>
<td>2,614</td>
<td>-6.1</td>
</tr>
<tr>
<td>1960-1961</td>
<td>2,891</td>
<td>10.6</td>
</tr>
<tr>
<td>1961-1962</td>
<td>3,511</td>
<td>21.4</td>
</tr>
<tr>
<td>1962-1963</td>
<td>4,336</td>
<td>23.5</td>
</tr>
<tr>
<td>1963-1964</td>
<td>4,752</td>
<td>9.6</td>
</tr>
<tr>
<td>1964-1965</td>
<td>5,999</td>
<td>26.2</td>
</tr>
<tr>
<td>1965-1966</td>
<td>8,468</td>
<td>57.8</td>
</tr>
</tbody>
</table>

selected factors to grade achievement, and (3) to compare the success of transfer students with that of a related group of native students. The variables studied included previous academic record, standardized test scores, type of institution from which transfer was made, school or college of Drake to which transfer was made, sex of the student, and level of the student's academic career at which transfer was made.

For the purpose of this study transfer students were defined as those undergraduate students who entered Drake between fall term 1961 and fall term 1964, inclusive, with recognized college credit of at least one academic year. A native student was defined as a full time undergraduate student admitted to Drake with no previous collegiate experience or credit.

The study was based on the academic records of those who entered and completed at least one year of undergraduate work at Drake in an academic
curriculum. The academic fields were defined as business administration, education, fine arts and liberal arts. In part three of the study, records of a sample of 147 native students were compared with those of an equal number of transfer students. In total the records of 1,003 students were used.

The study was designed to treat a number of questions indicative of its scope. The more fundamental of these questions were:

1. What was the relative contribution of certain measured factors including previous grades and test scores in explaining variability in the academic performance of transfer students?

2. Have there been significant differential patterns of success at Drake for transfer students:
   a. Related to the type of sending institution?
   b. According to the level at entry -- sophomore, junior, senior?
   c. Who entered the various colleges at Drake?
   d. According to the sex distribution?

3. How has scholastic achievement of transfer students, after entering Drake, compared with the success of a similar group of native students?
Numerous studies have been made on the success of transfer students at senior institutions. Basically these have been either (1) studies of transfer students coming from specific colleges to one senior college or (2) broad surveys of several thousand students who entered one of several senior institutions.

Within both of these major categories, it was noted that much research was on junior-community college transfers to state colleges and universities. A lesser number of studies had included transfers from other colleges in addition to the junior-community college group. The instances have been rare in which success was analyzed for students who transferred to a single private senior institution.

Due to the diversity of the studies encountered, the literature was recorded chronologically as either (1) studies at specific senior institutions or (2) comprehensive transfer studies. The former classification was dichotomized to (a) studies of students transferring from junior-community colleges and (b) studies of transfers who came from junior or senior colleges.

**Studies at Specific Senior Institutions**

*Studies of students transferring from junior-community colleges*

Fichtenbaum (14), studying nearly 900 junior college transfers to the University of Texas during 1935-38, found that the scholarship average of the native students excelled that of the transfers with the difference less in the senior than in the junior year. He found that the transfer
students carried loads equally as heavy as those carried by the native students.

Martorana and Williams (28) compared a group of transfer and a group of native students at the State College of Washington. The two groups were matched on a number of factors -- sex, major subject area, high school attended, year in college, aptitude test scores and on high school cumulative grade point average. The authors found that transfer students had a problem of adjustment which actually affected their academic effectiveness during the semester just after transfer. As this adjustment was made, the difference between mean grade point averages of the transfer and non-transfer groups became negligible. Considered as groups there was no significant difference between the academic success of the transfer and the native student. Grossman (15) also found no significant difference in achievement of native and transfer students in upper division work.

Bird (5) indicated that junior college transfer students to the University of Iowa made approximately the same records as transfer students from four-year colleges. The Iowa data illustrated wide differences in mean grade point attained by the transfer students from different junior colleges. For example the mean grade for one junior college was significantly higher than the university's mean, and the average for another significantly lower.

After analysis of studies made in Iowa, California, Michigan, and other states, Bird (5) stated the following:

"1. Junior college transfer students make records approximately the same as those made by transfers from four-year colleges and by native students. They usually show a drop in grades in the first
term after transfer but then recover that loss.

"2. Junior college transfer students retain the relative scholastic standing after transfer that they held before transfer. Those who originally have high scholastic standing tend to retain such relative standing.

"3. There is variation, sometimes wide, in the findings relevant to success of transfer students in different senior institutions and also as between colleges in the same institution."

The purpose of a study by Dean (9) was to develop a formula to predict the probability which transfer students, entering Iowa State University from Iowa junior colleges, had of achieving graduation.

The criterion of achievement was graduation from an approved degree program at Iowa State University. Predictor variables included (1) ACE scores, (2) English placement score, (3) junior college grade point averages. The sample included 117 transfer entrants to Iowa State University in fall term 1959.

It was concluded that the use of English placement scores and the grade point averages were unnecessary when ACE scores were available for predicting the probability of graduation.

Hoyt (19) attempted to find empirical answers to a number of questions regarding students who transferred to Kansas State University (KSU) from various Kansas junior colleges. A sample was drawn, such that each junior college student was matched with a native KSU student in terms of sex, Kansas State University school, number of college credits, and year of first college enrollment.

The following results were indicated:
1. Early KSU grades predicted later KSU performance substantially better than did junior college grades.

2. "Transfer shock" was noted and in general the longer a junior college student stayed in the junior college, the greater was the drop in his grades upon transfer.

3. Junior college students earned about the same grades at Kansas State as did their matched partners whose original registration was at KSU.

4. There were wide differences among students from junior colleges in terms of their scholastic aptitude scores, ACE. When these ability differences were controlled, there were still large and statistically significant differences in junior college grades for students from different schools. Kansas junior colleges appeared to have different grading standards.

5. When ability differences were controlled, students from various junior colleges made about the same grades at KSU. Kansas junior colleges seemed to be uniform with respect to their ability to prepare students for work at Kansas State University.

A primary objective of a study at Michigan State University (16) was to determine how native and junior college transfer students compared with respect to selected academic and personal characteristics. For the transfer students, the researcher also investigated the predictive efficiency of selected educational variables.

The sample included comparison of 173 transfer students with an equal number of native students. The two groups were matched with respect to sex and number of credit hours achieved.
It was concluded that the transfer students achieved grade point averages which were, on the average, slightly lower than those for native students. A significantly greater number of the transfers than native students failed to maintain a passing (2.0) average. The best single predictor of academic success was previous (junior college) grade point average.

Klitzke (23) reported a study on the extent of academic success of Colorado junior college transfers at a senior teacher training institution -- Colorado State College, Greeley. Two hundred thirty-one transfer entrants to Greeley during 1953-1957 were matched with a similar group of native students. The two groups were matched on (1) lower division college background, (2) same number per year, (3) major by year, (4) sex by year, and (5) similar credit hours completed.

Klitzke found non-significant differences in aptitude as measured by ACE scores, in high school rank, in dropouts per quarter and in mean cumulative grade point averages. There was a significant difference between the proportion of native and transfer students who graduated, 90 to 70 per cent, respectively.

A study by Lambe (27) was designed to answer the question: Are there significant differences between community college grade point averages and academic performance at Western Michigan University of (1) groups of students classified according to community college grade point average, (2) men and women, (3) groups transferring from different two-year institutions, (4) groups entering different schools of Western, and (5) transfer students and native Western students?

The population included all students transferring to Western from
Michigan's public community colleges in the academic years of 1958 and 1959 and who had completed fifty or more semester hours of credit. The sample selected for the study consisted of 311 students.

The following conclusions were drawn:

1. Students whose community college averages were below 2.00 (A=4) encountered serious academic difficulty at Western. Less than half earned degrees. Students with community college grade point averages above 2.46 compiled sound scholastic records at Western, and nearly all earned degrees.

2. There were significant differences in grade point average earned at Western by groups of students from different community colleges. However, community college students retained approximately the same relative ranks that they held before transfer.

3. Transfer students entering the School of Education earned substantially higher averages, both before and after transfer, than students entering Western's other schools.

4. Women earned substantially higher averages both before and after transfer than did men.

An investigation of the junior college directed by Hoyt and Munday (20) reported on the predictive validity of ACT data for junior colleges. ACT scores indicated that junior college students were somewhat less academically able than their peers in four-year colleges. Their average ACT scores were about one-half a standard deviation lower, while their high school grades were about one-third of a grade point below the four-year group.

For the junior colleges in this study, ACT data possessed a very
satisfactory degree of predictive validity. The median correlation with overall freshmen grades was .64.

This study supported the belief that grading standards at a given institution reflect only the relative abilities within that institution. For example, freshmen grades in junior colleges and four-year colleges tended to be about the same despite the clearly established differences in academic potential. This finding indicated that normally a student will make higher grades in a junior college than in a four-year college.

Studies of transfer students who come from junior or senior colleges

The purpose of a study by Trail (31) was to report on the scholastic performance of transfer students to the University of Connecticut at Storrs.

The basic data were average semester marks of 1,073 transfer students who entered the University over a period of six consecutive semesters. These were grouped first into pre-transfer and post-transfer average marks and then according to the number of semesters of work transferred by the student. An analysis of variance design was applied to each of the two groups in order to determine whether pre-transfer and post-transfer performance differed by number of semesters transferred.

Marked differences appeared in pre- and post-transfer performance for those students who transferred four or fewer semesters of work. It was also concluded that, in general, the students transferring from state colleges in Connecticut had higher marks before entering the University and those from out-of-state colleges had higher marks after entrance. Transfer students to the Schools of Education, Engineering, and Physical Therapy were generally superior in pre-transfer performance and those to
Home Economics and Physical Therapy were generally superior in post-transfer performance.

The primary purpose of a study by Willingham (34) was to evaluate various means of estimating the academic promise of transfer students at Georgia Institute of Technology, 1961. The sample was 750 students who transferred to Georgia Tech during 1957-60. About 50 per cent of the transfer students had previously attended other Georgia colleges.

For the transfer group, previous college grade point averages had a somewhat poor relation with grades after transfer, $r=0.44$. Test scores -- College Entrance Board Examination Achievement Test in Science and Mathematics -- did improve accuracy of prediction, $r=0.60$.

Willingham noted a transfer shock of about 0.75 letter grade, on the average, for first term. Further, junior college transfer students appeared to suffer more severely from transfer shock than did other transfer groups. In general the transfer students made lower grades in quantitative than in verbal courses.

The primary purpose of a study at Pennsylvania State University (37) was to investigate the influence of the type of sending institution on the subsequent academic performance of the student.

Transfer entrants of September, 1961 were included in the study if they had attended only one other college and had at least 12 semester hours of credit accepted by Penn State. The sending colleges were placed into one of the following categories: junior colleges, liberal arts colleges, women's colleges, teacher training institutions or public and private universities.

The junior college transfer student made a significantly poorer
academic adjustment than did other transfer students. The researcher implied that in this case it would be feasible to require transfer students from junior colleges to meet a high admission standard, possibly a 2.5 grade point average.

Ahman (2) studied students who transferred to the engineering curriculum at Iowa State University. He devised a means for predicting the probability of academic success in engineering for incoming transfer students. Academic success was defined by a dichotomy -- graduated or did not graduate.

In all, six prediction variables were considered. These were ACE (1) Q-, and (2) L-scores (1945 edition), (3) high school grade point average, (4) score on the U. S. Air Force Institute Test on Correctiveness and Effectiveness of Expression, A. F. I. T., (5) an achievement rating derived by persons in the Office of Admissions, Iowa State University and (6) first quarter grade point average attained at Iowa State.

The sample included 840 male engineering transfer students who enrolled sometime between fall term 1946 and fall 1949, inclusive. Of these, over three-fourths were World War II veterans.

The probability of survival (graduation) could to some extent be predicted at the time of matriculation from the Q-score, the high school average, the A.F.I.T. score and the Iowa State University rating. At the end of one quarter at Iowa State, the probability of survival was best predicted from the first quarter grade point average.

Comprehensive Transfer Studies

In 1963 Casey (8) completed an extensive study assessing the role of
the public junior-community colleges in Iowa. The study included 1,088 transfer students, from the 16 public community colleges in Iowa, to the three state senior institutions -- Iowa State University, I.S.U.; State University of Iowa, S.U.I.; and State College of Iowa, S.C.I.

Of the 1,080 students for whom survival-attrition information was available, 661 (61.49 per cent) graduated from one of the senior institutions. Fifty per cent of those who transferred to I.S.U., 62 per cent who transferred to S.U.I., and 77 per cent who transferred to S.C.I. graduated. Survival rate ranged from 79.03 per cent in education, to 69.5 per cent in commerce, to 68.0 per cent in agriculture, to 49.32 per cent for those who entered engineering.

Of those who were graduated from a community college and then transferred to I.S.U., 27.19 per cent later graduated. The percentages at S.U.I. and S.C.I. were 45.76 and 62.86, respectively. Slightly over 17 per cent of the community college non-graduates that matriculated at S.U.I. graduated, 18.29 per cent graduated from S.C.I., 23.68 per cent graduated from I.S.U.

Three objectives were directed toward the prediction of academic success of community college transfer students. More specifically these objectives were to predict for post-transfer work (1) first term grade point average, (2) first year cumulative grade point average, and (3) probability of graduation. The study was delimited to include only those who (1) transferred during the fall of 1955 up to, but not including, fall term 1959 and who had taken (2) 30 or (3) 60 semester hours in an (one) Iowa community college before transfer.

Variables used in prediction of first term grade point average were
high school grade point average, community college grade point average and ACE score (I.S.U. only). For the first year achievement study, the first term post-transfer grade point average was added as a predictor variable. The prediction of graduation was based on community college and high school grade point averages.

Transfer students to S.C.I., S.U.I., and I.S.U. had overall high school grade point averages of 2.16, 2.20 and 2.70 and community college averages 2.38, 2.62 and 2.53, respectively.

Casey found best prediction at S.U.I. of first term grade average through use of both high school and community college grade averages. In the case of the transfer groups to S.C.I. and I.S.U., only the latter measure was required. For the first year achievement criterion at both S.U.I. and S.C.I., and at both the 30 and 60 hour levels, the first term post-transfer grade point average was a single best predictor. At I.S.U. the community college grade point average also held significant predictive ability with first year achievement.

For prediction of graduation, the community college grade point average was of significant value. This was true for all three of the universities.

Hills (17) discussed Leland Medsker's The Junior College: Progress and Prospect (New York: McGraw-Hill Book Co., 1960). Medsker's work encompassed students from 16 four-year colleges in eight states. Data was collected on over 2,500 transfer students who were juniors in fall term, 1953.

Only about 70 per cent of the transfers as compared to 80 per cent of the native students persisted the last two years. In this case transfer
students were slower at getting degrees than were the native students.

Hills cautioned that Medsker's data included no institution in which aptitude of students was controlled. Thus there existed the possibility that the persistors were just the more able transfer students. If this were the case, then apparent recovery from transfer shock was merely evidence of continued academic selection in operation.

Hills (17) summarized the findings of more than a score of studies made between 1910 and 1963, involving virtually tens of thousands of students. He concluded,

"1. Students who enter junior colleges and transfer to four-year colleges typically experience an appreciable drop in grades after transfer.

"2. Usually grades after transfer are lower than the average grades of native students.

"3. The transfer student seems to suffer most if he enters a curriculum which requires competence or training in mathematics, if he transfers to a major state university, or if he transfers from a junior rather than a four-year college.

"4. The transfer student will be less likely to survive to graduate than will the native student, on the average.

"5. The transfer student who does survive to graduate will probably take longer to reach graduation than will a native student."

A study directed by Knoell and Medsker (25) was an attempt to provide a national picture of college transfer problems. The study encompassed a sample of 41 four-year colleges and universities located in ten states. Colleges were selected on a geographic basis and by type of statewide
Eight thousand four hundred twenty-four junior college students who transferred in 1960 from one of 345 junior colleges were included in the study group. In addition a sample of 3,352 native students was drawn from the 1962 graduating class for comparison with the transfer student graduates.

The major objective of the analysis was the assessment of the relative contribution of various individual and institutional factors to the variance associated with grade point achievement at the four-year colleges. The individual variables which could be correlated with grade averages after transfer were high school rank and junior college grades. The institutional or cultural factors which could be related to grade achievement were type of four-year college and state in which the four-year college was located. The five types of four-year colleges were (1) major state universities, (2) other state universities, (3) teacher colleges, (4) private universities and (5) technical institutions.

In summary the following implications came from the first Knoell-Medsker study:

1. Cumulative averages for transfer students at the four-year colleges were generally lower than their junior college averages but reflected steady improvement following the first term loss at post-transfer. The cumulative average at the four-year colleges for the entire group was 2.34 compared to a cumulative junior college average of 2.56.

2. Considerable variance was found in the performance of the transfer students in the individual four-year colleges, in the various types of college, and in the states in which the colleges were
located. Significant differences were found among the five types of college in: (1) the junior college grade point averages with which the students transferred, (2) the averages earned at the four-year colleges, and (3) academic status two years after transfer. Differences among colleges within each type were also found to be significant in most of the chi-square and analysis of variance tests which were made.

3. The student's probability of persistence and "on time" graduation was found to be significantly related to his choice of major as well as to his choice of four-year college.

4. Women earned higher grades than men and were more likely to graduate on time.

5. Performance in high school -- including type of program pursued, rank in graduating class and proportion of the graduating class going on to college -- was found to be related to performance after transfer.

6. Performance after transfer was highly related to level of achievement in the junior college, particularly when differences between types of four-year college were controlled.

7. Non-academic characteristics were found to be related to performance at a considerably lower level of significance than were the educational variables.

8. The transfer students earned consistently higher grade point averages than the native students in the lower division (freshmen, sophomore) but the native students excelled in higher division work. Grade differences between the groups of native and
transfer student graduates from four of the five types of four-year college were significant at the .01 level. A notable exception was teachers colleges where the transfer students in some instances earned higher grades after transfer than they did in junior college.

9. Differences among the five types of college in the kinds of students they attracted appeared in many instances to be greater than differences between the native and transfer student samples. That is, students, who were attracted to a particular type of college, appeared to have similar characteristics, regardless of their classification as native or transfer.

In general, the major objectives which the second Knoell-Medsker study (24) were designed to achieve included:

1. To discern what individual and institutional factors might account for the finding that students in some four-year colleges were so much more successful than students in other colleges.

2. To examine the present role and possible contributions of testing in the four-year colleges in admitting, counseling, evaluating, and placing transfer students from junior colleges.

3. To disclose the extent to which differences in the academic ability of native and transfer students might account for differences which were found in their performance in the universities.

The researchers concluded that the success of students who transferred after two years in junior college was remarkably greater than that of students who transferred after only one year.

Attrition among the students who transferred with only sophomore
standing was about 45 per cent compared with only 26 per cent for those who transferred with junior standing. Cumulative findings suggested that the transfer students had about the same probability of eventual success in the various majors. Attrition was found to be about the same in each of the broad major fields.

Numerical differences in the grade point averages of the native and transfer students were statistically significant for many of the major universities. Two contributing factors were: (1) junior college grading standards, or a quality of preparation, which differed from that of the university, and (2) a difference in the academic ability of the native and transfer students.

Findings suggested that the grading standards of the junior colleges and the teachers colleges were fairly comparable in that the transfer student had little or no grade point disadvantage in transferring to the teachers college. They were most consistently at a disadvantage in transferring to the major state universities.

Comparisons were made of the test scores of the graduates for whom various analyses of grades had been made earlier. There was evidence of significant differences in the ability of the two groups of graduates, transfers and natives, from the major university types. The teachers colleges provided a single exception to this generalization.

It was hoped that findings from the research cited might enlighten the present study by indicating some broad conclusions and relevant trends in college transfer. Thus, it seemed reasonable to state that,

1. Most of the current research on college transfer came from studies made at state universities. Little, if any, information was
available on the transfer function at private universities.

2. Interest and awareness of the magnitude of the transfer function has increased as was indicated by several studies of state and national scope.

3. Previous academic records (grades) and test scores have been studied for use in guiding transfer students. The relative merit of these directives is yet uncertain -- except for specific transfer situations.

4. Various physical factors such as institution type, sex, area of study, year, and level of transfer affect the student's chances of eventual success. In several instances widespread differences of success were noted within institutions or collegiate systems.

5. In comparisons of achievement of native and transfer students, a "transfer shock" and recovery was noted for the latter group. Native students, in most cases, performed somewhat better than transfer students in the upper division courses.

6. The avenue of entrance to college by transfer has expanded. Were this avenue not open, many capable students would be unable to afford a higher education.
METHOD OF PROCEDURE

The present chapter encompasses a description of the data and its treatment. Topics include collection and nature of the data, criterion of achievement, variables affecting achievement, hypotheses tested and statistical methods employed. In addition, definitions are given for terms used throughout the study.

Definition of Terms

For the purposes of this study, the following definitions were adopted:

Transfer. A full time undergraduate student admitted to Drake with accepted college credit of at least one year.

Native. A full time undergraduate student admitted to Drake with no previous collegiate experience or credit.

Sending institution. Any collegiate institution which provided transfer students to Drake during the period under study.

Academic curricula. Included studies in business administration, education, fine arts and liberal arts.

Level of entry. The highest academic grade or standing, junior, or senior -- attained prior to entry to Drake.

Collection and Nature of the Data

The data consisted of pre-transfer cumulative grade averages, transfer classification, post-transfer grade averages and test scores on the School and College Ability Test, SCAT, the Cooperative English Test, CET,
1960 edition, and on the American College Test, ACT, college form. Similar information, except pre-transfer grades, was obtained for a sample of native students.

A variety of marking systems was encountered in analyzing transcript records from various sending institutions. Consequently, it was necessary to convert all grades to a comparable scale. Thus, all academic measures, both pre- and post-transfer were expressed on a four-semester point scale as used at Drake: A=4, B=3, C=2, D=1, F=0 quality points per semester hour of credit. To further guarantee uniformity of grading units, all grades in freshman physical education, in college orientation, in chorus, in freshman ROTC courses, and in "makeup" or prep courses of high school caliber were excluded from computation of grade averages.

Pre-transfer credit was evaluated on all collegiate level work attempted prior to entry to Drake. In cases where the transfer student had attended more than one college, the sending institution was defined as that wherein the student had taken the greatest amount of work.

Data was obtained through the Office of the Registrar, the Counseling and Testing Center and the various Dean's of Colleges Offices at Drake University.

One thousand one hundred ninety-nine students (10, 12) had enrolled in academic curricula as transfer students to Drake during one of the fall terms 1961 through 1964, inclusive. The restrictions that pre- and post-transfer records, including test scores, be complete, reduced the number of transfer students in the study to 856. In addition, the records of 147 native students were randomly selected from a listing of all Drake non-transfer entrants during fall term 1961. A distribution, by college and
Table 2. Number of students entering academic programs at Drake in fall terms 1961 through 1964, inclusive

<table>
<thead>
<tr>
<th>Year</th>
<th>Type</th>
<th>Bus. Admin.</th>
<th>Education</th>
<th>Fine Arts</th>
<th>Lib. Arts</th>
<th>Total Studied</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Tot.Study</td>
<td>Tot. Study</td>
<td>Tot. Study</td>
<td>Tot. Study</td>
<td></td>
</tr>
<tr>
<td>1961</td>
<td>native</td>
<td>172</td>
<td>48</td>
<td>107</td>
<td>33</td>
<td>142</td>
</tr>
<tr>
<td>1961</td>
<td>trans.</td>
<td>87</td>
<td>48</td>
<td>59</td>
<td>33</td>
<td>22</td>
</tr>
<tr>
<td>1962</td>
<td>trans.</td>
<td>66</td>
<td>62</td>
<td>76</td>
<td>60</td>
<td>31</td>
</tr>
<tr>
<td>1963</td>
<td>trans.</td>
<td>86</td>
<td>54</td>
<td>80</td>
<td>69</td>
<td>26</td>
</tr>
<tr>
<td>1964</td>
<td>trans.</td>
<td>90</td>
<td>64</td>
<td>74</td>
<td>57</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>276</td>
<td>252</td>
<td>77</td>
<td>398</td>
<td>1003</td>
</tr>
</tbody>
</table>

For each student the sending institution was recorded from the transcript record. Each sending institution was classified according to its listing in the World Almanac, 1966 edition (35) as (1) a major, state or private, university, (2) a liberal arts college of up to 3,000 students, (3) a junior college or teachers college, (4) Grandview College or (5) an Iowa state supported university or college. One classification -- the technical institution -- afforded too few cases to be included in the study.

For one part of the study, a random sample of 1961 Drake freshmen non-transfer entrants was selected. Their records were matched on the "pairs" basis with an equal number of 1961 transfer entrants. Pairing was on sex, college on entry, aptitude, and level at which achievement was measured -- sophomore, junior or senior year.
Criterion of Achievement

For this investigation the grade point average attained by the transfer student in the first year at Drake, approximately 32 semester hours of work, was considered a suitable measure of achievement. A fact enhancing this choice was that most of those studied had attended a college for less than four years. Consequently, a more comprehensive measure was not available on all students.

Two criteria were tested in the study comparing achievement of native students with that of a matched group of transfer students. In the first analysis, records were compared on achievement in one year of work. In this instance all those studied had adequate time -- at least five years -- to complete a baccalaureate program. Thus, in the second comparison, achievement was dichotomized to graduation-non-graduation.

Variables Affecting Achievement

The variables considered were, in all cases, measures of academic attainment. Specifically the variables were:

1. Grade point average attained at the sending institution, denoted $X_1$. Pre-transfer grades were converted to the four-point scale used at Drake.

2. School and College Ability Test, Verbal Score, SCAT V-score, denoted $X_2$. The SCAT V-score attempts to measure the students ability to understand sentences and give the meaning of words.

3. Cooperative English, Level of Comprehension, CET L-score denoted $X_3$. 
The L-score is indicative of how well the student can understand what he reads when time is not a major factor.

The English expression score attempts to measure the student's ability to select appropriate usages and to see incorrect images. This score is related to the student's ability to write well in an essay situation.

5. SCAT, Quantitative score, SCAT Q-score, denoted $X_5$.
The Q-score attempts to measure the student's developed ability to perform operations with numbers and to solve mathematical problems stated in words.

6. SCAT, Total, SCAT T-score, denoted $X_6$.
This score is indicative of the student's general capacity to do college work. It is the simple composite of the V- and Q-scores.

This score is generally considered to be the best single index of verbal skill.

CET S-score measures how fast the student can read passages with comprehension.

9. American College Test, Total score, ACT T-score, denoted $X_9$.
The ACT total score gives a measure of general capacity for college work. The total score is a composite of the scores in
science, math, English, and social studies.

The foregoing variables were used in prediction of academic achievement. In each case, the raw score, indicative of the correct number of responses, was used.

The following variables were considered in the analysis of variation of achievement for the transfer students,

10. Sex.

11. Level of entry.
   The academic level of entry was sophomore, junior, or senior.

12. College of entry.
   The four classifications were business administration, education, fine arts and liberal arts.

13. Year of entry.
   The academic years 1961-62 through 1964-65, were included.

   Achievement was considered in terms of pre-transfer grade attainment. All grades were converted to the Drake grading system.

15. Sending institution.
   The five institution classifications, mentioned earlier, were used.

Hypotheses Tested and Statistical Methods Employed

The study was divided into four major sections. The basic problems to be resolved in each of the first three parts were stated in hypothesis form. Part four was a statistical derivation.
Part 1. Prediction of achievement for transfer students

The first part was an attempt to evaluate the relative contribution of certain measured factors in predicting achievement in the academic performance of transfer students. To this end tests were made on:

Hypothesis 1: (1) Transfer cumulative grade point average, (2) SCAT V-, Q-, and T-scores, (3) CET V-, L-, S-, and E-scores, and (4) ACT T-score had no significant value in predicting achievement in a first year of post-transfer work at Drake.

The five transfer student groups were evaluated separately by institution type. An equation for prediction of the achievement of each group was established on those variables which held significant relation to the criterion.

Toward resolving hypothesis 1, the techniques of multiple regression and correlation were applied. In a first analysis, a correlation matrix was established on variables $X_1$ through $X_9$ with $Y$ -- the measure of first year achievement at Drake. From analysis of five such matrices, the four best predictor variables were selected for regression analysis. The best predictor variables were those having highest correlation with the criterion and lowest intercorrelation with all other variables.

Under the assumption of a linear relation between the criterion and predictor variables, the regression equation in raw score form was (30),

$$ Y_i = a + b_1X_{i1} + b_2X_{i2} + b_3X_{i3} + b_4X_{i4} + e_i \quad \text{for } i = 1, 2, \ldots, n $$

where,

- $Y_i$ was a measure of first year post-transfer achievement at Drake
- $X's$ were predictor variables
- $a, b_1, b_2, b_3, b_4$ were appropriate constants
- $e_i$ were independent chance quantities which came from the same normally
distributed population.

The values $a, b_1, \ldots, b_4$ were chosen such that the equation of best fit, as defined by the least squares criterion, was derived. Herein a "best" equation was defined as one in which the sum of squares of the errors between actual and predicted Y-values was a minimum, that is to minimize $\sum e_i^2 = \sum (Y - Y_i)^2$. These errors of prediction are commonly called residuals.

It was desired not only to predict academic achievement but also to determine the value of each prediction combination. To this end, the coefficient of correlation indicated the strength of the linear relationship of predictor variables with the criterion. In each regression analysis a correlation matrix -- a list of coefficients of correlation between all prediction variables and the criterion -- was presented.

To further discern the relative strength of predictor variables on the criterion, an analysis of regression was computed. From the results of this analysis, an F-value, standard error of estimate and multiple, or simple, coefficients of correlation were known for each predictor combination. By utilizing this information it was possible to select the variables which gave the best prediction combination.

In the selection of variables for prediction purposes, a high correlation with the criterion but a low intercorrelation with all other predictor variables was sought. Also desirable was a low standard error of estimate, as this would indicate that the dispersion of sample values about the regression line was small. This would strengthen the assumption of linearity.

Starting with the four variable prediction combination, variables were
tested one at a time and the significance of loss in prediction ability, due to the removal of single variables, was measured by an F-test. The procedure was continued to the point where further dropping of a variable resulted in a marked decrease in predictive ability as evidenced by a significant F-value. The prediction was based on the regression for the remaining variables. Such an analysis was made separately on the records of transfer students from each of the five institution types.

The analysis involving ACT scores utilized records for all transfer students for whom ACT total scores were available. Of the 120 records analyzed, some were of transfers from each of the five types of sending institutions.

A second prediction of achievement was based on the dichotomized criterion, graduated versus did not graduate.

Hypothesis 2: (1) Transfer cumulative grade average, (2) Drake first year average, (3) SCAT V-score and (4) CET E-score had no significant value in predicting graduation from Drake.

Hypothesis 2 was tested through the use of the techniques of serial correlation and discriminant analysis. These techniques have been employed in cases where the criterion was a dichotomy. The analysis essentially followed the procedures of regression and correlation. The major formulations used included (32):

1. A test of significance: \( F_{m,N-m-1} = \frac{\Delta(N-m-1)}{\frac{NZ^2}{pq} - \Delta} \)

2. A test for significant loss in predicting graduation:

\( F_{n,N-m-1} = \frac{(\frac{\Delta_m - \Delta_{m-n}}{NZ^2}}{\frac{(N-m-1)}{pq} - \Delta_m} \)

\n
3. Computation of coefficients of point biserial correlation:

\[ R_{\text{bis}} = \frac{d}{\sigma} \left( \frac{pq}{Z} \right) \]

4. Computation of multiple coefficients of biserial correlation:

\[ R_{\text{bis}} = \frac{pq}{Z^2} \sqrt{\frac{\Delta}{N}} \]

5. Formulation of the discriminant equation:

\[ v = a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 \]

with

- \( p \) = proportion of students who graduated
- \( q \) = proportion of students who do not graduate
- \( N \) = total number of observations studied
- \( Z \) = height of the ordinate dividing the standard normal distribution into \( p \) and \( q \) parts.
- \( m \) = total number of independent variables
- \( n \) = number of variables eliminated
- \( \Delta \) = the discriminant function or discriminant sum of squares
- \( d \) = difference between the categories in means of the numerical variable
- \( v \) = standardized scores
- \( a_1, a_2, a_3, a_4 \) were appropriate constants

The major assumptions were that (1) the dichotomized variable was actually normally distributed and (2) that the discriminant function was actually linear. The analysis and interpretation of results were essentially those of regression.
Part 2. Analysis of the affects of selected factors on the achievement at Drake of transfer students

The second major problem concerned analysis of patterns of success at Drake for transfer students. The grade attainment in a first year of work at Drake was used as the criterion of success studied in each of the hypotheses. The several hypotheses tested were:

Hypothesis 3: There was no significant difference in the success for students at Drake who came from the various types of sending institutions.

Hypothesis 4: There was no significant difference in the success for students who entered Drake at various levels of their academic careers.

Hypothesis 5: There was no significance of difference in the success for transfer students who entered the various colleges at Drake.

Hypothesis 6: There was no significance in the difference of success for students at Drake as based on sex.

Hypothesis 7: There was no significance of difference in the success of students at Drake according to the year of entry.

Hypothesis 8: There was no significance of difference in the success for transfer students at Drake according to pre-transfer cumulative grade attainment.

Hypothesis 9: There was no significant difference in the success of transfer students having different scholastic aptitudes.

Tests on hypotheses three through nine employed the techniques of analysis of variance and covariance. In all cases the data involved unequal and disproportionate subclass frequencies for two or three way classifications. Due to the lengthy calculations encountered, the analyses were made with the aid of the computer facilities at Iowa State University.
Since no prior information was available to indicate the appropriate statistical model and thus an appropriate analysis, techniques suggested by Bancroft (2, 3) were utilized. Bancroft suggested performing a preliminary analysis of variance, AOV, test toward finding the correct equation and model. Then appropriate tests were employed on the main effects.

Specifically for the two variable analysis, one would test the model:

\[ Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}, \]

where

\[ \mu = \text{the overall mean} \]
\[ \alpha_i = \text{values of the first major source of variation for } i = 1, 2, 3, \ldots, r \]
\[ \beta_j = \text{values of the second major source of variation for } j = 1, 2, 3, \ldots, s \]
\[ (\alpha\beta)_{ij} = \text{a combined effect of the two main factors, called interaction} \]
\[ \varepsilon_{ijk} = \text{residuals or errors in estimation} \]

against the model:

\[ Y_{ijk} = \mu + \alpha_i + \beta_j + \varepsilon_{ijk} \]

For the second formula, the notation and assumptions were those specified above except that no interaction term, \((\alpha\beta)_{ij}\), was given. The analysis, by the least squares procedure, was based on satisfactory fulfillment of the following assumptions,

(1) The \( \varepsilon_{ijk} \) were independent random variables coming from a single normally distributed population that had zero mean and fixed variance.

(2) That all parameters were fixed, that is, that

\[ \sum_i \alpha_i = \sum_j \beta_j = \sum_i (\alpha\beta)_{ij} = \sum_j (\alpha\beta)_{ij} = 0 \]
Here \( c_i, d_j, e_i, f_j \) were the constants found to satisfy the restrictions that each summation equal zero. In order to specify the appropriate model, a preliminary test of significance was made on the interaction factor. An F-test was appropriate.

\[
F = \frac{\text{Mean Square for Interaction}}{\text{Within Mean Square}}
\]

If the F-value was significant at some preassigned probability level, then model (1) was used for tests on the main effects. Otherwise model (2) and procedures applicable thereto were utilized. Since the data involved unequal and disproportionate subclass numbers with some empty cells, the technique of fitting constants \( (3, 30) \) was used. This technique used the rationale of least squares. The essential calculations are illustrated in the following tables, Tables 3 and 4.

The analysis for the two way -- A by B -- classification utilized a preliminary analysis of variance as appears in Table 3.

Where in Table 3,

\( n_{ij} \) indicated the number of observations in the \( i^{\text{th}}j^{\text{th}} \) subclass for \( i = 1, 2, \ldots, r \) and \( j = 1, 2, \ldots, s \)

\( n_i \) was the number of observations in \( A_i \), \( n_i = \sum_{j} n_{ij} \)

\( n_j \) was the number of observations in \( B_j \), \( n_j = \sum_{i} n_{ij} \)

\( n \) was the total number of observations, \( n = \sum_{i} \sum_{j} n_{ij} \)

\( Y_{ijk} \) was the numerical value of the \( k^{\text{th}} \) observation in the \( i^{\text{th}} \) row and the \( j^{\text{th}} \) column.

\( Y_{ij} \) was the total value of all observations in the \( ij^{\text{th}} \) subclass,

\( Y_{ij} = \sum_{k} Y_{ijk} \)
Table 3. Calculations preliminary to the analysis of variance for a two factor factorial experiment

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subclasses</td>
<td>rs-1</td>
<td>$\sum Y^2_{i,j}/n_{i,j} - CT$</td>
<td>Subclass S.S./ rs-1</td>
</tr>
<tr>
<td>A, ignoring B</td>
<td>r-1</td>
<td>$\sum Y^2_{i,.}/n_{i,.} - CT$</td>
<td>S.S. A, ignoring B/ r-1</td>
</tr>
<tr>
<td>B, ignoring A</td>
<td>s-1</td>
<td>$\sum Y^2_{.j}/n_{.j} - CT$</td>
<td>S.S. B, ignoring A/ s-1</td>
</tr>
<tr>
<td>Within</td>
<td>n.. -rs</td>
<td>Total S.S.-Subclass S.S.</td>
<td>Within S.S./ n.. -rs</td>
</tr>
<tr>
<td>Total</td>
<td>n.. -1</td>
<td>$\sum Y^2_{ijk} - CT$</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Analysis of variance for the two factor factorial experiment

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, eliminating B</td>
<td>r-1</td>
<td>R(a)</td>
<td>$MS_A = R(a)/ r-1$</td>
</tr>
<tr>
<td>B, eliminating A</td>
<td>s-1</td>
<td>R(b)</td>
<td>$MS_B = R(b)/ s-1$</td>
</tr>
<tr>
<td>Interaction, (AB)</td>
<td>(r-1)(s-1)</td>
<td>R(ab)</td>
<td>$MS_{AB} = R(ab)/ (r-1)(s-1)$</td>
</tr>
<tr>
<td>Within (Error)</td>
<td>n.. -rs</td>
<td>S.S.E.</td>
<td>$MS_E = S.S.E./ n.. -rs$</td>
</tr>
</tbody>
</table>
Y_i.. was the total value of the observations in class A_i, Y_i.. = ∑_Y_i..j.k

Y_j. was the total value of the observations in class B_j, Y_j. = ∑_Y_j.i.k

Y... was the overall total value of all observations, Y... = ∑_Y ...i.k

and CT = (Y...)²/n was called the correction term.

The test on the main sources of variation was aided by another analysis of variance, Table 4.

Where in Table 4,

R(a) = ∑_a.._Y..i.. + ∑_b.._Y..j.. + mY... - ∑Y^2..j../n..j

R(b) = ∑_a.._Y..i.. + ∑_b.._Y..j.. + mY... - ∑Y^2..i../n..i.

R(ab) = ∑_Y..i..j../n..i..j - ∑_a.._Y..i.. - ∑_b.._Y..i.. - mY...

S.S.E = Total S.S. -- Subclass S.S.

where m, a_i, b_j, (ab)_{ij} were the estimates of μ, α_i, β_j, and (αβ)_{ij} respectively.

If the assumption of no interaction was valid, that is, if the F-test on interaction was not significant, then valid tests on main effects were,

H_0: α_i = 0 as tested by F = MS_A / MS_E

and

H_0: β_j = 0 as tested by F = MS_B / MS_E

Yet if a significant interaction effect existed, a test other than that specified was more valid. However, since the analyses involved some empty subclasses, the present method was quite applicable. Further, the formulations for the three way analyses were essentially an extension of the two-way case.

When significant main effects were found, tests were made to discern significance of differences between individual means. The technique em-
ployed was an application of the Duncan test (3, 26, 30).

It was hypothesized that achievement in upper division work at Drake was affected by the student's native scholastic aptitude. Thus if transfer students differed with respect to aptitude, how might one discern whether differences in achievement reflect previous training or just magnify known discrepancies in academic ability? In order to resolve this question, grades at Drake were adjusted through the application of a covariate, CET E-score. Hopefully by holding fixed differences in scholastic aptitude, as measured by the CET E-score, tests might more accurately reflect differences due to other sources of variation.

The basic covariance model utilized was,

$$
Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k(X_{ijk} - \bar{X}) + (\alpha\beta)_{ij} + \varepsilon_{ijk}
$$

where,

- $X_{ijk}$ was the value of the covariate for the $k^{th}$ observation in the $i^{th}$ row and the $j^{th}$ column
- $\gamma_k$ was the coefficient of the covariance term, and other symbols coincide with the notation given earlier. The assumptions of both analysis of variance and regression were required.

Tests on institutions, hypothesis 3, were performed, both before and after adjustment for aptitude. Thus by holding fixed differences in aptitude, a more precise test was made for differences in the ability of the five institution types to prepare students for work at Drake.

A second covariate, used independently of the CET E-score, was grade average attained at the sending institution. The purpose of using this covariate was to eliminate discrepancies in grading standards used by the various sending institutions. Hence, a second set of tests, was made on
Table 5. Summary of analysis of covariance for the two factor completely random design with one independent variable

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>(X,X) Sum of Products</th>
<th>(X,Y) Sum of Products</th>
<th>(Y,Y) Sum of Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>n..-1</td>
<td>T_{X,X}</td>
<td>T_{X,Y}</td>
<td>T_{Y,Y}</td>
</tr>
<tr>
<td>Subclass</td>
<td>rs-1</td>
<td>S_{X,X}</td>
<td>S_{X,Y}</td>
<td>S_{Y,Y}</td>
</tr>
<tr>
<td>Factor A</td>
<td>r-1</td>
<td>A_{X,X}</td>
<td>A_{X,Y}</td>
<td>A_{Y,Y}</td>
</tr>
<tr>
<td>Factor B</td>
<td>s-1</td>
<td>B_{X,X}</td>
<td>B_{X,Y}</td>
<td>B_{Y,Y}</td>
</tr>
<tr>
<td>Interaction (AB)</td>
<td>(r-1)</td>
<td>(AB)_{X,X}</td>
<td>(AB)_{X,Y}</td>
<td>(AB)_{Y,Y}</td>
</tr>
<tr>
<td>Error</td>
<td>n..-rs</td>
<td>E_{X,X}</td>
<td>E_{X,Y}</td>
<td>E_{Y,Y}</td>
</tr>
<tr>
<td>Factor A + Error</td>
<td>+r-2</td>
<td>A_{X,X} + ^{r-2}E_{X,X}</td>
<td>A_{X,Y} + ^{r-2}E_{X,Y}</td>
<td>A_{Y,Y} + ^{r-2}E_{Y,Y}</td>
</tr>
<tr>
<td>Factor B + Error</td>
<td>+s-2</td>
<td>B_{X,X} + ^{s-2}E_{X,X}</td>
<td>B_{X,Y} + ^{s-2}E_{X,Y}</td>
<td>B_{Y,Y} + ^{s-2}E_{Y,Y}</td>
</tr>
<tr>
<td>Interaction + Error</td>
<td>+r-s</td>
<td>(AB)<em>{X,X} + ^{r-s}E</em>{X,X}</td>
<td>(AB)<em>{X,Y} + ^{r-s}E</em>{X,Y}</td>
<td>(AB)<em>{Y,Y} + ^{r-s}E</em>{Y,Y}</td>
</tr>
</tbody>
</table>

Y adjusted for X

<table>
<thead>
<tr>
<th>df Unadjusted Adjusted</th>
<th>Sum of squares</th>
<th>Mean squares</th>
<th>Sum of squares</th>
<th>Mean squares</th>
<th>Sum of squares</th>
<th>Mean squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>n..-rs</td>
<td>SS_{E}</td>
<td>SS_{E}</td>
<td>SS_{E}</td>
<td>n..-rs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r-1</td>
<td>SS_{A+E}</td>
<td>SS_{A+E} - SS_{E}</td>
<td>SS_{A+E} - SS_{E}</td>
<td>r-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>s-1</td>
<td>SS_{B+E}</td>
<td>SS_{B+E} - SS_{E}</td>
<td>SS_{B+E} - SS_{E}</td>
<td>s-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(r-1)(s-1)</td>
<td>SS_{AB+E}</td>
<td>SS_{AB+E} - SS_{E}</td>
<td>SS_{AB+E} - SS_{E}</td>
<td>(r-1)(s-1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
hypothesis 3. In similar fashion tests were made on hypotheses 4 through 9.

The tests on main effects followed the outline given in Table 5. Therein "X" denoted the covariate and "Y" was the symbol used to indicate the dependent variable.

The notation was consistent with that given earlier,

\[ T_{x,x} = \sum_{ijk} (x_{ijk})^2 - \frac{(X_{..})^2}{n_{..}} \]

\[ T_{x,y} = \sum_{ijk} (x_{ijk})(y_{ijk}) - \frac{(X_{..})(Y_{..})}{n_{..}} \]

\[ T_{y,y} = \sum_{ijk} (y_{ijk})^2 - \frac{(Y_{..})^2}{n_{..}} \]

\[ S_{x,x} = \sum_{ij} \left( \left( x_{ij} \right)^2 \right) - \frac{(X_{..})^2}{n_{..}} \]

\[ S_{x,y} = \sum_{ij} \left( \frac{x_{ij}}{n_{ij}} \right)^2 - \frac{(X_{..})(Y_{..})}{n_{..}} \]

\[ S_{y,y} = \sum_{ij} \left( y_{ij} \right)^2 - \frac{(Y_{..})^2}{n_{..}} \]

\[ A_{x,x} = \sum_{i} \left( x_{i..} \right)^2 - \frac{(X_{..})^2}{n_{..}} \]

\[ A_{x,y} = \sum_{i} \left( \frac{x_{i..}}{n_{i..}} \right)^2 - \frac{(X_{..})(Y_{..})}{n_{..}} \]

\[ A_{y,y} = \sum_{i} \left( y_{i..} \right)^2 - \frac{(Y_{..})^2}{n_{..}} \]

\[ B_{x,x} = \sum_{j} \left( x_{.j} \right)^2 - \frac{(X_{..})^2}{n_{..}} \]

\[ B_{x,y} = \sum_{j} \left( \frac{x_{.j}}{n_{.j}} \right)^2 - \frac{(X_{..})(Y_{..})}{n_{..}} \]

\[ B_{y,y} = \sum_{j} \left( y_{.j} \right)^2 - \frac{(Y_{..})^2}{n_{..}} \]
\[ (AB)_{x,x} = S_{x,x} - A_{x,x} - B_{x,x} \]

\[ (AB)_{x,y} = S_{x,y} - A_{x,y} - B_{x,y} \]

\[ (AB)_{y,y} = S_{y,y} - A_{y,y} - B_{y,y} \]

\[ E_{x,x} = T_{x,x} - S_{x,x} \]

\[ E_{x,y} = T_{x,y} - S_{x,y} \]

\[ E_{y,y} = T_{y,y} - S_{y,y} \]

\[ SS_E = E_{y,y} - \left( \frac{E_{x,x}}{E_{x,x}} \right)^2 \]

\[ SS_{A+E} = (A_{y,y} + E_{y,y}) - \frac{(A_{x,y} + E_{x,y})^2}{A_{x,x} + E_{x,x}} \]

\[ SS_{B+E} = (B_{y,y} + E_{y,y}) - \frac{(B_{x,y} + E_{x,y})^2}{B_{x,x} + E_{x,x}} \]

\[ SS_{AB+E} = (AB)_{y,y} + E_{y,y} - \frac{(AB)_{x,y} + E_{x,y})^2}{(AB)_{x,x} + E_{x,x}} \]

First the test of significance for the interaction effect, \( H_0: (\alpha \beta)_{i,j} = 0 \), was performed by computing, \( F = \frac{MS_{(AB)}}{MS_E} \). If a non-significant ratio was obtained, valid tests on the main effects could then be made. The mean squares given in the last column of Table 4 could be used to construct the appropriate F-tests.

Part 3. Comparison of the achievement of native and transfer students

The third part of this study involved comparisons of the success of matched pairs of native and transfer students. Success was measured in two ways (1) by grade achievement in a first year of work at Drake and (2) by percentage who graduated from Drake.

Hypothesis 10: There was no significant difference in the success of
matched groups of native and transfer students in a year of work in the upper division at Drake.

In testing hypothesis 10, the technique of analysis of variance was used. The model was,

\[ Y_{ij} = \mu + \alpha_i + \beta_j + \epsilon_{ij} \quad i = 1,2(s) \]
\[ j = 1,2, \ldots, 147(t) \]

with: \( \mu \) = overall mean
\( Y_{ij} \) = a measure of academic achievement in one year at Drake
\( \alpha_i \) = type of student background -- native or transfer -- effect
\( \beta_j \) = matched pairs effect

The usual assumptions of analysis of variance were taken. The analysis employed an F-test, using the mean squares indicated in Table 6.

An important reason for pairing observations was to eliminate the effect of factors which were known to differ but that were of little interest to analyze. In this instance the groups were matched on sex, year of entry, college of study, level at which achievement was measured and aptitude as measured by the SCAT V-score. With these extraneous factors eliminated, the resulting analysis indicated true differences between the native and transfer groups.

As a further analysis of transfer and native students, a second comparison was made. This was on the criterion of survival-attrition.

Hypothesis 11: There was no significant difference in the survival (graduation) rate of transfer and native students at Drake. The technique employed here was an analysis on differences in proportions. The test statistic, a Z-score, was defined,
Table 6. Analysis of variance on background of students

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>s-1</td>
<td>$\sum_{i} Y_{i}^{2}/t - \frac{(Y^{..})^{2}}{st}$</td>
<td>Background S.S./s-1</td>
</tr>
<tr>
<td>Pairs</td>
<td>t-1</td>
<td>$\sum_{j} Y_{j}^{2}/s - \frac{(Y^{..})^{2}}{st}$</td>
<td>Pairs S.S./t-1</td>
</tr>
<tr>
<td>Within</td>
<td>(s-1)(t-1)</td>
<td>By subtraction</td>
<td>Within S.S./(s-1)(t-1)</td>
</tr>
<tr>
<td>Total</td>
<td>st-1</td>
<td>$\sum_{ij} Y_{ij}^{2} - \frac{(Y^{..})^{2}}{st}$</td>
<td></td>
</tr>
</tbody>
</table>

$Z = \frac{X_{1} - X_{2}}{\sqrt{p(1-p)\left(\frac{1}{n_{1}} + \frac{1}{n_{2}}\right)}}$ with $p = \frac{X_{1} + X_{2}}{n_{1} + n_{2}}$

where $X_{1}$ = the number of transfer students who graduated

$X_{2}$ = the number of native students who graduated

$n_{1} = n_{2} = 147$

or one may use,

$X^{2} = \sum_{i} \left[\frac{(O - E)^{2}}{E}\right]$  

where $O$ = observed values

$E$ = expected values

As a final comparison of transfer and native students, an analysis was made on differences in cumulative grade averages.

**Hypothesis 12**: There was no significance in the differences of mean cumulative grade point average attained by the graduates of the two groups.

Hypothesis 12 indicated a test on the difference of mean grade achievement. The test statistic, a normal distribution Z-score was de-
defined:

\[ Z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \]

where

\( \bar{X}_1 \) = Drake grade average of the transfer graduates
\( \bar{X}_2 \) = Drake grade average for the native graduates
\( S_1^2 \) = Variance within the transfer grades
\( n_1 \) = number of transfer students who graduated.

Assumptions for this relation were that the samples of natives and transfer students:

(1) Came from independent random samples, but
(2) Came from the same normal population

**Part 4. A statistical derivation: an unbiased test for interaction which extends the method of weighted squares of means**

A statistical derivation was made of a test on the interaction effect in the analysis of variance. The test utilized the factorial design with proportionate numbers in the subclasses. It was an extension of the tests on main effects by the method of weighted squares of means (3, 4, 30).
FINDINGS

The analyses were separated into four major parts: (1) prediction of achievement for transfers, (2) analysis of the effects of selected factors on the achievement at Drake of transfer students, (3) comparison of native and transfer students, (4) a statistical derivation.

Part 1. Prediction of Achievement for Transfer Students

In all cases the predictor variables tested were, pre-transfer average, $X_1$, SCAT V-score, $X_2$, CET L-score, $X_3$, and CET E-score, $X_4$. Achievement in the first year of post-transfer work at Drake was the criterion in all cases. In the final analysis of this section ACT T-score was used in place of the CET L-score.

Records were classified according to type of institution from which pre-transfer work was taken. A separate analysis appears for each of the five institutional groups. The single analysis involving ACT T-scores utilized records from all five institution groups.

Hypothesis 1: (1) Transfer cumulative grade point average, (2) SCAT V-score CET (3) L- and (4) E-scores for students coming from Iowa state supported colleges and universities, had no significant value in predicting achievement in a first year of post-transfer to Drake.

An analysis of mean scores and standard deviations for predictor variables and the criterion were presented in Table 7. The number of cases in each calculation was 187.

The summary of analysis of multiple regression for Drake average,
Table 7. Mean scores and standard deviations for predictor variables and criterion for transfer students from Iowa state supported colleges and universities

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean Scores</th>
<th>Standard Deviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-transfer average, $X_1$</td>
<td>2.45</td>
<td>0.56</td>
</tr>
<tr>
<td>SCAT V-score, $X_2$</td>
<td>39.12</td>
<td>8.65</td>
</tr>
<tr>
<td>CET L-score, $X_3$</td>
<td>22.44</td>
<td>4.09</td>
</tr>
<tr>
<td>CET E-score, $X_4$</td>
<td>47.61</td>
<td>10.69</td>
</tr>
<tr>
<td>Drake average, $Y$</td>
<td>2.52</td>
<td>0.60</td>
</tr>
</tbody>
</table>

Table 8, contained information obtained from the calculation of analysis of regression for all possible combinations of predictor variables. Multiple correlations, computed F-values and standard errors of estimate were presented.

This table was used to select the combination of variables to be analyzed and the order in which variables would be tested for dropping from the prediction equation. Choice of the best combination of variables for prediction, using 4,3,2,1 variables respectively, was that having the highest multiple correlation coefficient and the lowest standard error of estimate.

Zero order coefficients of correlation and inter-correlation were computed between Drake average and the predictor variables. Table 9, gives a correlation matrix listing these values.

In order to predict a criterion -- Drake average, $Y$ -- from four predictor variables a regression analysis was made for $Y$ on $X_1, X_2, X_3,$ and $X_4$. The results for this analysis were summarized in Table 10.
Table 8. Summary of analysis of multiple regression for first year achievement of transfer students from Iowa state supported institutions

<table>
<thead>
<tr>
<th>Variables used for prediction</th>
<th>Variables eliminated</th>
<th>Computed &quot;F&quot; values, level of significance</th>
<th>Standard error of estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Var.</td>
<td>No. Var.</td>
<td>&quot;F&quot; values, .01</td>
<td>R_y</td>
</tr>
<tr>
<td>4</td>
<td>X₁X₂X₃X₄</td>
<td>16.47</td>
<td>.5156</td>
</tr>
<tr>
<td>3</td>
<td>X₁X₂X₃</td>
<td>19.12</td>
<td>.4886</td>
</tr>
<tr>
<td>3</td>
<td>X₁X₂X₄</td>
<td>21.26</td>
<td>.5084</td>
</tr>
<tr>
<td>3</td>
<td>X₁X₃X₄</td>
<td>21.82</td>
<td>.5134</td>
</tr>
<tr>
<td>3</td>
<td>X₂X₃X₄</td>
<td>16.33</td>
<td>.4596</td>
</tr>
<tr>
<td>2</td>
<td>X₁X₂</td>
<td>26.75</td>
<td>.4746</td>
</tr>
<tr>
<td>2</td>
<td>X₁X₃</td>
<td>25.22</td>
<td>.4638</td>
</tr>
<tr>
<td>2</td>
<td>X₁X₄</td>
<td>30.58</td>
<td>.4995</td>
</tr>
<tr>
<td>2</td>
<td>X₂X₃</td>
<td>18.21</td>
<td>.4057</td>
</tr>
<tr>
<td>2</td>
<td>X₂X₄</td>
<td>23.88</td>
<td>.4540</td>
</tr>
<tr>
<td>2</td>
<td>X₃X₄</td>
<td>23.73</td>
<td>.4529</td>
</tr>
<tr>
<td>1</td>
<td>X₁</td>
<td>31.21</td>
<td>.3800</td>
</tr>
<tr>
<td>1</td>
<td>X₂</td>
<td>33.36</td>
<td>.3909</td>
</tr>
<tr>
<td>1</td>
<td>X₃</td>
<td>22.70</td>
<td>.3306</td>
</tr>
<tr>
<td>1</td>
<td>X₄</td>
<td>43.80</td>
<td>.4375</td>
</tr>
</tbody>
</table>

*a* Indicates the best predictor combination for each class of predictor variables.
Table 9. Correlation matrix for first year achievement and predictor variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>$X_1$</th>
<th>$X_2$</th>
<th>$X_3$</th>
<th>$X_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-transfer average, $X_1$</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCAT V-score, $X_2$</td>
<td>.3194</td>
<td>1.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CET L-score, $X_3$</td>
<td>.1813</td>
<td>.6302</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>CET E-score, $X_4$</td>
<td>.3534</td>
<td>.6940</td>
<td>.5286</td>
<td>1.0000</td>
</tr>
<tr>
<td>Drake average, $Y$</td>
<td>.3800</td>
<td>.3909</td>
<td>.3306</td>
<td>.4375</td>
</tr>
</tbody>
</table>

Table 10. Analysis of multiple regression using $X_1, X_2, X_3, X_4$ for predicting first year achievement

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>4</td>
<td>17.8425</td>
<td>4.4606</td>
</tr>
<tr>
<td>Residuals</td>
<td>182</td>
<td>49.2621</td>
<td>0.2707</td>
</tr>
<tr>
<td>Total</td>
<td>186</td>
<td>67.1046</td>
<td></td>
</tr>
</tbody>
</table>

Standard error = .5203

$F_{4,182} = 16.48$

$R_y(1,2,3,4) = .5156$

Tabled values .01 3.32

.05 2.37
An F-value, $F=16.48$, was obtained. This value was highly significant beyond the one per cent level, hereafter denoted with a double asterisk, that is, $F=16.48^{**}$. The standard error of estimate was 0.5203. Hence the four variable linear regression equation could be used to predict achievement in the first year of post-transfer work at Drake. Consequently, hypothesis one was not tenable. That is, at least one of the variables was of significant value in predicting grade achievement.

Since the best combination of three variables for prediction, as indicated in Table 8, was $X_1, X_3, X_4$, multiple regression was next analyzed for that combination. This is presented in Table 11.

Again a significant $F=21.82^{**}$ was obtained. The multiple correlation $R_{Y(1,3,4)}=0.5197$. The regression equation of Drake average on pre-transfer grades, CET L- and E-scores could be used for prediction of achievement.

A test as indicated in Table 12, was made of the loss in prediction ability due to the elimination of SCAT V-score, $X_2$.

The F-value, 0.58, was not significant. There was no significant loss in ability to predict achievement at Drake for these students with the dropping of SCAT V-score.

The best two variable combination, $X_2$ and $X_4$, as indicated by Table 8, was then used to compute a new analysis or regression. This is presented in Table 13.

A highly significant $F=30.58^{**}$ and $R_{Y(1,4)}=0.4995$ resulted. The regression equation for pre-transfer average and CET E-score could be used to predict achievement in the first year of post-transfer work at Drake University.

A test was made on the significance of the loss in prediction ability
Table 11. Analysis of multiple regression using $X_1, X_3, X_4$ for predicting first year achievement

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>3</td>
<td>17.6844</td>
<td>5.8948</td>
</tr>
<tr>
<td>Residual</td>
<td>183</td>
<td>49.4201</td>
<td>0.2700</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>186</td>
<td><strong>67.1046</strong></td>
<td></td>
</tr>
</tbody>
</table>

Standard error = .51967

$F_{3,183} = 21.82^{**}$

$\text{Tabled values .01} = 3.78$

$\text{Tabled values .05} = 2.60$

Table 12. Loss in prediction ability due to the elimination of SCAT V-score, $X_2$

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression (4 var)</td>
<td>4</td>
<td>17.8425</td>
<td></td>
</tr>
<tr>
<td>Regression (3 var)</td>
<td>3</td>
<td>17.6844</td>
<td></td>
</tr>
<tr>
<td>Loss due to $X_3$</td>
<td>1</td>
<td>.1581</td>
<td>.1581</td>
</tr>
<tr>
<td>Residual (4 var)</td>
<td>182</td>
<td>49.2621</td>
<td>.2707</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>186</td>
<td><strong>67.1046</strong></td>
<td></td>
</tr>
</tbody>
</table>

$F_{1,182} = 0.58$

<table>
<thead>
<tr>
<th>Tabled values .01</th>
<th>6.63</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tabled values .05</td>
<td>3.84</td>
</tr>
</tbody>
</table>
Table 13. Analysis of multiple regression using $X_1, X_4$ to predict first year achievement

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2</td>
<td>16.7398</td>
<td>8.3699</td>
</tr>
<tr>
<td>Residual</td>
<td>184</td>
<td>50.7648</td>
<td>.2737</td>
</tr>
<tr>
<td>Total</td>
<td>186</td>
<td>67.1046</td>
<td></td>
</tr>
</tbody>
</table>

Standard error = .5231

$F_{2,184} = 30.58^{**}$

$r_y(1,4) = .4995$

Tabled values .01 4.61

.05 3.00

Table 14. Loss in prediction ability due to the elimination of CET L-score, $X_3$

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression (3 var)</td>
<td>3</td>
<td>17.6844</td>
<td></td>
</tr>
<tr>
<td>Regression (2 var)</td>
<td>2</td>
<td>16.7398</td>
<td></td>
</tr>
<tr>
<td>Loss due to $X_3$</td>
<td>1</td>
<td>.9446</td>
<td>.9446</td>
</tr>
<tr>
<td>Residual (3 var)</td>
<td>183</td>
<td>49.4201</td>
<td>.2700</td>
</tr>
<tr>
<td>Total</td>
<td>186</td>
<td>67.1046</td>
<td></td>
</tr>
</tbody>
</table>

$F_{1,183} = 3.50$

Tabled values .01 6.63

.05 3.84
due to the elimination of the CET L-score, $X_3$. The calculations for the
test of loss in prediction due to this elimination are presented in Table
14.

The $F = 3.50$ was not significant. However, it was quite near the .05
level critical value. Dropping the CET L-score from the regression did not
reduce prediction ability significantly.

CET E-score, $X_4$, alone was used in a simple linear regression to pre­
dict grade achievement at Drake. The analysis is presented in Table 15.

The $F$ value, $43.79^\ast\ast$, was highly significant. The linear regression
equation using CET E-score was satisfactory to predict Drake grade achieve­
ment.

The test to determine if pre-transfer cumulative average $X_1$, could be
eliminated from the regression appears in Table 16.

The resulting highly significant $F$ value, $14.23^\ast\ast$, indicated that pre­
transfer average could not be eliminated from the regression without exces­
sive loss in prediction ability. It was retained.

From preceding analysis on transfers from Iowa state supported univer­
sities and colleges, the regression of Drake average on CET E-score, $X_4$,
and pre-transfer average, $X_1$, appears to be the best prediction combination
of those studied. The regression equation used to predict achievement in
the first year of post-transfer work at Drake University was:

$$Y = .2767X_1 + .0195X_4 + .9159$$

Analyses similar to that just presented, were made on the records of
transfer students who came from universities and colleges type one through
four. The records of all five groups were treated separately. Each analy­
sis was an attempt to find the equation for best prediction of achievement
Table 15. Analysis of regression using CET E-score, $X_4$ to predict first year achievement

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>1</td>
<td>12.8456</td>
<td>12.8456</td>
</tr>
<tr>
<td>Residual</td>
<td>185</td>
<td>54.2589</td>
<td>.2933</td>
</tr>
<tr>
<td>Total</td>
<td>186</td>
<td>67.1046</td>
<td></td>
</tr>
</tbody>
</table>

Standard error = .5416

$F_{1,185} = 43.79^{**}$

$F_{y(4)} = .4375$

Tabled values .01 6.63

.05 3.84

Table 16. Loss in prediction ability due to the elimination of pre-transfer average, $X_1$

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression (2 var)</td>
<td>2</td>
<td>16.7398</td>
<td></td>
</tr>
<tr>
<td>Regression (1 var)</td>
<td>1</td>
<td>12.8456</td>
<td></td>
</tr>
<tr>
<td>Loss due to $X_1$</td>
<td>1</td>
<td>3.8942</td>
<td>3.8942</td>
</tr>
<tr>
<td>Residual (2 var)</td>
<td>184</td>
<td>50.7648</td>
<td>.2737</td>
</tr>
<tr>
<td>Total</td>
<td>186</td>
<td>67.1046</td>
<td></td>
</tr>
</tbody>
</table>

$F_{1,184} = 14.23^{**}$

Tabled values .01 6.63

.05 3.84
in the first year of post-transfer work at Drake. The prediction variables tested in all cases were (1) pre-transfer grade average, (2) SCAT V-score, (3) CET L-score and (4) CET E-score. In each case the null hypothesis, or statement of no significant predictive value, was rejected.

For the major universities outside the state of Iowa, the best prediction combination of those tested was CET E-score, $X_4$, and pre-transfer average, $X_1$. The best prediction, based on those variables studied, was through the equation:

$$Y = .2957 X_1 + .0148X_4 + 1.0614$$

The coefficient of multiple correlation was, $R_y(1,4) = .4571$ and the standard error of estimate was 0.5077. The highest zero order correlation with the criterion was $r_y(4) = .3988$. One hundred eight student records were studied in this instance.

Analysis of regression for the 263 records on transfer students from liberal arts colleges again utilized the predictor variables $X_1$, $X_2$, $X_3$, and $X_4$. Here pre-transfer average, $X_1$ and CET L-score, $X_3$, made significant contribution in predicting pre-transfer average. Prediction was based on the equation:

$$Y = .5626X_1 + .0321X_3 + .2582$$

The coefficient of multiple correlation was $R_y(1,3) = .4618$ and the standard error of estimate was 0.5897. The highest zero order coefficient of correlation with the criterion was $r_y(1) = .4263$.

One hundred fifty-eight records of transfer students who came from teachers colleges and junior colleges outside of Iowa were analyzed. Only pre-transfer grades and CET E-score made significant contribution to the linear regression. The best prediction, based on those variables tested, was through the equation:
\[ Y = .4033X_1 + .0282X_4 - .1101 \]

The coefficient of multiple correlation was \( R_{y(1,4)} = .5675 \) and the standard error of estimate was 0.6170. The highest zero order coefficient of correlation with the criterion was \( r_{y(4)} = .5027 \).

Grandview college transfer records provided 140 cases. Only pre-transfer grades, \( X_1 \), contributed significantly to prediction of pre-transfer achievement. The regression equation of best fit was:

\[ Y = .6782X_1 + .6034 \]

The correlation of pre-transfer and post-transfer grades was \( r_{y(1)} = .5874 \). The standard error of estimate was 0.4893.

In the final regression analysis 110 records were analyzed. Records were for students from all five of the university groupings. This analysis was a regression of first year post-transfer achievement on pre-transfer average, \( X_1 \), SCAT V-score, \( X_2 \), CET E-score, \( X_4 \), and ACT T-score, \( X_9 \).

Of those predictor variables tested, pre-transfer grade, \( X_1 \), alone made significant contribution to the regression equation. The regression equation of best fit was:

\[ Y = 89.0508 + 0.5758X_1 \]

The correlation of first year pre-transfer grades and post-transfer grades was \( r_{y(1)} = .4744 \). Correlation of ACT T-score with the criterion was \( r_{y(9)} = 0.2004 \).

The techniques of discriminant analysis and biserial correlation (30) were used in the analysis on the criterion of graduation.

**Hypothesis 2:** Pre-transfer cumulative average, \( X_1 \), first year post-transfer average, \( X_{10} \), SCAT V-score, \( X_2 \), and CET E-score, \( X_4 \), have no significant value in predicting graduation from Drake.
Only transfer entrants of fall 1961 were studied. This group of 147 had been allowed five years at Drake toward completion of a baccalaureate degree.

The analysis of a discriminant equation follows closely the pattern of analysis of normal equations in linear regression. Data pertinent to the discriminant analysis appear in Table 17.

The coefficients for a four variable discriminant equation -- $a_1$, $a_{10}$, $a_2$, $a_4$ -- were obtained through solution of the equations,

\begin{align*}
1.6397 &= 40.9752a_1 + 25.5627a_{10} + 110.0855a_2 + 174.4568a_4 \\
33.8877 &= 25.5627a_1 + 66.6516a_{10} + 332.9704a_2 + 435.4488a_4 \\
149.7617 &= 110.0855a_1 + 332.9704a_{10} + 10367.7551a_2 + 8165.7347a_4 \\
118.0603 &= 174.4568a_1 + 435.4488a_{10} + 8165.7347a_2 + 17812.4626a_4
\end{align*}

The values obtained were,

\begin{align*}
a_1 &= -0.3612 \\
a_2 &= 0.6855 \\
a_3 &= 0.0023 \\
a_4 &= -0.0076
\end{align*}

The relative contribution of the variables in predicting graduation was made by comparing relative contribution to the discriminant function, $\Delta_4$. The function, $\Delta$, serves the purpose comparable to that of total sum of squares in regression analysis.

\[\Delta_4 = a_1NZd_1 + a_{10}NZd_{10} + a_2NZd_2 + a_4NZd_4\]

\[= -0.5923 + 23.2300 + 0.3445 - 0.8973\]

\[= 22.0849\]

Percentage contribution to the discriminant function, $\Delta_4$, for the predictor variables appears in Table 18.

A test of significance was made on the ability of the four variable combination to predict graduation. The analysis appears in Table 19.
Table 17. Preliminary information for discriminant analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Arithmetic Mean</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Graduates, Non-graduates, n₁=95</td>
<td>n₂=52</td>
<td>d₁</td>
<td>NZd₁</td>
</tr>
<tr>
<td>Pre-transfer average, X₁</td>
<td>2.45</td>
<td>2.42</td>
<td>.03</td>
<td>1.6397</td>
</tr>
<tr>
<td>Post-transfer average, X₁₀</td>
<td>2.56</td>
<td>1.94</td>
<td>.62</td>
<td>33.8877</td>
</tr>
<tr>
<td>SCAT V-score, X₂</td>
<td>39.01</td>
<td>36.27</td>
<td>2.74</td>
<td>149.7617</td>
</tr>
<tr>
<td>CET E-score, X₄</td>
<td>47.31</td>
<td>45.15</td>
<td>2.16</td>
<td>118.0603</td>
</tr>
</tbody>
</table>

Table 18. Percentage contribution to the discriminant function

<table>
<thead>
<tr>
<th>Variable</th>
<th>Absolute value</th>
<th>Per cent contribution to Δ₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-transfer average, X₁</td>
<td>.5923</td>
<td>2.4</td>
</tr>
<tr>
<td>Post-transfer average, X₁₀</td>
<td>23.2300</td>
<td>92.6</td>
</tr>
<tr>
<td>SCAT V-score, X₂</td>
<td>.3445</td>
<td>1.4</td>
</tr>
<tr>
<td>CET E-score, X₄</td>
<td>.8973</td>
<td>3.6</td>
</tr>
<tr>
<td>1Δ₁</td>
<td>25.0641</td>
<td></td>
</tr>
</tbody>
</table>

Table 19. Discriminant analysis using X₁,X₂,X₄,X₁₀ for predicting graduation of transfer students from Drake

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sums of squares</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discriminant</td>
<td>4</td>
<td>22.0849</td>
<td>5.5212</td>
<td>11.74*</td>
</tr>
<tr>
<td>Residuals</td>
<td>142</td>
<td>66.7839</td>
<td>0.4703</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>146</td>
<td>88.8688</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The test indicated significance at the .01 level. The multiple coefficient of biserial correlation, $R_{bis}$, was 0.5927. The four variable discriminant equation could be used to predict graduation. The null hypothesis, that is hypothesis 2, was rejected.

Since SCAT V-score made the least contribution to the discriminant relation, it was the first tested for elimination. Consequently, a second discriminant relation was based on the remaining variables $X_1, X_4, \text{ and } X_{10}$. For this combination $\Delta_3 = 22.0486$. The percentage contributions were pre-transfer average, 2.4 per cent; post-transfer average, 94.4 per cent; CET E-score, 3.2 per cent. The preliminary test of significance on $\Delta_3$ appears in Table 20.

Again a significant relation was observed and $R_{bis}$ was 0.5922. Thus next a test was made for loss in prediction ability with the elimination of SCAT V-score, $X_2$. This appears in Table 21.

The loss in ability to predict graduation through elimination of SCAT V-score was not significant.

Because pre-transfer average, $X_1$, made the least contribution to the three variable discriminant equation, it was next tested for removal. An analysis was made on the two remaining variables, CET E-score and post-transfer grade averages. The value of $\Delta_2$ was 17.9422. Percentage contribution was for grade averages 95.8 per cent and for CET E-score 4.2 per cent. The test of significance appears in Table 22.

The test indicated a significant relation and, therefore, that graduation of transfer students might be predicted from an appropriate two variable discriminant equation. Here $R_{bis}$ was 0.5396. As is indicated in Table 23, a test was made for the elimination of the predictor variable
Table 20. Test of significance on the three variable discriminant relation

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discriminant</td>
<td>3</td>
<td>22.0486</td>
<td>7.3495</td>
<td>15.73**</td>
</tr>
<tr>
<td>Residuals</td>
<td>143</td>
<td>66.8202</td>
<td>0.4673</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>146</td>
<td>88.8688</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 21. Test for elimination of SCAT V-score from the discriminant equation

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discriminant (4 var)</td>
<td>4</td>
<td>22.0849</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discriminant (3 var)</td>
<td>3</td>
<td>22.0486</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss due to $X_2$</td>
<td>1</td>
<td>0.0363</td>
<td>0.0363</td>
<td>0.08</td>
</tr>
<tr>
<td>Residual (4 var)</td>
<td>142</td>
<td>66.7839</td>
<td>0.4703</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>146</td>
<td>88.8688</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 22. Test of significance for the two variable discriminant equation

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discriminant</td>
<td>2</td>
<td>17.9422</td>
<td>8.9711</td>
<td>18.22**</td>
</tr>
<tr>
<td>Residuals</td>
<td>144</td>
<td>70.9266</td>
<td>0.4925</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>146</td>
<td>88.8688</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 23. Test for elimination of pre-transfer average from the discriminant equation

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discriminant (3 var)</td>
<td>3</td>
<td>22.0486</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discriminant (2 var)</td>
<td>2</td>
<td>17.9422</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss due to $X_1$</td>
<td>1</td>
<td>4.1064</td>
<td>4.1064</td>
<td>8.79**</td>
</tr>
<tr>
<td>Residual (3 var)</td>
<td>143</td>
<td>66.8202</td>
<td>0.4673</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>146</td>
<td>88.8688</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
pre-transfer average, $X_1$.

A significant test value, indicated that pre-transfer grades could not be eliminated without noticeable loss in prediction ability. Thus the best discriminant combination, of those tested, was that of pre-transfer averages, $X_1$, post-transfer average, $X_{10}$, and CET E-score, $X_4$. The discriminant equation of best fit was (32):

$$V - ar{V} = a_1(X_1 - ar{X}_1) + a_{10}(X_{10} - ar{X}_{10}) + a_4(X_4 - ar{X}_4)$$

$$V = .3745 = - .3627(X_1 - 2.44) + .6915(X_{10} - 2.33) + .0067(X_4 - 56.51)$$

$$V = -.3627X_1 + 0.6915X_{10} + 0.0067X_4 + 0.6619$$

Part 2. Analysis of the Affects of Selected Factors on the Achievement at Drake of Transfer Students

A three way AOV design was used to study the affects of (1) transfer institutions, (2) level of entry and (3) sex on achievement at Drake University. The analysis, which appears in Table 24, encompassed the records of all 856 transfer students. The computations were made on the 360-50 IBM computer at Iowa State University, Ames.

Hypothesis 3: There was no significant difference in the achievement at Drake of transfer students who came from different sending institutions. Hypothesis three was rejected. Yet as there was a significant interaction effect of institutions by sex, interpretation of individual institution differences was somewhat unclear.

However, a test was made on colleges to discern wherein significant grade differentials existed. The procedure used was that formulated by Duncan (4, 30) and extended by Kramer (26) to tests on group means with unequal numbers of replicates. Basically two ranked means differed signi-
Table 24. Analysis of variance for the factors institutions, sex and level of entry on achievement at Drake

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sums of squares</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of entry, L</td>
<td>2</td>
<td>10.7759</td>
<td>5.3879</td>
<td>13.94**</td>
</tr>
<tr>
<td>Sex, S</td>
<td>1</td>
<td>9.1829</td>
<td>9.1829</td>
<td>23.77**</td>
</tr>
<tr>
<td>Institutions, I</td>
<td>4</td>
<td>8.4092</td>
<td>2.1023</td>
<td>5.44**</td>
</tr>
<tr>
<td>L x S</td>
<td>2</td>
<td>3.2981</td>
<td>1.6490</td>
<td>4.27*</td>
</tr>
<tr>
<td>L x I</td>
<td>8</td>
<td>5.3599</td>
<td>0.6700</td>
<td>1.74</td>
</tr>
<tr>
<td>S x I</td>
<td>4</td>
<td>1.6614</td>
<td>0.4153</td>
<td>1.07</td>
</tr>
<tr>
<td>L x S x I</td>
<td>8</td>
<td>5.4202</td>
<td>0.6775</td>
<td>1.75</td>
</tr>
<tr>
<td>Error</td>
<td>826</td>
<td>319.1951</td>
<td>0.3864</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>855</td>
<td>363.3027</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

...significantly if their difference exceeded a value called the shortest significant range. This was the critical or test value.

The shortest significant range, \( R_p \) was dependent upon (1) confidence desired, (2) variability in the population and (3) differences in sample size. Mean differences, \( \bar{X}_i - \bar{X}_j \), were compared against, \( R_p \) as follows:

\[
p = \begin{array}{c} 2 \quad 3 \quad 4 \quad 5 \\
R(n_2=826, \alpha=.05): 2.77 \quad 2.92 \quad 3.02 \quad 3.09 \\
R_p: \quad .157 \quad .134 \quad .169 \quad .164 \\
\end{array}
\]

for example 2 against 3  2 against 5  3 against 5  3 against 1

\( p = \) The number of means encompassed in a comparison of two ranked means.

\( n_2 = \) The number of degrees of freedom for the error term in the related analysis of variance.
\[ R = A \text{ tabular significant range for specified confidence, } \alpha, \text{ and error degrees of freedom, } n^2. \]

\[ R_p = R \times \left( \frac{1}{2} \left( \frac{1}{n_i} + \frac{1}{n_j} \right) \right) \times S^2 \]

Herein \( n_i \) and \( n_j \) designated the number of observations comprising either mean. \( S^2 \) was the error mean square taken from the analysis of variance.

Any difference which exceeded an appropriate \( R_p \) value indicated a significant difference in the two means being compared. In the test on institutions using the preceding test scale of \( R_p \), the following differences occurred:

<table>
<thead>
<tr>
<th>Institution</th>
<th>3</th>
<th>2</th>
<th>4</th>
<th>5</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size, ( n_i )</td>
<td>109</td>
<td>262</td>
<td>158</td>
<td>140</td>
<td>187</td>
</tr>
<tr>
<td>Mean</td>
<td>2.15</td>
<td>2.32</td>
<td>2.34</td>
<td>2.52</td>
<td>2.52</td>
</tr>
</tbody>
</table>

As a guiding rule, those means which were cut by the same line did not differ significantly. Thus in the institutions test, the mean grade point average attained at teachers and junior colleges outside of Iowa, type three, was significantly below the average of every other group. Averages for types two and four were below those from Iowa state institutions and large universities, types five and one. Again, caution was made that the sex by institution interaction effect might distort these conclusions.

**Hypothesis 4**: There was no significant difference in the achievement at Drake according to level of entry. This hypothesis was also rejected. Again the Duncan test was made for individual differences. The results of that test were as follows:
Level of entry | 2 | 4 | 3
---|---|---|---
\(n\) | 256 | 193 | 407
Mean | 2.20 | 2.43 | 2.44

That is, those who entered as juniors or seniors achieved better than those who transferred at the sophomore level.

Because a computer solution was not readily available, the analysis of differences of achievement by year for the years 1961 through 1964, was made by desk calculator. A stratified random sample of 110 records was used. Allocation of sample items in proportion to the population required the ratio of 1961: 1962: 1963: 1964 = 2:3:3:3. The techniques employed were those described by Bancroft (4) and Snedecor (29) as analysis of variance with proportional subclasses.

**Hypothesis 7:** There was no significant difference in the achievement at Drake of transfer students who entered in different years. The analysis of grade achievement was based on the factors sending institutions and year of transfer. The analysis of variance appears in Table 25.

No significant differences were noted for this sample. Differences in grade achievement attributable to year of entry were negligible. The researcher was unable to reject hypothesis seven. The grade point averages for the entrants of the four years 1961 through 1964 were 2.44, 2.15, 2.21 and 2.28, respectively.

An analysis was made of the achievement of students who transferred into the several colleges at Drake.

**Hypothesis 5:** There was no significant difference in the achievement of students who transferred to the various colleges at Drake. The analysis
Table 25. Analysis of variance for the factors years and institutions

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>Expected mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutions</td>
<td>4</td>
<td>1.993</td>
<td>.498</td>
<td>(\sigma^2 + .013K_{AB}^2 + 21.45K_A^2)</td>
<td>1.13</td>
</tr>
<tr>
<td>Years</td>
<td>3</td>
<td>1.048</td>
<td>.349</td>
<td>(\sigma^2 + .546K_{AB}^2 + 27.28K_B^2)</td>
<td>0.81</td>
</tr>
<tr>
<td>Interaction</td>
<td>12</td>
<td>5.385</td>
<td>.449</td>
<td>(\sigma^2 + 5.32K_{AB}^2)</td>
<td>1.02</td>
</tr>
<tr>
<td>Error</td>
<td>90</td>
<td>39.747</td>
<td>.442</td>
<td>(\sigma^2)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>109</td>
<td>48.173</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 26. Analysis of variance for the factors college and sex

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>Expected mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colleges</td>
<td>3</td>
<td>4.4580</td>
<td>1.486</td>
<td>(\sigma^2 + .150K_{AB}^2 + 24.984K_A^2)</td>
<td>3.13*</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>1.3570</td>
<td>1.357</td>
<td>(\sigma^2 + 2.987K_{AB}^2 + 53.333K_B^2)</td>
<td>6.28**</td>
</tr>
<tr>
<td>Interaction</td>
<td>3</td>
<td>0.5534</td>
<td>0.184</td>
<td>(\sigma^2 + 12.337K_{AB}^2)</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>100</td>
<td>27.5254</td>
<td>0.275</td>
<td>(\sigma^2)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>107</td>
<td>33.8938</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
was with proportional allocation in the ratio of 3:3:1:5 for transfer students to business, education, fine arts and liberal arts, respectively. The analysis appears in Table 26. The sample size was 108.

A significant F-value was found for the factor colleges. Consequently, hypothesis five was rejected. The Duncan test was applied to find wherein individual differences existed.

The sample means for the four colleges were as follows:

<table>
<thead>
<tr>
<th>College</th>
<th>Business</th>
<th>Education</th>
<th>Liberal Arts</th>
<th>Fine Arts</th>
</tr>
</thead>
<tbody>
<tr>
<td>n_i</td>
<td>27</td>
<td>27</td>
<td>45</td>
<td>9</td>
</tr>
<tr>
<td>Mean</td>
<td>2.15</td>
<td>2.52</td>
<td>2.54</td>
<td>2.86</td>
</tr>
</tbody>
</table>

Transfer students to the college of business administration achieved poorer than all other groups. Their mean grade point average was well below that of all other colleges.

By the introduction of a covariate to the analysis, tests were made on the two factors used as covariates, pre-transfer grade point average and CET E-scores. A first analysis appears in Table 27. The technique used has been described by Federer (13).

After removing the affects of differences in aptitude, there was no significant interaction or sex effect. Thus after adjustment for aptitude, differences in achievement of men and women was not significant. There was yet a significant grade differential based on the college of entry at Drake. To test for differences by college, the adjusted grade point averages were computed as shown in Table 28.

In accordance with the procedures defined by Steel and Torrie (30) paired comparisons were tested with
Table 27. Covariance analysis of achievement at Drake for transfer students based on college of entry and sex with covariate CET E-score

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>$\Sigma X^2$</th>
<th>$\Sigma Y^2$</th>
<th>$\Sigma XY$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>107</td>
<td>10,313.630</td>
<td>33.894</td>
<td>264.015</td>
</tr>
<tr>
<td>Subclasses</td>
<td>7</td>
<td>1,003.186</td>
<td>6.368</td>
<td>46.456</td>
</tr>
<tr>
<td>Colleges (ignoring sex)</td>
<td>3</td>
<td>108.815</td>
<td>4.458</td>
<td>5.683</td>
</tr>
<tr>
<td>Sex (ignoring college)</td>
<td>1</td>
<td>613.334</td>
<td>1.357</td>
<td>28.850</td>
</tr>
<tr>
<td>Interaction</td>
<td>3</td>
<td>281.038</td>
<td>0.553</td>
<td>11.932</td>
</tr>
<tr>
<td>Colleges (adjusted for sex)</td>
<td>3</td>
<td>104.886</td>
<td>4.447</td>
<td>5.436</td>
</tr>
<tr>
<td>Sex (adjusted for colleges)</td>
<td>1</td>
<td>609.405</td>
<td>1.346</td>
<td>28.603</td>
</tr>
<tr>
<td>Error</td>
<td>100</td>
<td>9,310.444</td>
<td>27.525</td>
<td>217.550</td>
</tr>
<tr>
<td>Error and Colleges</td>
<td>103</td>
<td>9,415.330</td>
<td>31.972</td>
<td>222.986</td>
</tr>
<tr>
<td>Error and Sex</td>
<td>101</td>
<td>9,919.849</td>
<td>28.871</td>
<td>246.153</td>
</tr>
<tr>
<td>Error and Interaction</td>
<td>103</td>
<td>9,591.482</td>
<td>28.078</td>
<td>229.482</td>
</tr>
</tbody>
</table>

Unadjusted Sum of squares      | df | Sum of squares | Mean squares |
|                               |    |               |             |
|                               | 99 | 22.442        | .227        |
|                               | 3  | 4.249         | 1.416       |
|                               | 1  | 0.321         | 0.321       |
|                               | 3  | 0.146         | 0.049       |
Table 28. Adjusted means under the grouping by college of entry to Drake

<table>
<thead>
<tr>
<th>College</th>
<th>$Y_i$</th>
<th>$b_{yx}(\bar{X}<em>i - \bar{X}</em>.)$</th>
<th>Grade point averages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Adjusted</td>
</tr>
<tr>
<td>Business, 1</td>
<td>2.15</td>
<td>-0.0179</td>
<td>2.13</td>
</tr>
<tr>
<td>Education, 2</td>
<td>2.52</td>
<td>-0.0195</td>
<td>2.50</td>
</tr>
<tr>
<td>Fine Arts, 3</td>
<td>2.86</td>
<td>-0.0238</td>
<td>2.84</td>
</tr>
<tr>
<td>Liberal Arts, 4</td>
<td>2.54</td>
<td>0.0270</td>
<td>2.56</td>
</tr>
</tbody>
</table>

\[ S_{d}^{-1} = \left( \text{Error Mean Square} \right) \left[ \frac{1}{n_1} + \frac{1}{n_2} \right] + \frac{\left( \bar{X}_1 - \bar{X}_2 \right)^2}{E_{xx}} \]

For the adjusted means it was found that transfer students entering business administration had achieved poorer than those entering education, fine arts or liberal arts, $S_{d} = 0.130$. Other comparisons indicated that the adjusted grade point averages for those in education and liberal arts were both well below the average for those in fine arts. Under adjustment for aptitude, hypothesis five, no difference in achievement by college of entry, was rejected.

**Hypothesis 9:** There was no significant difference in the success of transfer students having different scholastic aptitudes. The fact that the factor sex was significant before treatment with the covariate, GET E-score, but not after was indication of significant differences in aptitude. Thus hypothesis nine was rejected.

Another analysis of covariance allowed a test of the affect of the covariate pre-transfer grade point average on the criterion. The factors institutions and levels of entry were tested after adjustment for the
covariate. The analysis, which appears in Table 29, was performed by computer and allowed a test of hypothesis eight.

**Hypothesis 8:** There were no significant differences in the pre-transfer grade point averages of the transfer students to Drake University.

Hypothesis eight was rejected. There were relatively large differences in pre-transfer grades. After adjustment for differences in pre-transfer grading there were still significant differences in achievement for those who entered Drake as sophomores, juniors or as seniors. The (1) institution and (2) entry by institution interaction were neither one significant. Since adjusted means were not readily obtained from the computer analysis, further comparisons were omitted.

The final analysis of covariance allowed a second test on hypothesis eight. The factors (1) colleges, (2) level of entry and (3) their interaction were treated with the covariate pre-transfer grades. The summary of this test appears in Table 30.

Again hypothesis eight was rejected. That is, pre-transfer grades
Table 30. Covariance analysis with factors colleges and level of entry with covariate pre-transfer grade point average

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-transfer grades</td>
<td>1</td>
<td>54.5047</td>
<td>54.5047</td>
<td>164.51**</td>
</tr>
<tr>
<td>Colleges, C</td>
<td>3</td>
<td>12.7335</td>
<td>4.2445</td>
<td>12.81**</td>
</tr>
<tr>
<td>Level of entry, L</td>
<td>2</td>
<td>4.5655</td>
<td>2.2828</td>
<td>6.89**</td>
</tr>
<tr>
<td>C x L</td>
<td>6</td>
<td>2.4527</td>
<td>0.4088</td>
<td>1.23</td>
</tr>
<tr>
<td>Error</td>
<td>843</td>
<td>279.2881</td>
<td>0.3313</td>
<td></td>
</tr>
</tbody>
</table>

differed significantly for those studied. Moreover both factors, colleges and levels of entry, were significant after adjustment for the covariate. Differences in each factor could not be attributed to differences in achievement in pre-transfer work. The interaction effect was not significant.

Part 3. Comparison of the Achievement of Native and Transfer Students

In a first comparison of achievement of native and transfer students the criterion was grade point average for one year of work at Drake. Each pair, one native and one transfer student, was matched on year of entry, level of entry, sex, college at Drake wherein work was taken, aptitude as measured by the SCAT V-score and level at which achievement was evaluated. The 147 pairs were selected from the 1961 entrants of transfer and native students to Drake.

Hypothesis 10: There was no significant difference in the success of
matched groups of native and transfer students in a year of work at the upper division level at Drake. The F-test was applied to a random block design where pairs were employed as blocks. The calculations appear in Table 31.

The test indicated that the average grades of these native and transfer students did differ significantly. Hypothesis ten was rejected. The mean grades for the native students was 2.54 and that of the transfer students 2.33.

Hypothesis 11: There was no significant difference in the survival (graduation) rate of transfer and native students at Drake. This comparison was of the proportion of graduates from the native and transfer groups. This analysis -- graduation or not graduating -- was made after at least five years of collegiate work had expired for all those studied. The test statistic was the chi-square, $X^2$. The data for this analysis appears in Table 32.

The test indicated a highly significant $X^2 = 9.055^{**}$. Hypothesis eleven was rejected. The proportion of transfer graduates differed significantly

---

**Table 31. Analysis of variance on background of students**

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background (Native-Transfer)</td>
<td>1</td>
<td>3.0223</td>
<td>3.0223</td>
<td>9.88**</td>
</tr>
<tr>
<td>Pairs</td>
<td>146</td>
<td>61.3738</td>
<td>0.4204</td>
<td>1.39</td>
</tr>
<tr>
<td>Error</td>
<td>146</td>
<td>44.6722</td>
<td>0.3060</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>293</td>
<td>109.0683</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 32. Comparison of proportion of native and transfer students who graduated

<table>
<thead>
<tr>
<th>Classification</th>
<th>Transfer Students</th>
<th>Native Students</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observed</td>
<td>Expected</td>
<td>Observed</td>
</tr>
<tr>
<td>Graduated</td>
<td>95</td>
<td>106.50</td>
<td>118</td>
</tr>
<tr>
<td>Did not graduate</td>
<td>52</td>
<td>40.50</td>
<td>29</td>
</tr>
<tr>
<td>Total</td>
<td>147</td>
<td>147</td>
<td>294</td>
</tr>
</tbody>
</table>

from the proportion of native students who graduated. A comparable test of significance on this data, using a Z-test, also gave indication of noticeable differences. The Z-value, 3.00**, was also highly significant.

Hypothesis 12: There was no significant difference in the cumulative grade point average attained by the graduates of the two groups. A comparison was made of the differences in average grades earned by the graduates of the two groups. There were 118 graduates of the 147 native student group and 95 graduates from the 147 transfer students. Table 33 indicates measures used in the comparison of the grade point averages.

The data in Table 33 was utilized in three comparisons of mean grade achievement for the native and transfer students.

1. The test for significance of difference in pre-transfer grade averages was (28):

\[ Z = \frac{2.81 - 2.45}{\sqrt{\frac{.2411}{118} + \frac{.2714}{95}}} = 5.14^{**} \]

2. The test for differences in first year of post-transfer work was:
Table 33. Measures comparing grade achievement of native and transfer students

<table>
<thead>
<tr>
<th>Measure</th>
<th>Arithmetic Mean</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Native</td>
<td>Transfer</td>
</tr>
<tr>
<td>Pre-transfer cumulative average</td>
<td>2.81</td>
<td>2.45</td>
</tr>
<tr>
<td>Post-transfer first year average</td>
<td>2.64</td>
<td>2.55</td>
</tr>
<tr>
<td>Post-transfer cumulative average</td>
<td>2.65</td>
<td>2.44</td>
</tr>
</tbody>
</table>

\[
Z = \frac{2.64 - 2.55}{\sqrt{\frac{.2502}{118} + \frac{.2816}{95}}} = 3.96^{**}
\]

3. The comparison of differences in average grades for the two groups at time of graduation was:

\[
Z = \frac{2.65 - 2.44}{\sqrt{\frac{.2067}{118} + \frac{.2767}{95}}} = 9.72^{**}
\]

Thus there was a significant difference in average grades prior to transfer, after a year of work for the transfer student at Drake and at the time of graduation. Hypothesis twelve was rejected. In all cases the native students excelled in grades above the transfer group.

Part 4. A Statistical Derivation: An Unbiased Test For Interaction Which Extends the Method of Weighted Squares of Means

The derivation was an extension of the method of weighted squares of means test in the analysis of variance. It provided an unbiased test for
the interaction effect in the two way-3 by n-factorial experiment with proportionate subclass numbers. Earlier analyses for interaction by weighted squares provided a test for at most the 2 by n case (4, 30).

Analysis was performed on the cell means, \( \bar{Y}_{ijk} = \frac{Y_{ijk}}{n_{ij}} \). Proportionality was defined in the rows by \( r_1: r_2: r_3: \) and in the columns by \( c_1: c_2: c_3: \) \( \ldots: c_n \). The number of observations in each cell, \( n_{ij} \), was represented as \( r_i \cdot c_j \).

The model assumed was, \( Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_{ij} + \varepsilon_{ijk} \) where, \( i = 1, 2, 3, \quad j = 1, 2, 3, \ldots, n, \quad k = 1, 2, \ldots, n_{ij} \).

Assumptions were:

1. The \( \varepsilon_{ijk} \) were normally and independently distributed with zero mean and constant variance, \( \sigma^2 \).

2. Homogeneity of variance existed within subclasses (cells),

\[ \text{var}(\bar{Y}_{ij}) = \frac{\sigma^2}{n_{ij}} = \frac{\sigma^2}{r_i \cdot c_j} \quad \text{where} \quad n_{ij} = r_i \cdot c_j. \]

3. There were no empty cells.

4. \( \sum a_i = 0 \quad \sum a_i b_i = 0 \quad \sum b_i = 0 \quad \sum \frac{a_i b_i}{r_i} = 0 \quad i = 1, 2, 3. \)

Linear forms were defined,

\*Solutions were found for \( a_i \) and \( b_i \) where \( i = 1, 2, 3 \). The solution of a quadratic form was dependent that there were no empty cells, that is, upon assumption three. Computations were made most easily when \( r_1, r_2, r_3 \) were ordered so that \( r_1 \leq r_2 \leq r_3 \) and by arbitrarily setting \( a_2 = b_2 = 1 \). Equations essential to finding the \( a_i \) and \( b_i \) were, (footnote continued on next page)
The conditions in (4) above imposed orthogonal contrasts on the linear forms, $U_j$ and $V_j$. Consequently, the sums of squares based on these separate forms were independent. This condition was essential to the establishment of an unbiased test.¹

It was found that $E(U_j) = \sum_{i} a_{ij} \mu_{ij} = \theta_j$, $E(V_j) = \sum_{i} b_{ij} \nu_{ij} = \lambda_j$,

$$\text{var}(U_j) = \sigma^2 \sum_{i} \frac{a_{ij}}{N_j}, \quad \text{var}(V_j) = \sigma^2 \sum_{i} \frac{b_{ij}}{M_j},$$

The reciprocals of variance components were used as weights to form sums of squares appropriate to the computation of an interaction effect.

These sums of squares were,

$$Q_1 = \sum_{j} N_j (U_j - \bar{U})^2 \quad \text{with} \quad \bar{U} = \frac{\sum_{j} U_j}{\sum_{j} N_j}$$

$$Q_2 = \sum_{j} M_j (V_j - \bar{V})^2$$

Each sum of squares, $Q_1$ and $Q_2$, was non-central chi-square with non-centrality parameters $\theta_j$ and $\lambda_j$, respectively. Interaction was zero when

(footnote continued from previous page) $a_1^2 + a_2 (\partial_1 - \partial_3 + 1) + a_3 = 0$ with $a_2 = b_2 = 1$, $a_3 = -(1+a_1)$, $b_1 = \partial_1/a_1$, $b_3 = -(1+b_1)$,

$$\partial_1 = \frac{\frac{1}{r_2} - \frac{1}{r_3}}{\frac{1}{r_3} - \frac{1}{r_1}}, \quad \partial_3 = \frac{\frac{1}{r_2} - \frac{1}{r_1}}{\frac{1}{r_1} - \frac{1}{r_3}}.$$ ¹Intermediate computations may be found in the appendix.
\( \theta_1 = \theta_2 = \ldots = \theta_n \) and \( \lambda_1 = \lambda_2 = \ldots = \lambda_n \). Hence, these conditions specified the null hypothesis. Then, under the null hypothesis and with independence of \( Q_1 \) and \( Q_2 \), \( Q = Q_1 + Q_2 \) had non-central chi-square distribution with \( (2(n-1)) \) degrees of freedom. Consequently, \( Q \) furnished an unbiased estimate of the interaction effect. That was,

\[
\begin{align*}
E(Q_1) &= E(Q_2) = (n-1) \sigma^2 \\
E(Q_1^2) &= E(Q_2^2) = (n^2-1) \sigma^2 \\
E(Q_1Q_2) &= E(Q_1) \cdot E(Q_2) = (n-1)^2 \sigma^4 \\
E(Q) &= 2(n-1) \sigma^2 \text{ and } var(Q) = 4(n-1) \sigma^4
\end{align*}
\]

An F-ratio, appropriate to a test on interaction, was obtained by comparing \( Q \) with an independent estimate of the population variance, \( S \). The latter was the error (within) mean square. It had a central chi-square distribution with \( k \) degrees of freedom. The test was a non-central \( F \) with \( (2(n-1)) \) and \( k \) degrees of freedom. It was unbiased.
DISCUSSION

This study was an analysis of the affect of selected factors on the academic achievement of transfer students to Drake University.

The findings conformed somewhat with results of other research as cited in the review of literature. As in the studies of Casey (8) and of Knoell and Medsker (24), the pre-transfer grade point average made a significant contribution to the prediction of first year post-transfer achievement. Certainly a good indication of future student performance should be how that student had succeeded in the past. This idea was magnified herein by the fact that in the discriminant analysis of the criterion "graduation", the contribution of first year post-transfer average, 94.49 per cent, far exceeded that of all other variables.

The tests indicated that the SCAT, the CET, and the ACT, for the most part, added very little to prediction ability. Those standardized tests attempting to measure aptitude, ability to verbalize, vocabulary and comprehension made only minor contribution. Thus it was somewhat surprising that the CET expression-score made a useful contribution in predicting achievement. The CET E-score attempted to measure the student's ability to express himself well through written media. This capacity in communication or expression must then have some importance in the transfer student's general achievement at Drake.

It was informative that the CET E-score was significant in predicting achievement for students from all sending institutions except for those coming from the Iowa state supported colleges and universities. For the latter group only pre-transfer average had significant bearing on the
criterion. This seemed to indicate that the grading standards of Drake and the state supported institutions of Iowa were somewhat comparable.

Diametrically opposed to the findings of Hoyt and Munday (20), the ACT score was, in the present study, of little value in describing achievement. Herein the ACT scores were taken primarily from records of pre-transfer testing. That is, the ACT tests were administered at the respective sending institutions, no doubt under varying and diverse conditions. Consequently, it seemed quite likely that these test scores were not realistically comparable.

The strength of regression relations was quite moderate. These ranged from a multiple coefficient of correlation of 0.50 to one of 0.59. Analysis of higher order regressions or equations might have produced a marked increase in correlation values. However, it was felt that factors, other than those considered, might have accounted for a substantial amount of the variability in grade achievement of these students. Consequently, part two, which used institutional and personal factors, was performed.

The quantitative measure of factors which were basically qualitative by nature, academic standing, college wherein study was taken, sex, year of entry, etc., was approached through the techniques of analysis of variance and covariance. Measurement was desired of the affect of each of these factors on the criterion, achievement in a first year of work at Drake.

Due to the extensive calculations required, the researcher was unable to utilize all 856 records in every analysis of part two. Where computer analysis was available all the data was used; in the other cases stratified random samples were used which utilized proportional allocation of student records. Records of approximately 100 students were used in each sample
treatment. The reader should keep this fact in mind. Tests which were made first with a sample and then for the whole 856 records were in good agreement.

The technique of covariance added certain strength to the tests made in part two. First, differences in performance of students could not clearly be attributed to inadequacies of the sending institution or to other factors until inadequacies of the students themselves had been ruled out experimentally or statistically. Consequently, tests were desired which would incorporate or account for the affects of differing student capabilities and still allow a realistic measure of achievement. To this end a measure of aptitude, the CET E-score was incorporated as a covariate.

Like Hoyt and Munday (20) the author felt that "... grading standards at a given institution reflect only the relative abilities within that institution". Thus under the assumption that past achievement or success had a great deal of bearing on future performance, the grade point average attained at the sending institution was utilized as a second covariate.

The findings indicated that there were significant differences in grade point average achievement of (1) non-Iowa teacher and junior college transfer students, group three, against those from either (2) Iowa state supported institutions, group five, and (3) major U. S. universities, group l. The grade point average of the former group was noticeably below that of all other sending institution types.

That the indicated significant differences no longer existed after adjustment for the covariate, pre-transfer grades, indicated that these students, group three, were less well prepared at their mother institutions
for work at Drake than were those from the Iowa institutions and major
non-Iowa universities. That is, the grade differentials were a matter of
discrepancies in pre-transfer grading or standards.

The fact that transfer students to Drake coming from Iowa state sup­
ported colleges and universities achieved, above all other transfer groups,
indicated a favorable position for this institution, Drake. This informa­
tion was highly related to the finding, in part one, of a strong relation
of student achievement at Iowa state supported institutions and their
achievement after transfer to Drake.

There was evidence of significant differences in achievement for per­
sons who entered at different levels -- sophomore, junior or senior
standing. This was true with and without adjustment for covariates. Thus
there appeared a distinct advantage in entering Drake as a transfer student
with junior or senior standing rather than as a sophomore. Similarly,
Knoell and Medsker (25) found that junior college transfer students who
finished two years achieved significantly better than transfer students
having only one year of pre-transfer training.

The achievement of transfer students, enrolled in business administra­
tion, was significantly below that of the fine arts and education majors.
After adjustment for the transfer grade covariate, it was also significant­
ly less than the grade point average attained by the liberal arts transfer
students. Consequently, the difference was due to factors other than dis­
crepancies in (1) general aptitude of the students entering the program or
(2) grades or achievement at the sending institution. After adjustment for
a covariate, the liberal arts and education averages were also significant­
ly below that of the fine arts transfer students.
As a possible explanation of certain of the above differences, Hills (18) suggested that:

The transfer student seems to suffer most if he transfers into a curriculum which requires competence or training in mathematics, if he transfers into a major state university, or if he transfers from a junior college instead of from a four-year college.

There is a possibility that certain courses or core requirements, mathematics or statistics may affect noticeably the transfer students' overall achievement. For instance, in the past, the college of business administration has had a mathematics and statistics requirement. Similar requirements were not existent in the other three curricula.

Lambe (27) found that in his study women transfer students excelled beyond the men. For the Drake transfer students the preceding statement was true unless the factors aptitude and previous grades were fixed. Thereafter no significant differences existed. That is, for the sample studied, women excelled because of (1) higher aptitude, as indicated by greater proficiency in written expression, or (2) better attainment of pre-transfer learnings as evidence by higher pre-transfer grades.

No significant differences were noted in year of entry. This could mean that (1) Drake has taken about the same caliber transfer student over the years or (2) that with time better students have entered while at the same time the university has raised its academic standards.

The third analysis was a comparison of the achievement of a matched group of 147 pairs of native and transfer students. In related studies, Grossman (15) and Fichtenbaum (14) found the native students made a significantly higher grade point average in post-transfer work. Martorana and Williams (28) found no significant difference in average attainment for the
two groups.

In the present study, the pre-transfer and terminal post-transfer grade point averages for the native students exceeded significantly those respective measures for the transfer students. Moreover, their first year post-transfer grade point averages differed significantly. This latter finding was expected considering the usual grade decrease as a result of transfer shock (5, 17, 19, 23).

Moreover, the percentage of native students who graduated was well above the percentage for transfer students. Such also were the findings of the Klitzke (23) and Hennessy (16) studies. Since, in the present situation, all students had at least five years to complete a degree, this gave a good indication of differences in the proportion who would eventually receive a degree from Drake.

The final comparison, in part three, was on the criterion of first year grade achievement. The technique of analysis of variance was used to test on background, native or transfer. Matched pairs were used as a blocking effect. These blocks were ineffective in removing extraneous variation as indicated by a quite small mean square for "pairs". Yet a significant difference was found for the factor background. That is, the native students achieved well above the transfer students in their first year at Drake. Because the blocking was ineffective, these conclusions seemed unsafe. This finding did, however, seem logical as a consequence of transfer and the somewhat common drop in grade point averages during the terms just after transfer.

The findings of the native-transfer student comparisons were integrated with those of part two. Thus it appeared that the native students,
in general, succeeded beyond the level of transfer students and exceeded certain transfer groups much more than others. The native student had a definite advantage at Drake University over transfer students.

Regardless of the fact that many transfer students entered Drake with certain academic handicaps, there has existed a far more important fact. That is, many transfer students have been successful in graduating from Drake. With the saturation of the major state universities and with development of numerous junior colleges in the Iowa-midwest area, there will, no doubt, be many more transfer students coming to Drake. Consequently, it was hoped that the present study would be of aid in the transfer function at Drake University.
SUMMARY

This study was an analysis of the affects of selected factors on the success of transfer students in a first year of work at Drake University. Records were studied for 856 undergraduate transfer students who entered Drake sometime between autumn term 1961 and autumn 1964, inclusive. Also records were studied of 147 students who entered Drake as freshmen during autumn term 1961. The total analysis encompassed 1,003 student records.

The information collected for each student included year of entry, pre-transfer cumulative grade point average, first year Drake grade point average, sex, test scores on the School and College Ability Test, SCAT, and on the Cooperative English Test, CET, college of entry, level of entry and sending institutions by type. The colleges of entry studied were business administration, education, fine arts and liberal arts. Levels of entry or class standing were sophomore, junior or senior. Sending institutions were classified into five types, (1) major universities, over 5,000 students, (2) liberal arts colleges, (3) non-Iowa state teachers and junior colleges, (4) Grandview college in Des Moines and (5) Iowa state supported institutions. All information was gathered from the office of the Registrar, from the Dean's of Colleges offices, and the Counseling and Testing Center on the Drake campus.

The analysis was separated into four parts. The first was an attempt to predict the achievement of transfer students in their first year of work at Drake. In all, 856 records were studied for this analysis.

The analysis utilized the techniques of multiple linear regression and correlation and was made with the aid of the 360-50 computer at Iowa State
Table 34. Summary of prediction of first year achievement at Drake of transfer students

<table>
<thead>
<tr>
<th>Group</th>
<th>Best prediction combination of those studied</th>
<th>$R_y$</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major universities, 1</td>
<td>$X_1$ and $X_4$</td>
<td>.4995</td>
<td>187</td>
</tr>
<tr>
<td>Liberal arts colleges, 2</td>
<td>$X_1$ and $X_4$</td>
<td>.4571</td>
<td>108</td>
</tr>
<tr>
<td>Teachers and junior colleges, 3</td>
<td>$X_1$ and $X_3$</td>
<td>.4618</td>
<td>263</td>
</tr>
<tr>
<td>Grandview, 4</td>
<td>$X_1$ and $X_4$</td>
<td>.5675</td>
<td>158</td>
</tr>
<tr>
<td>Iowa state supported, 5</td>
<td>$X_1$</td>
<td>.5874</td>
<td>140</td>
</tr>
</tbody>
</table>

University, Ames. The criterion was grade achievement in the first year of pre-transfer work at Drake. Predictor variables considered were pre-transfer grade point average, $X_1$, SCAT verbalization score, $X_2$, CET linguistic score, $X_3$, CET expression score, $X_4$, and ACT total score, $X_5$.

The records were separated according to type of sending institution from which the transfer student came. Records of students coming from each institution classification were treated separately. The results appear in Table 34.

Hypothesis 1: (1) Transfer cumulative grade point average, (2) SCAT V-, Q-, and T-scores, (3) CET V-, L-, S-, and E-scores, and (4) ACT T-score had no significant value in predicting achievement in a first year of post-transfer work at Drake. Table 34 indicates that hypothesis one was rejected. Several significant relations were found.

In general the single best indication of post-transfer success during the first year after transfer was pre-transfer grade point average, $X_1$. The CET expression score, $X_4$, also appeared useful in predicting achieve-
ment for all groups except those who came from the Iowa supported institutions. Since all five coefficients of multiple correlation were not high, being of the range 0.50 to 0.60, the researcher felt tests on other available information might aid in obtaining a more complete indication of first year achievement. However, equations for prediction, based on above variables, were computed for each group.

A final regression analysis involved the variables \( X_1, X_2, X_4, \) and \( X_5 \). Records were available on ACT T-scores, \( X_5 \), for only 110 of the transfer students. The analysis indicated a quite small zero order coefficient of correlation \( r_y(5) = 0.2004 \). This value, 0.2004, seemed unrealistic in part due to the fact that most of the ACT scores were attained before these students came to Drake.

The final analysis in part one was of overall achievement in work at Drake. The criterion used was a dichotomy, graduation-non-graduation. In this instance the analysis was limited to the 147 transfer students who entered during autumn 1961. These students had been allowed adequate time to graduate, five years.

**Hypothesis 2:** (1) Transfer cumulative grade point average, (2) Drake first year average, (3) SCAT V-score and (4) CET E-score had no significant values in predicting graduation from Drake. The statistical techniques used were discriminant analysis and multiple biserial correlation, \( R_{bis} \). The prediction variables included pre-transfer grade point average, \( X_1 \), SCAT V-score, \( X_2 \), post-transfer first year grade point average, \( X_6 \), and CET E-score, \( X_4 \). Hypothesis two was rejected at the .01 risk level.

The best discriminant equation of those tested utilized the variables \( X_1, X_4, \) and \( X_6 \). The greatest single contribution to the discriminant rela-
tion was made by pre-transfer grade point average, 94.4 per cent. For the three variable combination $R_{bis}$ was 0.5922. An equation, $V = -0.3627X_1 + 0.6915X_6 + 0.0067X_4 + 0.6619$, was derived which might be used to compute chances in 100 of graduation.

The second part of this study was on analysis of the affects of selected factors on the achievement at Drake of transfer student's. The selected factors were mostly qualitative measures and included type of sending institution, college of entry, level of entry, year of entry, and sex. The criterion was again achievement for the first year at Drake as measured by grade point average attainment.

The analysis of all 856 records through two or three way classifications in an analysis of variance, AOV, test on means was found to be difficult and impractical to be done by hand. That is, all three way classifications involved unequal and disproportionate subclass numbers. An analysis of 856 cases would have been formidable except that a computer analysis was available for a part of the calculations.

For the cases where computer solution was not available the alternative selected was analysis of a portion of the data through use of samples selected by stratified random sampling. Proportionate sample allocation was utilized. A sample size of approximately 100 was used in each analysis. A summary Table 35, indicates the findings of these AOV tests.

**Hypothesis 5**: There was no significant difference in the success for transfer students who entered the various colleges at Drake. Hypothesis five was rejected at the .01 level. Transfer students majoring in business, group 1, achieved significantly less well than those in education and fine arts. Transfer students in liberal arts and education achieved
Table 35. Summary of the analysis of variance tests

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Factor</th>
<th>Levels</th>
<th>Significant differences</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Colleges</td>
<td>1,2,3,4</td>
<td>1 was below 2,3</td>
<td>110</td>
</tr>
<tr>
<td>7</td>
<td>Years</td>
<td>1,2,3,4</td>
<td>None</td>
<td>110</td>
</tr>
<tr>
<td>3</td>
<td>Institutions</td>
<td>1,2,3,4,5</td>
<td>3 was below 1,2,4,5</td>
<td>856</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 and 4 were below 1 and 5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Level of entry</td>
<td>soph., jr., sr.</td>
<td>soph. was below jr. and sr.</td>
<td>856</td>
</tr>
<tr>
<td>6</td>
<td>Sex</td>
<td>male, female</td>
<td>males achieved below the females</td>
<td>856</td>
</tr>
</tbody>
</table>

less well than those in fine arts.

Hypothesis 3: There was no significant difference in the success for transfer students to Drake who came from the various types of sending institutions. Hypothesis three was rejected at the .01 risk level. For those studied, the transfer students coming from non-Iowa teachers and junior colleges, group 3, attained grade averages which were significantly poorer than those earned by transfer students from major universities or from Iowa state supported institutions. Average grades for group 3 transfer students were well below those of all other groups studied.

Hypothesis 6: There was no significant difference of success for male and female transfer students to Drake. Hypothesis six was rejected at the .01 level. There was a significantly higher attainment of women-in over-all grade point average than for men transfer students.

Hypothesis 7: There was no significance of difference in the success of students at Drake according to the year of entry. This hypothesis could not be rejected at the .01 risk level. That is, non-significant differ-
ences were noted for the factor years.

**Hypothesis 4:** There was no significant difference in the success for students who entered Drake at various levels of their academic careers.

Hypothesis four was rejected at the .01 level. The test on level of entry indicated significant differences favoring entry at the junior or senior level over entry as a sophomore.

Only one of the first or second order interactions encountered was significant. That was the interaction of level of entry and sex.

Other analyses, utilizing the tool of covariance, tested the effects of the same selected factors on first year post-transfer grade point average attainment. Covariance was used with the separate covariates (1) pre-transfer grades and (2) aptitude as measured by the CET E-score. The summary of findings through tests on factor means, adjusted for the affects of either covariate, appears in Table 36.

**Hypothesis 8:** There were no significant differences in the success for transfer students at Drake according to pre-transfer grade attainment. Hypothesis eight was rejected at the .01 level.

**Hypothesis 9:** There was no significant difference in the success of transfer students having different scholastic aptitudes. Hypothesis nine was also rejected.

The covariance tests indicated that after adjustments were made for pre-transfer grades certain differences yet existed. First transfer students from non-Iowa teacher and junior colleges achieved less well than those from major universities and from Iowa state supported institutions. The differences were not, however, statistically significant. The level of entry factor was significant after adjustment for pre-transfer grades.
Table 36. Summary of tests on adjusted factor means through covariance analysis with covariate pre-transfer grade point average or CET E-score

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Covariate</th>
<th>Factor</th>
<th>Levels</th>
<th>Significant differences</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>CET E-score</td>
<td>Colleges</td>
<td>1,2,3,4</td>
<td>1 was below 2,3,4</td>
<td>110</td>
</tr>
<tr>
<td>7</td>
<td>CET E-score</td>
<td>Years</td>
<td>1,2,3,4</td>
<td>None</td>
<td>110</td>
</tr>
<tr>
<td>3</td>
<td>Pre-transfer grades</td>
<td>Institutions</td>
<td>1,2,3,4,5</td>
<td>None</td>
<td>856</td>
</tr>
<tr>
<td>4</td>
<td>Pre-transfer grades</td>
<td>Level of entry</td>
<td>1,2,3</td>
<td>1 was below 2,3</td>
<td>856</td>
</tr>
<tr>
<td>6</td>
<td>Pre-transfer grades</td>
<td>Sex</td>
<td>1,2</td>
<td>None</td>
<td>856</td>
</tr>
</tbody>
</table>

Discrepancies based on level of entry were not a reflection of pre-transfer grades.

Those transfer students studying business had significantly poorer success than those in any of the other three colleges studied. Also those in liberal arts fell well below the average achievement of the fine arts group.

Regarding grade achievement, non-significant differences were found for the factor sex. Also none of the interaction tests for the above factors were significant.

Part three encompassed the comparison of achievement of native and transfer students at Drake. Each analysis in this part utilized the records of the 147 matched pairs. The two groups were paired on year of entry, sex, college wherein work was taken, aptitude as measured by the SCAT V-score, and level at which work was taken. Because the criterion was
graduation or non-graduation and time was an important factor, only the 1961 entrants were studied.

A first comparison was on the cumulative grade point averages of the two groups. Separate tests, each using the Z-statistic, were made on (1) pre-transfer grade point average, (2) first year post-transfer grade point average and (3) terminal grade point average.

**Hypothesis 10:** There was no significant difference in the success of matched groups of native and transfer students in a year of work at the upper division level at Drake. The hypothesis was rejected at the .01 risk level. Significant differences were found in all three tests. All differences favored the native students.

A second comparison was of the proportion of native and transfer students who graduated within a specified time. The time limitation was spring term 1966, at least five years since any of these students had started collegiate work.

The test of difference in proportions utilized the chi-square statistic.

**Hypothesis 11:** There was no significant difference in the survival (graduation) rate of transfer and native students at Drake. There was a significant difference at the 0.01 test level, again favoring the native students. One hundred eighteen, 80.3 per cent, native students graduated in the specified time while only 95, 64.6 per cent, of the transfer students attained graduation.

The final test of paired comparisons had as criterion grade point average in one year of work at Drake. The AOV technique utilized "pairs" to block or remove variation and therefore make a more precise test on
background of collegiate work.

Hypothesis 12: There was no significant difference in the cumulative grade point average attained by the graduates of the two groups. The test afforded a significant difference favoring the native students. That is, the null hypothesis was rejected.

In brief summary the regression analyses, part one, indicated that a somewhat inadequate prediction of first year achievement would result from those predictor variables tested. The best single predictor of first year post-transfer achievement was cumulative pre-transfer grade point average. Moreover, the best single variable, of those studied, for predicting eventual graduation was achievement for the first year at Drake.

In part two AOV and covariance computations indicated that transfer students from non-Iowa teachers and junior colleges achieved poorer than did students from other institution types. Especially, the students from Iowa supported institutions and major universities achieved above this group. Differences were other than basic differences in pre-transfer grading standards or aptitude.

AOV tests indicated differences in academic achievement favoring females over males. But after removing affects of aptitude and previous grading standards, these differences no longer existed.

Transfer students to the college of business administration, achieved less well than those in education, fine arts and somewhat less well than those in liberal arts. This was true both before and after adjustment for the covariates.

Comparison of the matched group of native and transfer students, in part three, indicated significantly better achievement by the native stu-
dents in a first year of work as well as significantly better chance of graduation within a reasonable amount of time.

Part four was a derivation which extended the test for interaction in AOV as based on the procedure of weighted squares of means. An unbiased test was developed, with the aid of orthogonal contrasts, for the 3 by n factorial design. The test was a non-central $F$ and was considered computationally shorter than other existing tests.
BIBLIOGRAPHY


I. Computation of \( E(Q) \) under the null hypothesis

\[ U_j = \sum_{i=1}^{r_{ij}} Y_{ij} \quad i=1,2,3, \quad j=1,2,...,n \]

\[ E(U_j) = \sum_{i=1}^{n} a_i \mu_{ij} = \theta_j \]

\[ \text{Var}(U_j) = \sum_{i=1}^{r_{ij}} \text{Var}(Y_{ij}) = \sum_{i=1}^{r_{ij}} \left( \frac{\sigma^2}{n_{ij}} \right) = \frac{\sigma^2}{c_j} \sum_{i=1}^{r_{ij}} a_i^2 = \sigma^2 \frac{a_i^2}{N_j} \]

where \( \frac{1}{N_j} = \frac{1}{c_j} \sum_{i=1}^{r_{ij}} a_i^2 \) so,

\[ Q_1 = \sum_{j=1}^{J} N_j (U_j - \bar{U})^2 \quad \text{where} \quad \bar{U} = \frac{\sum_{j=1}^{J} U_j}{\sum_{j=1}^{J} N_j} \]

Then the sum of squares may be written:

\[ Q_1 = \sum_{j=1}^{J} N_j (U_j - \bar{U})^2 = \sum_{j=1}^{J} N_j \left[ U_j - \frac{\sum_{j=1}^{J} U_j}{\sum_{j=1}^{J} N_j} \right]^2 = \sum_{j=1}^{J} N_j \left[ \frac{\sum_{j=1}^{J} a_i Y_{ij}}{\sum_{j=1}^{J} a_i} - \frac{\sum_{j=1}^{J} a_i \bar{Y}_{ij}}{\sum_{j=1}^{J} a_i} \right]^2 \]

Consequently, the expected value of the sum of squares:

1. \( E(Q_1) = E \left[ \sum_{j=1}^{J} N_j (U_j - \bar{U})^2 \right] = \sum_{j=1}^{J} N_j \left[ E(U_j - \bar{U})^2 \right] = \sum_{j=1}^{J} N_j \left[ \text{Var}(U_j - \bar{U}) \right. \]

\[ + \left( E(U_j - \bar{U})^2 \right) = \sum_{j=1}^{J} N_j \text{Var}(U_j - \bar{U}) + \sum_{j=1}^{J} N_j \left[ E(U_j - \bar{U})^2 \right] \]

but

2. \( \sum_{j=1}^{J} N_j \text{Var}(U_j - \bar{U}) = \sum_{j=1}^{J} \frac{N_j \text{Var}(U_j) - \text{Var}(N_j U_j)}{(\sum_{j=1}^{J} N_j)^2} \]

and
3. \[ \text{var} \left[ U_j(j_{N_j}) - \sum_j (N_j U_j) \right] = \text{var} \left[ U_j(j_{N_j}) \right] + \sum_j \text{var} U_j - 2 \text{cov} \left( U_j(j_{N_j}), \sum_j U_j \right) = \left( \frac{\sum_j}{N_j} \right) \frac{\sigma^2}{N_j} + \sum_j \left( \frac{\sum_j}{N_j} \right) - \frac{2 \sigma^2}{N_j} \left( \sum_j \right) N_j = \sigma^2 \left( \frac{\sum_j}{N_j} \right) \left( \frac{\sum_j}{N_j} - 1 \right) \]

Substituting (3) into (2) gives:

4. \[ \sum_j \text{var} (U_j - \bar{U}) = \sum_j \left( \frac{1}{N_j} \right) 2 \sigma^2 \left( \frac{\sum_j}{N_j} \right) \left( \frac{\sum_j}{N_j} - 1 \right) \]

\[ = \sigma^2 \sum_j \left[ \frac{1}{N_j} \sum_j \frac{1}{N_j} \right] = \sigma^2 \sum_j \left[ \frac{\sum_j}{N_j} \sum_j \frac{1}{N_j} \right] = (n-1) \sigma^2 \]

5. \[ \sum_j \left[ E(U_j - \bar{U}) \right]^2 = \sum_j \left[ E \left( U_j - \frac{\sum_j U_j}{\sum_j} \right) \right]^2 \]

\[ = \sum_j \left[ \frac{\sum_j E(U_j)}{\sum_j} - \frac{\sum_j U_j}{\sum_j} \right]^2 = \sum_j \left[ \frac{\sum_j \sum_j U_j - \sum_j U_j}{\sum_j \sum_j} \right]^2 = R_1 \]

Imposing the results of 4 and 5 on 1 gives

6. \[ E(Q_1) = E \left[ \sum_j (U_j - \bar{U})^2 \right] = (n-1) \sigma^2 + R_1 \]

Now the condition for zero interaction (null hypothesis) is specified by \[ \theta_1 = \theta_2 = \theta_3 = \ldots = \theta_n = 0 \]

\[ R_1 = \sum_j \left[ \theta - \frac{\sum_j \theta}{\sum_j} \right]^2 = \sum_j \left[ \theta \left( 1 - \frac{\sum_j \theta}{\sum_j} \right) \right]^2 = 0 \]

and the converse may be shown to be true.

7. Thus under the (null) hypothesis of zero interaction,

\[ R_1 = 0 \text{ and } E(Q_1) = (n-1) \sigma^2 \]
8. Similarly for \( Q_2 = \sum_{j} (V_j - \bar{V})^2 \)

\[
E(Q_2) = (n-1) \sigma^2
\]

9. So that \( Q = Q_1 + Q_2 \) has \( E(Q) = 2(n-1) \sigma^2 \) and so is unbiased.

II. Computation of \( var(Q) \) under the null hypothesis

\[
E(Q^2) = E(Q_1 + Q_2)^2 = E(Q_1 + 2Q_1^2 + Q_2) = E(Q_1^2) + E(Q_2^2) + 2E(Q_1Q_2)
\]

\[
Q_1 = \sum_{j} (U_j - \bar{U})^2 = N_1 \left[ \frac{1}{N_1} \left( \frac{U_1^2 + \cdots + U_{N_1}^2}{N_1} \right) \right] + \cdots + N_n \left[ \frac{1}{N_n} \left( \frac{U_{N_1+1}^2 + \cdots + U_{N_1+N_n}^2}{N_n} \right) \right]
\]

\[
= \frac{1}{N_1 + \cdots + N_n} \left[ N_1N_2(U_1 - U)^2 + N_1N_3(U_1 - U_2)^2 + \cdots + N_nN_{n+1}(U_{N_1} - U)^2 \right]
\]

Calculations preliminary to computing the desired expectations:

1. \[
E\left[ (U_i - U_j)^2 \right] = 3 \left[ var(U_i - U_j) \right]^2 = 3 \left[ var(U_i) + var(U_j) - 2 \text{cov}(U_i, U_j) \right]^2
\]

\[
= 3(\sigma^2)^2 \left[ \frac{1}{N_i} + \frac{1}{N_j} \right]^2
\]

2. Under the null hypothesis:

\[
E(U_i) = E(U_j) = 0 \iff \text{interaction sum of squares is zero so}
\]

\[
E\left[ (U_i - U_j)^2 \right] = var(U_i - U_j) + \left[ E(U_i - U_j) \right]^2 = \sigma^2 \left( \frac{1}{N_i} + \frac{1}{N_j} \right)
\]

3. Since \( U_i \sim N \left( \mu_{U_i}, \sigma_{U_i}^2 \right) \) and

\[
E(U_i^2) = \sigma_{U_i}^2 + \mu_{U_i}^2, \quad E(U_i^3) = 3\mu_{U_i} \sigma_{U_i}^2 + \mu_{U_i}^3, \quad E(U_i^4) = 3\sigma_{U_i}^4
\]

then \[
E\left[ (U_i - U_j)^2 (U_k - U_j)^2 \right] = E\left[ U_i^4 - 2U_i^3U_j + U_i^2U_j^2 - 2U_iU_j^3 + 4U_iU_j^2U_k - 2U_iU_jU_k^2 + U_k^2U_j^2 \right]
\]
\[ 2 \frac{U_i U_j U_k}{1} + \frac{U_j U_k}{j k} = 3 \sigma_i^2 - 2 \left[ \left( \frac{3 \mu U_i \sigma_i^2 + \mu U_i}{i} \right) \frac{\mu U_j}{j} \right] + \]
\[ \left( \frac{\sigma_i^2 + \mu U_i}{i} \right) \left( \frac{\sigma_j^2 + \mu U_j}{j} \right) - 2 \left[ \left( \frac{3 \mu U_i \sigma_i^2 + \mu U_j}{i} \right) \frac{\mu U_k}{k} \right] + \left( \frac{\sigma_i^2 + \mu U_j}{i} \right) \left( \frac{\sigma_j^2 + \mu U_k}{j k} \right) - 2 \left[ \frac{\mu U_i}{i} \frac{\sigma_j^2 + \mu U_j}{j} \right] \left( \frac{\sigma_j^2 + \mu U_k}{j k} \right) \left( \frac{\sigma_k^2 + \mu U_k}{k} \right). \]

= since under the null hypothesis \( \mu U_i = \mu U_j = \mu U_k \) act as if each were zero

= \[ 3 \sigma_i^4 + \frac{\sigma_i^2 \sigma_j^2}{i j} + \frac{\sigma_i^2 \sigma_k^2}{i k} + \frac{\sigma_j^2 \sigma_k^2}{j k} \]

Hence individual expectations may now be computed:

5. \( E(Q_1^2) = \frac{1}{(N_1 + \ldots + N_n)^2} \left[ \frac{N_1^2 N_2^2 (U_1 - U_2)^2}{N_1 + \ldots + N_n} + \ldots + \frac{N_{n-1}^2 (U_n - U_{n-1})^2}{N_{n-1} + \ldots + N_n} \right] \]

\[ = \frac{1}{(N_1 + \ldots + N_n)^2} \left[ \frac{N_1^2 N_2^2 \sigma^4}{N_1 + N_2} + \ldots + \frac{N_{n-1}^2 N_n \sigma^4}{N_{n-1} + N_n} \right] \]

\[ + 2N_1^2 N_2^2 \sigma^4 \left( \frac{3}{N_1} + \frac{1}{N_1 N_3} + \frac{1}{N_1 N_2} + \frac{1}{N_2 N_3} \right) + \ldots + 2N_{n-2}^2 N_{n-1}^2 \frac{1}{N_{n-1} + N_n} \]

\[ \frac{3}{N_n} + \frac{1}{N_{n-2} N_{n-1}} + \frac{1}{N_n N_{n-2}} \]

\[ = \frac{1}{(N_1 + \ldots + N_n)^2} \left[ \frac{3 \sigma^4 (N_1 + N_2)^2}{N_1 + N_3} + \ldots + \frac{3 \sigma^4 (N_{n-1} + N_n)^2}{N_{n-1} + N_n} \right] \]

\[ + 2 \sigma^4 \left( 3N_1 N_2^2 + N_1 N_3 + N_2 N_3 + N_1^2 + N_2^2 \right) + \ldots + 2 \sigma^4 \left( N_{n-1} N_n + N_{n-1}^2 \right) \].
\[ \sigma^4 \left( \frac{1}{N_1 + \ldots + N_n} \right)^2 \left\{ 3 \left( \frac{(N_1+N_2)^2 + (N_1+N_3)^2 + \ldots + (N_{n-1}+N_n)^2}{N_1+N_2+\ldots+N_n} \right) + 
\right. 
\]

\[ 2 \binom{n-1}{2} \left( \frac{N_1^2+N_2^2+\ldots+N_n^2}{N_1+N_2+\ldots+N_n} \right) + \left[ \frac{5(n-2)}{n-1} \left( \frac{(N_1N_2+N_1N_3+\ldots+N_{n-1}N_n)^2}{N_1+N_2+\ldots+N_n} \right) \right] \]

\[ = \sigma^4 \left( \frac{1}{N_1 + \ldots + N_n} \right)^2 \left\{ 3(n-1) + 2 \binom{n-1}{2} \right\} \left[ \frac{N_1+N_2+\ldots+N_n}{N_1+N_2+\ldots+N_n} \right] \]

\[ = (n^2-1)\sigma^4 \]

6. So similarly \( E(Q_2) = E(Q_1) = (n^2-1)\sigma^4 \)

III. Computation of \( E(Q_1Q_2) \) under the null hypothesis

Now \( E(Q_1Q_2) = E \left[ \left( \frac{N_1N_2(U_1-U_2)^2+\ldots+N_{n-1}N_n(U_{n-1}-U_n)^2}{N_1+N_2+\ldots+N_n} \right) \cdot \left( \frac{M_1M_2(V_1-V_2)^2+\ldots+M_{n-1}M_n(V_{n-1}-V_n)^2}{M_1+\ldots+M_n} \right) \right] \)

But \( U_i \) and \( V_i \) are independent for they are jointly normally distributed so that,

\[ E(U_iV_i) = \mu_{U_i}\mu_{V_i} + \sigma_{U_i}\sigma_{V_i} \]

\[ = \mu_{U_i}\mu_{V_i} = E(U_i)E(V_i) \]

so \( U_i \) and \( V_i \) are independent when the above holds for each value of "i". Under the condition of independence,

\[ E(Q_1Q_2) = E(Q_1) \times E(Q_2) = ((n-1)\sigma^2)((n-1)\sigma^2) = (n-1)\sigma^4 \]

IV. \( \text{Var}(Q) \) as a consequence of the results found in I, II, III

\[ E(Q^2) = E(Q_1^2) + E(Q_2^2) + 2E(Q_1)E(Q_2) \]

\[ = \sigma^4 \left[ 2(n^2-1) + 2(n-1)^2 \right] \]
\[
\text{Var} \ (Q) = E(Q^2) - [E(Q)]^2 = \sigma^4 \left\{ \left[ 2(n^2 - 1) + 2(n-1)^2 \right] - \left[ 2(n-1) \right]^2 \right\} \\
= 4(n-1)\sigma^4 \\
\]
so by (I) \( E(Q) = 2(n-1)\sigma^2 \)

(IV) \( \text{Var}(Q) = 4(n-1)\sigma^4 \) and these conditions satisfy as the mean and variance of a chi-square variate with \((2(n-1))\) degrees of freedom.

V. Justification that \( Q \) has non-central chi-square distribution

1. \( Q = Q_1 + Q_2 \) with \( Q_1 = \sum_{j} (U_j - \bar{U})^2 \)

\[
Q_2 = \sum_{j} (V_j - \bar{V}_j)^2 \\
\]

2. Now, for example, \( Q_1 \) can be written as a summation of terms of the form \( \frac{(U_j - \bar{U})^2}{\frac{1}{N} + \frac{1}{N_j}} \) where \( j \neq j' \) and

\[ \text{with} \ U_j \sim N \left( \mu_{ij}, \frac{\sigma^2}{N_j} \right) \]

so that

3. \( (U_j - \bar{U}_j) \sim N \left( \sum_{i} a_{ij} \mu_{ij}, \sigma^2 \left( \frac{1}{N_j} + \frac{1}{N_{j'}} \right) \right) \)

4. Under the null hypothesis \( \mu_{ij} = \mu_{ij} ' \iff E(\bar{U}_j) = E(\bar{U}_{j'}) \)

\[ \frac{(U_j - \bar{U}_j') - 0}{\left( \frac{1}{N_j} + \frac{1}{N_{j'}} \right)}^2 \sim X^2 x \sigma^2 \quad \text{with one degree of freedom} \]
and the \( X^2 \) is non-central.

5. But there are \((n-1)\) independent terms of the above form since \( j=1,2,...,n \). Thus using the additive property of non-central \( X^2 \),

\[ Q_1 \sim \sigma^2 X^2_{n-1} \text{, and is non-central.} \]
6. Again utilizing additivity of non-central $X^2$ variates
\[ Q = Q_1 + Q_2 \sim \sigma^2 \chi^2_{2(n-1)} \] and is non-central.

* Showing that conditions exist which are sufficient for $f = 0$.

1. $f = 0 \iff f = \text{cov}(U_j, V_j)/\sigma_{U_j} \sigma_{V_j} = 0 \iff \text{cov}(U_j, V_j) = 0$

2. Herein $U_j = \sum_{i=1}^{3} a_i \overline{Y}_{ij}$, $V_j = \sum_{i=1}^{3} b_i \overline{Y}_{ij}$ and by assumption $\overline{Y}_{ij}$ is independent of $\overline{Y}_{ij}'$ for $j \neq j'$.

3. Thus for $j \neq j'$, $\text{cov}(U_j, V_j) = 0 \iff \text{cov} \left( \sum_{i=1}^{3} a_i \overline{Y}_{ij}, \sum_{i=1}^{3} b_i \overline{Y}_{ij}' \right) = 0$

4. That is $a_1 b_1 \text{var} Y_{1j} + a_2 b_2 \text{var} Y_{2j} + a_3 b_3 \text{var} Y_{3j} = 0$

5. Under the AOV assumptions of independence of observations and homogeneity of cell means,
\[ \text{var} \left( \overline{Y}_{ij} \right) = \text{var} \left( \sum_{i=1}^{3} Y_{ijk} \right) = \frac{1}{r_1 c_j} \text{var} \left( \sum_{i=1}^{3} Y_{ijk} \right) \text{ indep.} \]
\[ \frac{1}{r_1 c_j} \sum_k \text{var} (Y_{ijk}) \frac{\text{homogeneous cell means}}{r_1 c_j} \cdot \sigma^2 = \frac{\sigma^2}{r_1 c_j} \]

6. Similarly, $\text{var} \left( \overline{Y}_{2j} \right) = \frac{\sigma^2}{r_2 c_j}$, $\text{var} \left( \overline{Y}_{3j} \right) = \frac{\sigma^2}{r_3 c_j}$

7. Consequently, $\text{cov}(U_j, V_j) = 0 \iff a_1 b_1 \frac{\sigma^2}{r_1 c_j} + a_2 b_2 \frac{\sigma^2}{r_2 c_j} + a_3 b_3 \frac{\sigma^2}{r_3 c_j} = 0$
\[ \iff \sum_j \frac{\sigma^2}{c_j} \left( \sum_i \frac{a_i b_i}{r_i} \right) = 0 \iff \sum_i \frac{a_i b_i}{r_i} = 0 \]