AN ABSTRACT OF THE THESIS OF

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Title ENGINEERING DRAWING AS A PREDICTIVE FACTOR FOR SUCCESS IN ENGINEERING STUDIES

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Following the Civil War, the great technical advances of the Industrial Revolution period brought about a demand for formally trained, "scientific" engineers. Even with this great need, engineering education was slow in being accepted as a legitimate part of formal higher education. By 1900 our modern college of engineering had become established and today is exceeded in enrollment only by teacher education and libert arts.

Almost from the beginning, the curricula of engineering and technical colleges included some required study and practice in drafting. It gradually became recognized as the "graphic language of industry", and the term "engineering drawing" used to describe it. Since the early 1900's there has been a gradual standardization of the practices, principles, symbols, and techniques.

Purpose of the study- Since engineering drawing as taught at California State Polytechnic College applies the subject matter of the general courses to the mechanics of drafting, it closely parallels the work of the specialized engineering courses within an engineering major. Further, since engineering drawing is required early in the curriculum of all engineering students, the student's success in engineering drawing may be useful as a predictive factor in determining his success in other engineering subjects. The purpose of this study is to determine to what extent engineering drawing can be used to measure success potential of engineering students

Methods and Procedures- A statistical study was made of the grades of 169 graduating engineers of the classes of 1950 and 1952 of California State Polytechnic College. Evaluations of each student's grades in engineering drawing, specialized engineering courses, and overall four-year college work were made. Means, standard deviations, and coefficients of correlation were calculated for both graduating classes and separately for Aeronautical Engineering, Air Conditioning and Refrigeration Engineering, Electrical Engineering, Electronics and Radio Engineering, and Mechanical Engineering departments, to determine the relationships of the three groupings of grades evaluated.

Facts- 1. Of 409 students enrolling in engineering drawing in the Fall quarter of 1946, 25.4% graduated in 1950; of 368 enrolling in 1948, 17.7% graduated in 1952.

2. 59.2% of students receiving a grade of "A" in engineering drawing during any one quarter, graduated four year later.

3. 43.3% of students receiving a grade of "B" in engineering drawing during any one quarter, graduated four year later.

4. 21.4% of students receiving a grade of "C" in engineering drawing during any one quarter, graduated four year later.

5. Only 2.68% of students receiving grades of "D", "E", or "F" in engineering drawing during any one quarter graduated four years later.

6. The mean grade for engineering drawing for the class of 1950 was 1.811; for the class of 1952 it was 1.814.

7. The mean grades for specialized engineering courses for the classes of 1950 and 1952 were 1.76 and 1.69.

8. Coefficients of correlation of .476 for the class of 1950 and .594 for the class of 1952 were determined between grades in engineering drawing and grades in specialized engineering courses.

9. Coefficients of correlation of .498 for the class of 1950 and .529 for the class of 1952 were determined between grades in engineering drawing and the students total college grade point average upon graduation.

Conclusions- In general, it was concluded that only about 25% of students beginning engineering drawing would graduate four years later, and the higher the grades a student received in engineering drawing the greater his chance of being one of those 25% that graduated. Engineering drawing when correlated with specialized engineering courses and total four-year college work, gives a correlation ratio of approximately .50. This level of correlation is classified "substantially correlated" and would indicate grades in engineering drawing as being useful for predicting levels of success of groups of students but not for predicting grades of individual students.

Recommendations- In addition to recommendations for further studies along this line, it is recommended that advisors and counselors, particularly of first year engineering students, be aware of the significance of the student's grades in engineering drawing. These grades in engineering drawing can be: (1) an indication of the probability of the student completing his four years work in engineering, and (2) used with grades in other key courses of his first year, such as mathematics and physics, as an indication of the level of work a student will probably attain throughout his four years of college.

ENGINEERING DRAWING AS A PREDICTIVE FACTOR FOR SUCCESS IN ENGINEERING STUDIES

by

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CHAPTER I

INTRODUCTION

Because of its extreme importance in a technological age, engineering drawing has been expressed as the "universal graphic language." Through this medium of concise and exact expression, the visualizations and ideas of the scientist, inventor, designer and manufacturer have been brought together to produce the product. From the inception of an idea through its period of development and finally to its realization as a product, engineering drawing, in some form or other, has played an important part in its inception, modification, refinement and manufacture.

Drawing, to the draftsman, is more than pictorial representation. It is a complete, descriptive, graphic language by which he may describe and present every shape, dimension and necessary operation. Unlike most languages, this technical language differs in that it cannot be spoken. Like all languages it is based upon a systematic alphabet; in this case, the "alphabet of lines" takes the place of the alphabet of characters or letters. Further, so that this language may be read and interpreted by others, it has definite "grammatic constructions and idioms" as would be peculiar to any specific language through common usage. That is, by a logical, standard system of related views, intricate and complicated shapes can be clearly shown. Exact and detailed sizes can be given without ambiguity, and individual parts can be identified for assembly and location. The drawing of the engineering draftsman can be fully read and understood only by one trained in the "language." Because its principles are essentially the same throughout the world, it is a universal language, and one of any other nation trained in its practices can, with slight adaptions, read the drawings of any other nation.

The universities and colleges offering work in engineering were early to recognize the necessity of the engineering students having a "reading and writing" knowledge of this graphic language. From the very beginning, courses in engineering drawing were required as prerequisites to further course work in engineering.

An aim, then, in a course in engineering drawing, is to study the "language" so that it can be written, expressed clearly to another familiar with it, and read and understood when it has been correctly written. It would be difficult to learn much of original French literature without a reading and writing knowledge of the French language. Likewise, it might be well to consider that the success a student attains in his specialized engineering studies is closely related with his reading and writing abilities in the graphic language of engineering, engineering drawing.

STATEMENT OF THE PROBLEM

Those working with the entrance and diagnostic testing of college engineering students are concerned most often with the testing of two factors: general intelligence and mechanical aptitude. From the scores of the intelligence type tests, the psychologists attempt to predict the student's aptitudes in such subjects as physics, mathematics, and English. Similarly, a student's possible success in adapting himself to such courses as welding, woodshop, and machine operation, might be predicted from his mechanical aptitude score.

However, success in courses of a specific engineering nature such as electrical construction, refrigeration layout, and machine design, require an analysis of the general subjects such as mathematics and physics, and their application to the mechanical operations of the problem. It is this application and coordination of the two apptitudes that the above mentioned tests do not purport to measure.

PURPOSE OF THE STUDY

Since engineering drawing as taught at California State Polytechnic College applies the subject matter of the general course to the mechanics and techniques of drawing, it closely parallels the work of the specialized engineering courses within an engineering major. Further, since engineering drawing is required early in the curriculum of all engineering students, the student's success in engineering drawing may be useful as a predictive factor in determining his success in other engineering subjects. The purpose of this study is to determine to what extent engineering drawing can be used to measure success potential of engineering students.

PROCEDURES

The following procedures were used in collecting and comparing the data:

1. Establish controlled groups for the study.
2. Compare the graduates' grades in engineering drawing with the grades of all students taking engineering drawing.
3. Predict the student's mathematical chances of completing his four-year engineering course on the basis of his grades in engineering drawing.
4. Determine the correlation between the student's grades in engineering drawing and his grades in the specialized engineering major subjects.

5. Determine for each major department the correlation between student's grades in engineering and his specialized major department subjects.

6. Establish a correlation between students' grades in engineering drawing and their college grades in all subjects.

7. Present criteria which may serve as a basis for establishing engineering drawing as a means of predicting the student's probable success in his engineering studies.

LOCATION OF THE STUDY

This study was made at California State Polytechnic College, San Luis Obispo, California, a state-supported men's college under the administration of the California State Board of Education and the State Superintendent of Public Instruction. During the period of this study, from September 1946 to June 1952, the college had an average enrollment of approximately 2500 men of which 1300 were enrolled in agriculture and 1200 in engineering.

California State Polytechnic College was chosen for the following reasons: (1) it was, at the time this study was initiated, the only state college offering a bachelors degree in engineering; (2) it is centrally located between the population centers of Los Angeles and San Francisco and draws students from all parts of the state of California; (3) its unique curriculum, to be explained in Chapter II, is most adaptable to this study; and (4) it offered the greatest opportunity for gathering and assembling the data and for making possible use of the findings of this study.

SUBJECT EMPLOYED

The data obtained for this study were taken from the official, original records of 170 graduating engineers of the graduating class of 1950, and 127 of the class of 1952, at California State Polytechnic College. These students had entered as first-year students in September 1946 and September 1948 respectively. They were enrolled in the following major departments:

(1) Aeronautical Engineering
(2) Air Conditioning and Refrigeration Engineering
(3) Electrical Engineering
(4) Electronics and Radio Engineering
(5) Mechanical Engineering.

All of these students completed the full year course sequence required in engineering drawing.

SOURCES OF MATERIAL

1. Textbooks in the field of general drafting and engineering drawing.

2. Historical, biographical, and statistical references.

3. Articles in periodicals and engineering journals.

4. Catalogs and curricula of California State Polytechnic College.

5. Grade records and instructor grade reports of students.

6. Interviews with students, faculty, and administration of California State Polytechnic College.

METHODS USED

In securing the desired data for this study, the inductive method was employed using the survey technique. School records were the principal research tool used in the collection of the data.

To avoid omissions and in order that all information and data needed could be accumulated in a systematic record, a data sheet was devised. The data sheet was not formulated in its final state until the student's official record had been carefully considered and after twenty-five student records had been evaluated on a trial sheet. A data sheet was prepared for each student used in the study.

It was realized that in a statistical study of this type many calculations involving the grouping of grades would be required. Therefore, the data sheet provided for the grouping of grades as they were taken from the official records. More data were included on the data sheet than was actually utilized in this study. This was done to eliminate the need for going back through the records a second time for additional data which might have been needed.

In presenting the data, averages, correlations and comparisons of this study, wide use has been made of tabular and graphic tools of research.

DEFINITION OF THE GRADE-POINT SYSTEM USED

Because the system of grade points was widely used in this study, and because there are some variations of the grade point or scholarship point systems in general use, the following definition and explanation of the system used at California State Polytechnic College is given.

The grades submitted by the instructors for all courses are:

A . . . Superior
B . . . Better than average (good)
C . . . Average (fair)
D . . . Barely Passing (poor)
E . . . Incomplete
F . . . Failure
W . . . Withdrew without course credit or failure.

In assigning grade points to the above grades the following point system is used:

For each unit of grade "A" . . . 3 points
For each unit of grade "B" . . . 2 points
For each unit of grade "C" . . . 1 point
For each unit of grade "D" . . . 0 points
For each unit of grade "E" . . . 0 points
For each unit of grade "F" . . . minus 1 point

LIMITATIONS OF THE STUDY

The scope of this study does not include the construction or revision of the course of study to establish engineering drawing as an indicator of success in engineering studies. Rather, it was directed toward the collection of data which might serve to indicate to what degree engineering drawing as now presented was an indicator of student success in college work in engineering.

The study was delimited in all respects practicable to make the accumulated data as valid and reliable as possible. It is conceded that the following limit the accuracy of the data and evidence presented:

1. Teacher's evaluation of the student's work may not be a reliable measure of the student's abilities.

2. It is possible that two teachers may not evaluate the work and ability of a student the same, even in the same subject.

3. An error is introduced by rounding off percentage grades to letter grades and then converting to grade points.

Inasmuch as a student's success in college is largely measured by his grades, it did not seem that the limitations mentioned above would seriously effect the comparisons and correlations of this study.

CHAPTER II

HISTORICAL BACKGROUND

Even though historians can trace evidences of engineering some thirty or more centuries before Christ, the modern "science of engineering" as considered in this study, had its beginnings following the Civil War. It might be true that the early pyramids and Roman aquaducts were great engineering feats, but they could hardly be compared with the complex engineering knowledge required of the modern engineer in the use of complicated materials and machines.

The early colonial colleges and universities, patterned after the academic universities of Europe, saw no reason to include the sciences and "practical" courses in their curricula for the professional men of industry. Educators have pointed out the early prejudices of the classics against the sciences and engineering. Industry, steeped in its traditions of apprenticeship and practical experience would not accept the college-trained engineers. Furthermore, professional engineers were not willing to accept responsibility as engineering educators. Dean Finch of Columbia University has recently written of the conflict, (9, pg. 92):

> In the American picture the American engineering schools long occupied a difficult position.

> They had come into being as a result of the growth of engineering science -- many of them carried the title "scientific." They were established only when the scientific movement in engineering had reached the stage where it became clear that this new type of training could be more effectively and efficiently taught through the formal processes of the classroom and laboratory than by the older methods of apprenticeship. The self-styled "practical man" who had come up the hard way through the ranks naturally regarded the product of these new scientific schools as steeped in theory and not having "a practical hair on his head." The American engineering school thus fell heir to the task of encouraging and carrying forward engineering science for almost half a century before the full import of the new movement became clear to American engineers.

The idea of a school of science or a college in which the applications of scientific discovery might be taught was slow in its growth, for their successful development demanded the evolution of instruction which was entirely new and even in violation of the accepted traditions of the early colleges.

Establishing Engineering Education in the United States

During the period from 1825 to 1860 the industries were being developed rapidly with such inventions as the reaper, the sewing machine and the telegraph. This period of the Industrial Revolution saw the utilization of steam power, development of steel, and the discovery of electricity. All of these required a higher knowledge of science and engineering than had ever been known.

A few pioneers visualized that increased scientific knowledge might contribute to the material advancement of this country's vast undeveloped resources. Out of this need was founded Rensselaer Polytechnic Institute in 1823, acclaimed as the first engineering college in America. This was followed by the establishment of the Franklin Institute in 1824. An increased demand for such education culminated in the Land Grant Act of 1862, "donating public lands to provide colleges for the benefit of agriculture and the mechanical arts."

The decade following the Civil War was a period of even more rapid growth in engineering education, and some of the outstanding schools of engineering were established during the period from 1860 to 1870. Harvard and Yale established their scientific schools; the University of Michigan was experimenting in engineering education; Columbia University opened its School of Mines; and, the Massachusetts Institute of Technology began its work. The Land Grant Act provided impetus for the colleges to provide for liberal and professional education.

After 1870 the teaching of the sciences had become established. The development of engineering education consisted of a period of expansion based on the success of the models already established. Finch (9, pg. 93) has written:

> ".....during this very era engineering schools increased and multiplied in America. There were but two in 1840 whereas by 1870 there were 70. The major factor in spreading the new gospel was the rapid increase after the Civil War in the demand for engineers. This was the great age of American expansion.

Engineers of distinction took increased leadership in engineering education. Through the authorship of leading professors, there began to develop American literature of engineering. The engineering profession began to influence the scheme of education in America. Thus the scene was set for the founding of an organization of engineering educators.

<u>Society for the Promotion of Engineering Education</u>

In connection with the World's Fair in Chicago in 1893, the American professional engineering societies met together as the World's Engineering Congress. There were at that time four engineering societies: The American Society of Civil Engineers (founded in 1852); The American Society of Mining Engineers (1872); The American Society of Mechanical Engineers (1883); and the American Society of Electrical Engineers (1884). These groups formed the four divisions, A, B, C, and D, respectively, of the World's Engineering Congress.

At some of the preliminary committee meetings before the Congress, it was suggested that there be included in the scope of the Congress a section on "engineering education." It was felt that as instructors of engineering, the educators, even though they were professional engineers, had problems and interests not within the general interests of the professional, practicing engineer. Accordingly, Division E, Engineering Education, was formed and a special committee appointed.

The sessions proved of such great interest and worth that the unanimous feeling of the group was that this meeting of engineering teachers should be continued as a permanent organization. An appointed committee drafted the first brief constitution and suggested the name, "The Society for the Promotion of Engineering Education." The constitution and name were adopted with but little discussion. DeVolson Wood, professor of Mechanical Engineering at Steven's Institute, New York, was elected the first president.

The charter membership was composed of the sixty-three who registered themselves in attendance at the Division E meeting. A recent president of the Society in reviewing the highlights of the history wrote: (24, pg 42)

> Regardless of the prejudices of the academic colleges against the sciences and engineering, the engineering teachers had no misgivings as to the status of their work. It is no wonder the Society began with a vigorous start and from the day of its establishment, began to exert the profound influence it has exercised in engineering education.

Basic committees had been appointed by President Wood at the Chicago sessions, and the first annual meeting of the Society for the Promotion of Engineering Education was held at Brooklyn, New York, in 1894 with an increased membership of 156.

In the first address to the Society in 1894, President Wood said of its purposes and possibilities (21, pg. 16):

> In less than forty years about 100 professional engineering schools have come into existence in this country graduating some 1200 annually. This growth without a central head or mutual conference, furnishes sufficient reason for the existence of this Society. If its efforts are properly directed, it may make of all these schools a kind of university, in which, though widely separated, there may exist a bond of unity for accomplishing the best results in this line of education; in which there may be "unity in variety", as there will be "variety of unity."

He further stated that the primary interest of the society should be: (1) what should be taught in engineering schools, (2) how should it be taught, and (3) who should teach it.

At the 1922 meeting, it became evident that certain areas of instruction within the Society could further their causes by subdivisions of the membership. Thus, "Divisions" of the Society were provided for, such as Division of Mechanical Engineers, Division of Engineering Drawing, and Division of Mathematics. These divisions provide their own officers and committees and meet in special sessions at the annual meetings to consider problems and reports peculiar to their individual areas of instruction. Of particular importance to the historical background of this study, the Division of Engineering Drawing has done much in studying the field of engineering drawing, providing standards of attainment, and suggesting methods for the improvement of the teaching of engineering drawing. The leaders of the Division have been the outstanding authorities and teachers of engineering drawing in the colleges and universities of the United States.

Through a revision and enlargement of the Society's constitution in 1946, it was felt that engineering education had been recognized as an important field of instruction and that it had been given a place in education of equal importance to the academic subjects. For that reason the promotional aspects of the Society for the Promotion of Engineering Education no longer remained a primary aim of the Society; it then became known as the American Society for Engineering Education.

H. P. Hammond, a recent President of the Society and Professor of Engineering at Pennsylvania State College has said of the history of the American Society for Engineering Education (14, pg. 45):

> The advancement that has come since the 90's has not been in fundamental status, in primary purpose, or, in general, in content or method. It has been a broadening, an enrichment, a deversification, and a steady enhancement of standards, accompanying a pronounced growth in magnitude.

Drawing in the Curricula

The earliest curricula of Rensselaer Polytechnic Institute show courses in drawing; their literature states, "Among the qualifications requisite for a candidate for the degree of Civil Engineer, he must be perfectly familiar with plotting and business drafting." Nearly all early American colleges of engineering introduced drafting into the curriculum even though little is known of the content or teaching methods of these courses.

The first half of the nineteenth century has been termed the "formative period" in the development of the graphic language. The methods of orthographic projection were discovered; textbooks on drawing were written; and schools for technical education were founded.

The second half of the century was a period of growth, of change, of development, and of expansion. Higbee has written of this era, (15, pg. 90):

> During the period from 1850 to 1900 the whole scheme of graphic representation underwent the same colossal change which was common in all lines of endeavor. Military and Civil Engineering ceased to be designators sufficient to indicate the character of constructive undertakings, and engineering and engineering education became divided into branches. With

> each of these branches of engineering there arose a need for a kind and style of drawing in keeping with the nature of the undertaking, and thus came the day of specialization.

At least two publications have contributed greatly to this evolution of engineering drawing and its concept as the graphic language of the engineer.

The first of these contributions was the publishing, in 1911, of Engineering Drawing, by Thomas E. French of the Ohio State University. It has been called "the first comprehensive and adequate text on engineering drawing," and has served as a pattern for most of the engineering drawing books published since that time. Now, after more than forty years, it is in its eighth edition and still continues to be the "best seller" of engineering text books. It served to unify and standardize, as nothing else had done, the courses in engineering drawing throughout the colleges and universities.

The second contribution was the instigation, by the Engineering Drawing Division of the American Society for Engineering Education, for a standardization of drafting procedures and techniques. This work was accepted by the American Standards Association and developed by committees of educators and representatives of industry. As late as 1946 this effort culminated in the publication and general acceptance by member societies of the "A.S.A. Drafting Room Standards."

Curriculum of California State Polytechnic College

California State Polytechnic College was first chartered in 1901 by the state legislature of California as the California Polytechnic School, a vocational school for teaching boys and girls the "practical home arts." No grade level of instruction had been specified in the charter. It opened in 1902 as a state vocational high school and was the forerunner in California of vocational education along both the agricultural and industrial lines. As the idea of vocational education spread, the district high schools finally began to provide adequate vocational instruction at the high school level. In 1927, to avoid duplication of local effort, California Polytechnic School raised its level of instruction to that of a junior college but still operated under state administration and support.

It continued as a junior college until 1933, when on the verge of being discontinued because of lack of funds during the depths of the depression, Julian A. McPhee was appointed president. He was, at the time, Chief of the Bureau of Agricultural Education for California, and had visions of using the established facilities for training and credentialing teachers of vocational agriculture. Agriculture teacher training was not offered in any college in the state. At this same time, the school was placed under the administration of the State Department of Education and changed from a junior college to a two-year and three-year technical college. In 1936 a degree-transfer program was added to make credentialing of agricultural teachers possible. In 1940 the State Board of Education authorized the college to grant Bachelor of Science degrees in agriculture and engineering for completion of a four-year curriculum. The first baccalaureate exercises were held in 1942.

The unique curriculum of the college, as mentioned in Chapter I, was the outgrowth of President McPhee's philosophy concerning practical education. He has insisted that, whenever possible, the practical, technical, and laboratory courses be put in the first two years of the student's program. The total program and course content of any of the four-year curricula is substantially the same as in similar majors of any typical "A & M" college, but is offered in an inverted order. This has been referred to by President McPhee as the "upside-down" educational plan.

The plan has not been readily accepted by engineering educators and engineering accrediting associations in general. Nationwide recognition of the plan has come through publication of articles in leading magazines and journals. From the student's standpoint it has been well received. It creates interest by giving him first-hand acquaintance with his major work early in his studies; it offers him job-getting skills in engineering in case he cannot finish the four-years work; and it gives him a basis for understanding the need and application of the theory that will come later.

CHAPTER III

PRESENTATION OF THE DATA

The problem, as explained in Chapter I, was to determine the predictive value of engineering drawing in measuring student potential in his specialized engineering course work. The procedures were to provide a basis for the analysis of the distributions, relationships and correlations of the student's grades as recorded on the student's official college records.

In reviewing the data that had been gathered for this study, four distinct steps seemed necessary: (1) selecting the subjects, (2) tabulating and comparing the frequency distributions, (3) calculating and analyzing the trends of central tendency and variation within the grades, and (4) calculating and evaluating the correlations and relationships between the different course grades of the groups. Each of these steps will be considered.

SELECTING THE SUBJECTS

The sampling of a graduating class seemed a natural grouping of students to consider in this study. Such individuals within a group would have been taught during the same period of time and would, as nearly as possible, be exposed to an identical learning environment. Therefore, the engineering degree graduates of California State

Polytechnic College in the graduating classes of June 1950 and 1952 were used.

The graduates of the 1950 class were chosen because they were of the first graduating class to begin their four years work following World War II. Also, they were the first students to take work under a revised and expanded course of study in engineering drawing. Because the class of 1950 was composed of a large majority of veteran students, it was felt that their maturity and technical training and experience in the armed forces might have some effect, particularly on their abilities in engineering drawing and engineering course work. If this were so, it seemed that a study of a later class would point out the differences. For that reason the class of 1952 was also used in the study. This graduating class of 1952 began their first year of college studies in 1948, and had about 20% smaller veteran enrollment. Both groups took their course work in engineering drawing from an identical faculty, and using the same facilities, text, and courses of study. It is felt that the conditions under which the classes of 1950 and 1952 worked and studied would closely parallel one another.

Engineering Drawing Courses

All first-year engineering students at California State Polytechnic College were required to take a sequence of three, two-unit courses in engineering drawing, identified as Mechanical Engineering 121, 122, and 123. The recognized course abbreviations of ME 121, ME 122, and ME 123 will be used to refer to these courses throughout the study. Each student completes these courses, composed of one hour of lecture and discussion each week and one supervised laboratory of three hours each week, each of the three quarters. Any student not completing the three quarters of work in engineering drawing at California State Polytechnic College was not used in the study.

Students graduating with the classes of 1950 and 1952 who had enrolled in engineering drawing, were registered in one of seven major departments of the college: (1) aeronautical engineering, (2) agricultural engineering, (3) air conditioning and refrigeration engineering, (4) architectural engineering, (5) electrical engineering (6) electronics and radio engineering, and (7) mechanical engineering. The college approved abbreviations for courses within these departments are AERO, AC, ARCH, EE, EL, and ME, respectively. These abbreviations will be used in the tables and graphs throughout this study.

For purposes of this study, students registering in the agricultural and architectural engineering departments were not considered. The department of agricultural engineering is classified as an agricultural rather than an engineering department. Their curriculum does not follow the same general pattern as the engineering departments and the general requirements are somewhat different. Also, those that graduated in 1952 had been required to take only two of the three quarters of engineering drawing.

The architectural engineering students, beginning in 1948, were not required to take any of the engineering drawing sequence. Their major course work is of an artistic nature and it too does not parallel the work of the other five engineering departments. For these reasons, the graduates of 1950 and 1952 with a major in architectural or agricultural engineering were excluded from further consideration in the study.

Student Enrollment

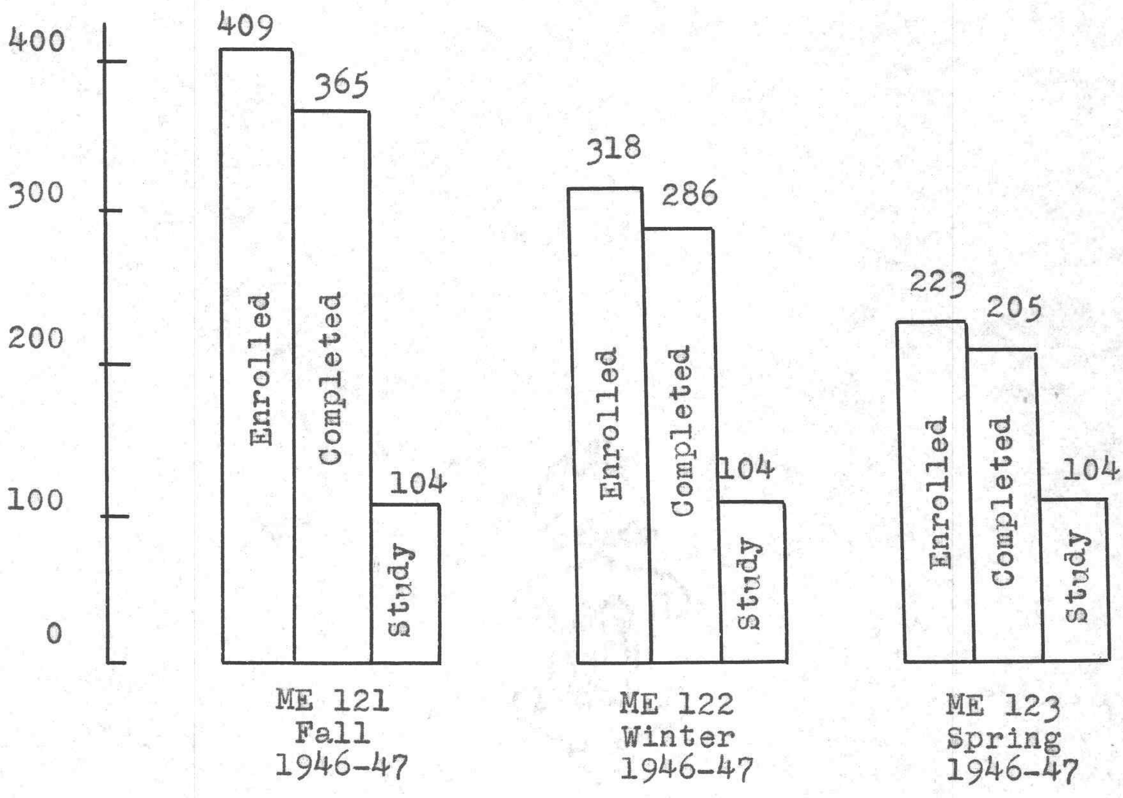
Graph 1, page 26 shows the actual enrollment (less agricultural and architectural engineering students) in engineering drawing at California State Polytechnic College during the school year 1946-47. It shows the number initially enrolling and the number completing each of the three quarter sequences of the course. The number of graduates finally considered in the study is also shown. Graph 2, page 27 gives similar enrollment information for the 1948-49 school year.

GRAPH 1

Student Enrollment in Engineering Drawing

Graduating Class of 1950

California State Polytechnic College

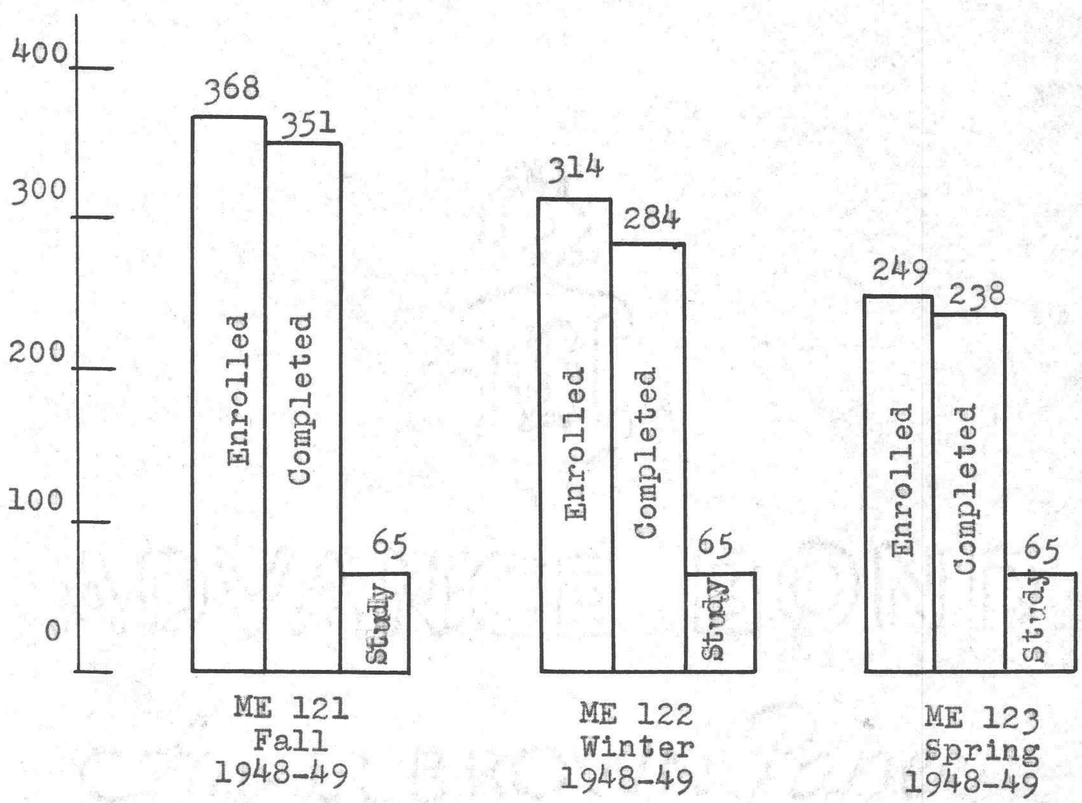


GRAPH 2

Student Enrollment in Engineering Drawing

Graduating Class of 1952

California State Polytechnic College



The drop in the number enrolled in each succeeding quarter, as shown in Graph 1 and Graph 2, is due primarily to the normal drop-out of first-year college students. Also, those that failed during the first or second quarters were not allowed to continue with the sequence of engineering drawing courses. The differences in the "enrolled" and "completed" columns is due to a provision whereby students under certain circumstances could "withdraw" from the course with credits and grade points neither credited nor discounted. The number used in the study remains constant in each quarter, as shown in the "study" column, as only those were being considered that had completed the entire three quarter sequence of engineering drawing.

The great difference in the number of students completing the engineering drawing courses and the number of students used in the study is due to the limitations placed on the choice of graduates for consideration in the study. The students must have completed the entire three quarter sequence at California State Polytechnic College during the school years 1946-47 or 1948-49, whichever was appropriate to his graduating class. In Graph 1, illustrating the class of 1950, only those 205 that had completed ME 123 (third quarter of the sequence) had successfully completed the previous two quarters and could be considered for the study. This shows that of 409 originally enrolled in the Fall of 1946, only 205, or 50.1%, completed the entire three quarters of the course. Further elimination was necessary within these 205 students because of enrollment in other than a four-year curriculum and normal college drop-outs during the second, third, and fourth years.

ENROLLMENT BY DEPARTMENTS

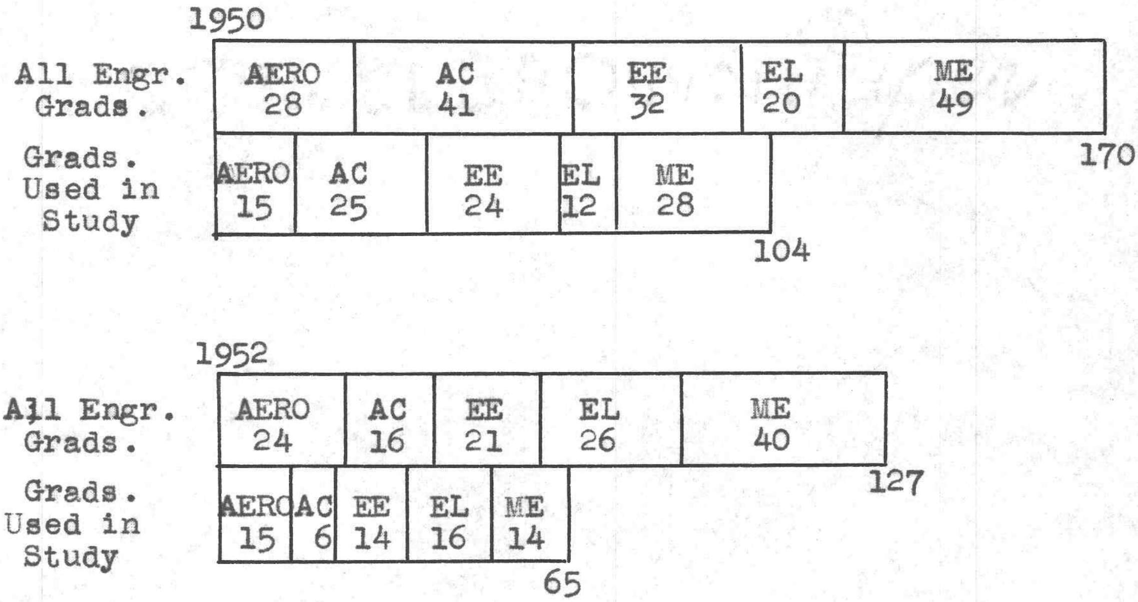
The total number of graduates in the five engineering departments are compared with the number of these graduates used in this study in Graph 3, page 30. These total numbers of graduates will not agree with the official figures of the college because the graduates in architectural engineering have not been included. The differences in the number of graduates in the various departments is a general indication of the enrollment within the department. It is not significant in this study and will not be considered further.

GRAPH 3

Engineering Graduates by Departments

Classes of 1950 and 1952

California State Polytechnic College



Veteran Enrollment

One reason for including the graduating class of 1952 in this study was to discover if there were any differences caused by the drop in the number of veteran students enrolled. It is believed the following point out the veteran influence.

In Graph 1, it was shown that of the 409 originally registering in engineering drawing in 1946, 104, or 25.4% of those beginning, actually completed their four years work and graduated in 1950. Compared with this, Graph 2 indicated 368 students beginning drawing in 1948, and 65, or only 17.7% graduating four years later. This difference of 7.7% is not great, but seems to indicate the greater veteran registration in the graduating class of 1950. Their maturity, family responsibilities, and government subsidized education were driving motives in their persistence to complete the four years of college.

Again, in Graph 3, the 10% difference between the percentages of 1950 and 1952 graduates used in this study is slight, but thought to be the influence of the veteran enrollments of the respective classes. Non-veterans, of which there was a greater percentage in 1952 than 1950, tend to stay near home for economic reasons and attend local junior colleges. They can complete the first year or two of general engineering subjects and then transfer as second or third year students to the engineering college. These students did not complete their engineering drawing at California State Polytechnic College and were thereby eliminated from the study.

FREQUENCY DISTRIBUTIONS

In order to analyze the grades that had been received by students in engineering drawing, frequency distributions were calculated from the official "Instructor's Grade Report" which is submitted by each instructor at the close of every quarter.

Table I, page 33, for those taking engineering drawing in 1946-47, and Table II, page 34, for the classes of 1948-49, give the letter grade distribution of grades in engineering drawing throughout the full three quarters of the course. In all cases shown the grade distribution is somewhat higher than a normal distribution curve. As this study was instigated after the grades were given, the knowledge of the study could have no effect upon the grades given. It should have no effect upon the comparisons of the study, and therefore will not be considered further.

Tables III and IV, pages 35 and 36 respectively, give the grade distribution in engineering drawing for those that took their engineering drawing in 1946-47 and 1948-49, and then finished their work and graduated in 1950 and 1952 respectively. These would represent the 104 students of 1950 and 65 students of 1952 that were used in the study. It can be noted that the frequency distribution is still higher than for Tables I and II.

TABLE I

Engineering Drawing Grade Distribution

All Students

1946-47 School Year

Grade	ME 121 Fall 1946-47 freq.	%	ME 122 Winter 1946-47 freq.	%	ME 123 Spring 1946-47 freq.	%
A	24	6.6%	16	5.6%	14	6.8%
B	154	42.2%	103	36.0%	74	36.1%
C	134	36.7%	130	45.5%	99	48.3%
D	31	8.5%	11	3.8%	10	4.9%
E	11	3.0%	5	1.7%	0	0.0%
F	11	3.0%	21	7.4%	8	3.9%
Totals	365	100%	286	100%	205	100%
Means (P.G.A.)	1.348		1.245		1.370	
Three quarter mean (G.P.A.)	1.320					

TABLE II

Engineering Drawing Grade Distribution

All Students

1948-49 School Year

	ME 121 Fall 1948-49		ME 122 Winter 1948-49		ME 123 Spring 1948-49	
Grade	freq.	%	freq.	%	freq.	%
A	31	8.8%	19	6.7%	21	8.8%
B	133	37.9%	84	29.6%	86	36.2%
C	122	34.8%	125	44.0%	100	42.0%
D	25	7.1%	8	2.8%	11	4.6%
E	7	1.9%	3	1.1%	1	.4%
F	33	9.5%	45	15.8%	19	8.0%
Totals	351	100%	284	100%	238	100%
Means (G.P.A.)	1.256		1.063		1.324	
Three Quarter Mean (G.P.A.)	1.212					

TABLE III

Engineering Drawing Grade Distribution

Graduating Class of 1950

(Drawing in 1946-47 School Year)

Grade	ME 121 Fall 1946-47 freq.	%	ME 122 Winter 1946-47 freq.	%	ME 123 Spring 1946-47 freq.	%
A	16	15.4%	11	10.6%	14	13.5%
B	64	61.5%	58	55.7%	52	50.0%
C	23	22.2%	35	33.7%	37	35.6%
D	1	.9%	0		1	.9%
E	0		0		0	
F	0		0		0	
Totals	104	100%	104	100%	104	100%
Means (G.P.A.)	1.921		1.769		1.759	
	Three Quarter Mean (G.P.A.)			1.814		

TABLE IV

Engineering Drawing Grade Distribution

Graduating Class of 1952

(Drawing in 1948-49 School Year)

Grade	ME 121 Fall 1948-49 freq.	%	ME 122 Winter 1948-49 freq.	%	ME 123 Spring 1948-49 freq.	%
A	13	20.0%	10	15.4%	10	15.4%
B	37	57.0%	32	49.3%	31	47.7%
C	15	23.0%	21	32.3%	21	32.3%
D	0		1	1.5%	1	1.5%
E	0		0		0	
F	0		1	1.5%	2	3.1%
Totals	65	100%	65	100%	65	100%
Means (G.P.A.)	1.969		1.742		1.687	
	Three Quarter Mean (G.P.A.)		1.811			

Comparing the individual graduating student's grade point average in engineering drawing with the minimum average of 1.212 of all entering students in engineering drawing in 1950 and 1952, the data show only 21 received a grade point average of less than 1.33 (equivalent to one "B" and two "C" grades in engineering drawing.) Or, 87.6% of the graduates of 1950 and 1952 received grades in engineering drawing that were better than the mean grade in engineering drawing of their entire beginning classes in the 1946-47 and 1948-49 school year.

Combining the grade distributions for 1950 and 1952 from Tables I and II, there is indicated 118 students received grades of "D", "E", or "F" in ME 121 in the Fall quarters of 1946-47 and 1948-49. This is a 16.5% of the 716 students completing ME 121 during those two years. Of these 118 students, Table III shows only one graduated with his class in 1950. This indicates a student receiving a grade of "D", "E", or "F" in his first quarter of engineering drawing has one chance in 118, (or 0.0085) of completing his four years of college work. Not a single one of the 44 students that failed ME 121 in the Fall of 1946-47 or 1948-49 completed his college work.

Throughout the full three quarters of engineering drawing for both the 1950 and 1952 classes, Tables I and II show 260 grades of "D", "E", and "F" given. Of these

260 grades, seven were received by students that graduated. This indicates a mathematical chance of .0268, or 2.68%, of those receiving grades of "D", "E", or "F" in any one of the three quarters will graduate. None of these seven men received a grade of "D", "E", or "F" in engineering drawing for more than one quarter of the three quarter sequence.

Of the 125 grades of "A" received by students during the three quarters of engineering drawing in 1946-47 and 1948-49, 74 were received by students that graduated, for a mathematical chance of 0.592. Of 634 receiving grades of "B", 274 were received by graduates for a mathematical possibility of 0.433, and for the "C" grades, 710 given, 152 were received by graduates for a mathematical ratio of 0.214.

On the basis of this data it is indicated that the higher a student's grades in engineering drawing the greater his chances of completing his four years work and graduating. Approximately 60% of those receiving a grade of "A" during any one of the three quarters of engineering drawing will graduate. 43% of those receiving grade "B" and 21% of those receiving "C" will graduate, while only about 2.68% of those receiving "D", "E", or "F" grades during any one quarter of the sequence will graduate.

AVERAGES

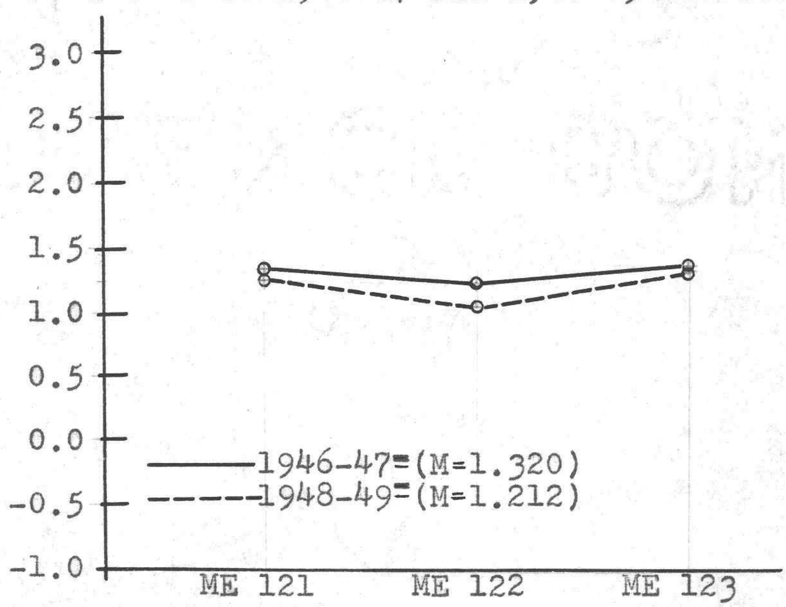
Broom (6 pg. 24) in his text dealing with educational statistics, advises: "There are three types of measures or facts that are necessary in summarizing or describing a series." In brief, these are described as: (1) averages, (2) variabilities, and (3) correlations or relationships. Following Broom's suggestion, the measures and comparisons will be considered in three parts.

Course Grade Averages

In Graph IV, below, is shown a comparison of the average of the grades in engineering drawing throughout the three quarters, for all students taking the courses. These were enrolled during the 1946-47 and 1948-49 school year.

GRAPH IV

Grade Point Averages of Grades in Engineering Drawing
All Students of 1946-47 and 1948-49 Classes.

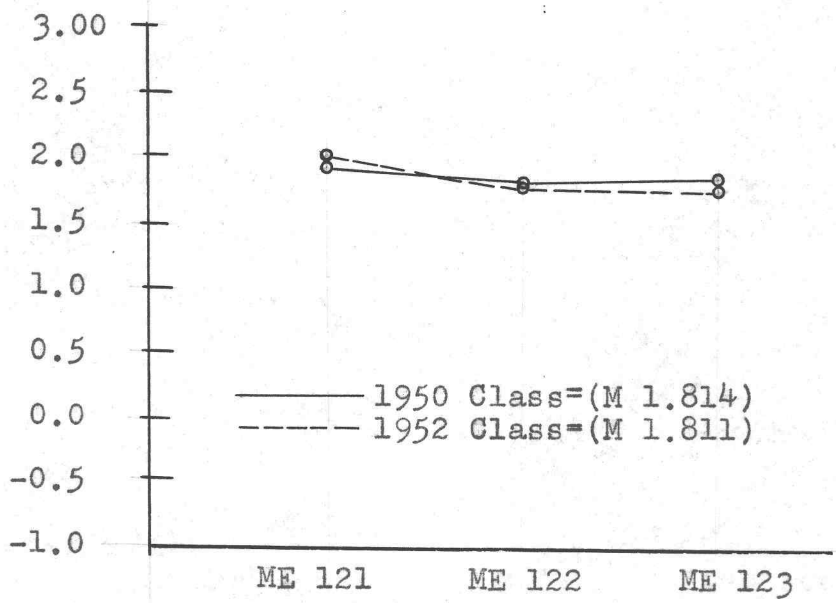


The two superimposed curves have the same tendencies: a drop from the first to second quarter and a rise to the third. The curves are so nearly coincident that for general comparison purposes they could be considered the same. If a student's grades in a course are a measure of his abilities in the subject matter and techniques of the course, then the abilities of the classes of 1946-47 and 1948-49 in engineering drawing could be considered the same.

The comparison of the averages of the graduates only who had taken engineering drawing in 1946-47 and 1948-49, is shown in Graph V, formulated from data of Tables III and IV.

GRAPH V

Grade Point Averages of Grades in Engineering Drawing
Graduates Only of Classes of 1950 and 1952



This shows a somewhat higher average in each quarter than was found for all students in Graph IV. This is to be expected because the graduates would compose a select group. There is even less difference in the two curves of this graph than there was shown in Graph IV, and for comparison purposes, the averages for the Class of 1950 and 1952 could be considered the same.

While there was found to be some significant difference in the veteran influence between the two classes as it effected the number that completed the sequence of courses in engineering drawing and also those that completed their four years of college, there appears to be no significant difference between those enrolling with the classes of 1950 and 1952.

Noting the three quarter means as indicated in Graph IV and Graph V, the means for all students were 1.320 and 1.212 for 1950 and 1952 classes respectively. This difference of about one-tenth of a grade point is too small to be considered significant in further comparisons. For the graduating students, the averages were 1.814 and 1.811, exactly the same to two decimal place accuracy.

Mean Grades by Departments

Table V, page 42, tabulates the calculated means of the work in engineering drawing and the work in the specialized engineering courses, by major departments for the two years of the study. The combined means for all students of both classes were also calculated.

TABLE V

Mean Grades in Drawing and Specialized Engineering Courses For Graduating Classes of 1950 and 1952 By Departments

	Engineering Drawing		Specialized Engr. Courses	
Dept.	1950	1952	1950	1952
AERO	1.93	2.00	1.79	1.74
AC	1.82	2.33	1.76	2.00
EE	1.75	1.62	1.62	1.43
EL	2.25	1.70	1.70	1.58
ME	1.63	1.76	1.89	1.90
Overall Average	1.814	1.811	1.76	1.69

Comparing the means for engineering drawing only, it is noted they are consistently high. The lowest mean of 1.62 would be interpreted as a "B minus" grade. This is due to the highly selected groups considered. Each must be a graduate, which requires a +1.00 grade point average. Therefore, only a very few student's grades can be below 1.00. Also, all courses failed must be repeated, thereby eliminating grades of "F" or -1.00 grade points. The validity of the high mean of 2.33 for the air conditioning majors within the 1952 class could be questioned because so few students were involved. Graph 3 had previously listed the number of subjects within each department for the classes of 1950 and 1952.

If the means of the engineering drawing grades, as listed in Table V, are compared between departments, there seems to be no general trends or consistencies. The departments with the highest and lowest mean grades in 1950 are not the same departments with the highest and lowest means in 1952. This would seem to indicate that students of one major have no greater ability in drafting than students in another major. Comparing the means between the two different years of drafting considered, it can be noted that aeronautical engineering majors were well above the means for all students during both 1950 and 1952, and the mechanical engineering majors somewhat below both years. This might indicate that those graduates in aeronautical engineering will consistently do better than average in engineering drawing and those in mechanical engineering consistently below the average. It is believed, however, that the sampling is so small and the number of graduating classes considered too few to make any such definite conclusions.

It does seem significant that the means for all students in engineering drawing in 1950 and 1952 were

1.814 and 1.811 respectively, or almost identical. Regardless of the differences in individual students, and interest in drawing brought by different major subject interests and abilities, the average of the measures of ability in engineering drawing for all students considered in 1950 as compared with those of 1952, were the same.

Considering the calculated means of the specialized engineering courses of the graduating classes of 1950 and 1952, also listed in Table V, it can be seen that they are, with but one exception, consistently lower than the means for drafting. A comparison between the means of the various departments, in this case, would not be valid due to the different major requirements of each department and the degree of proficiency and ability required within the major department courses. Again, the high mean of 2.00 for the air conditioning majors during 1952 might be considered invalid because of the small number of students evaluated.

The median for all groups was also calculated, but the highly selected groups and the limited spread of grades, caused it to be nearly the same as the mean in all cases. For purposes of comparison, the mean was chosen as the measure of central tendency.

VARIATIONS

The standard deviations were calculated to be used as the indication of the variations or spread of grades within the various series used. These measures of variation for grades in engineering drawing and the specialized engineering courses for the years 1950 and 1952 are tabulated by departments in Table VI. The overall deviations for the entire classes are also shown.

TABLE VI

Standard Deviations for Grades in Engineering Drawing and Specialized Engr. Courses Graduates of 1950 and 1952 By Departments

Dept	Engineering Drawing 1950	Engineering Drawing 1952	Specialized Engr Courses 1950	Specialized Engr Courses 1952
AERO	.56	.63	.33	.35
AC	.53	.61	.47	.34
EE	.44	.46	.45	.45
EL	.57	.64	.42	.39
ME	.43	.49	.38	.41
Overall Average	.54	.61	.43	.42

The extremes of all the standard deviations listed for engineering drawing vary by a maximum of only .21 of a grade point. The minimum and maximum standard deviations for the specialized departmental courses varies by only .14 of a grade point. The low values of the standard deviations are due partly to the relatively small number of samples used in each department, and in part to the selectivity of the group. Again, due to the 1.00 grade point average required for graduation, the grades will lie somewhere between the limits of +1.00 and +3.00, whereas a normal distribution would have limits of -1.00 and+3.00.

The reason the average standard deviations for drafting are somewhat higher than those for the specialized major courses during the same two years is because of the limit of three grades that could be averaged for the student's grade point average during the three quarters of drawing. That is, provided a student did +1.00 or better in each of his three quarters of drawing, he could obtain grade point averages of +1.00, +1.33, +1.67, +2.00, +2.33, +2.67, or +3.00, only. With an interval of .33 between grades and only six intervals between the limits, it would tend to give a higher standard deviation.

There seems to be no great significance in any of the calculated standard deviations, except that being nearly equal throughout, they would not present irregularities that would influence the interpretations of the data to be considered further.

CORRELATIONS

To see if any marked relationships existed between the student's grade point average in engineering drawing and his average in the specialized engineering courses, the coefficients of correlation were computed. Correlation coefficients were calculated for all major departments for the graduating classes of 1950 and 1952. As the scores were ungrouped and a maximum sampling of 28 students in any one department was being considered, the following formula was used:

$$r = \frac{\Sigma xy}{\sqrt{\Sigma x^2 \cdot \Sigma y^2}}$$

This allows for the calculation of the coefficient of correlation when the scores are ungrouped and the deviations are taken from the known means, as had previously been determined for use in Table V. These results are shown in Table VII, page 48.

TABLE VII

Coefficients of Correlation

Engineering Drawing with Specialized Major Courses

Graduates of 1950 and 1952 by Departments

	1950		1952	
Dept.	N	r	N	r
AERO	15	.478	15	.774
AC	25	.473	6	.278
EE	24	.706	14	.245
EL	12	.757	16	.612
ME	28	.419	14	.761
All Grads	104	.476	65	.594

N=number of subjects
r=coefficient of correlation

Engineering Drawing Correlated with Specialized Major Courses

Dr. Garrett has warned, (12, pg. 327,) "The direct comparisons of coefficients of correlation is not valid when the variabilities within the groups from which the correlations were computed are quite different." This should not invalidate the comparisons of these computed correlation coefficients, as the standard deviations varied only slightly, as shown in Table VI, page 45.

The extremes of the coefficients calculated and tabulated in Table VII, page 48, seemed excessive and beyond reason. This was particularly true of the .278 coefficient of correlation for air conditioning majors and the .245 for electrical engineering majors both of the 1952 graduating class. These very low correlation coefficients, the extreme variation between the correlations of different majors, and the difference between the correlations of the two different years of the same major, may be due to the small number of sampling used. For example, of the fourteen students used to calculate the coefficient of correlation for the electrical engineering graduates of 1952, one graduating student had a grade point average of 2.55 (highest in his class) in his specialized engineering courses. The mean of his whole class was only 1.43. To be correlated with this, he had a grade point average of only 1.33 to a class mean of 1.62 in engineering drawing. Assuming that this one student had done only average work in either drawing or his specialized major work, the correlation coefficient was again calculated and found to be well above the .400 level for the fourteen subjects within his major. When the effects of one student's grades can nearly double the calculated coefficient of correlation, then it would seem that the samplings were too few to give significance to the correlation ratios. For that reason, the coefficients of correlation within each department would not be considered a valid ratio to be used for comparison purposes.

The samplings of 104 for the class of 1950 and 65 for the class of 1952, seemed sufficiently large to give some significance to the coefficients of correlations for the entire classes as a group. Their grades in engineering drawing were correlated with their grades in the specialized engineering courses. Garrett points out (12, pg. 302), "The averaging of coefficients of correlation is a dubious and often incorrect procedure. Two substantial measures of correlation combine to give a result which indicates no real relationship." For this reason, even though the individual department's correlations between the same two variables had been previously calculated, the coefficient ratios for the entire classes were completely recalculated.

With large numbers of ungrouped scores involved in this total correlation, the product-moment method was employed making use of the correlation table and the Clinton Correlation Chart. Coefficients of correlation between grades in engineering drawing and grades in specialized engineering courses were .476 for the 104 graduates of the class of 1950 and .594 for the 65 of the class of 1952. These are tabulated in Table VII, page 48.

While these are positive correlations, they are not particularly high for the type of variables correlated. Nelson writes (17, pg. 98) that one can expect to find a coefficient of correlation, due to the student's intelligence factors alone, between .40 and .60 for any two school subjects correlated. These correlations would be located between the limits that Nelson suggests. These levels of correlation, .476 and .594, would be much too low to use in the predicting of grades of individual students, but could be used for forecasting the general achievements of selected groups of students.

For overall comparison purposes, the results of all the calculations involving engineering drawing and specialized engineering courses have been combined in Table VIII and Table IX, page 52.

TABLE VIII

Tabulations of all Calculations
of Engineering Drawing and Specialized Engineering Courses
Class of 1950 - By Departments

		Drawing		Major		
	N	M	σ	M	σ	r
AERO	15	1.93	.56	1.79	.33	.478
AC	25	1.82	.53	1.76	.47	.473
EE	24	1.75	.44	1.62	.45	.706
EL	12	2.25	.57	1.70	.42	.757
ME	28	1.63	.43	1.89	.38	.419
All Grads.	104	1.81	.54	1.76	.43	.476

TABLE IX

Tabulation of all Calculations
of Engineering Drawing and Specialized Engineering Courses
Class of 1952 - By Departments

		Drawing		Major		
	N	M	σ	M	σ	r
AERO.	15	2.00	.63	1.74	.35	.774
AC	6	2.33	.61	2.00	.34	.278
EE	14	1.62	.46	1.43	.45	.245
EL	16	1.70	.64	1.58	.39	.612
ME	14	1.76	.49	1.90	.41	.761
All Grads.	65	1.81	.61	1.69	.42	.594

N=number of subjects M=mean
σ= standard deviation r=coefficient of correlation

Engineering Drawing Correlated with Total College Grades

As a college student's total success is more often determined by his overall college average, or grade point average, a further set of correlations was calculated to establish a coefficient of correlation between grades in engineering drawing and the total grade point average of the graduates of 1950 and 1952. The results of these calculations are listed in Table X, below.

TABLE X

Coefficients of Correlation for Total Graduating Classes

	Class of 1950	Class of 1952
Number in study	104	65
Correlation of Engineering Drawing with Engineering Specialized Courses	.476	.594
Correlation of Engineering Drawing with Total College G. P. A.	.498	.529

For the class of 1950, a coefficient of correlation of .498 was indicated, being only slightly higher than the coefficient of .476 that had been calculated between engineering drawing and the specialized engineering courses. For the class of 1952 this coefficient was .529, just lower than the .594 of the previous calculation.

These correlation results seem to show that engineering drawing is no more an indication of success in specialized engineering courses than it is an indication of student success in his overall college work, which would include mathematics, history, physical science, English, language, etc.

It is felt that if the correlations could have been calculated to compare the grades of the first year of college work only, thereby having a more heterogeneous grouping of students receiving failing as well as average and above average grades, the correlation ratios would have been somewhat higher.

CHAPTER IV

SUMMARY

It was attempted in Chapter I to state the problem and establish the purpose of this study. Engineering drawing being so widely termed the "universal graphic language" of industry and engineering, it was proposed to evaluate this "language" by using students' grades in engineering drawing as a means of predicting student success in his studies in engineering. Certain inaccuracies were recognized due to the possible errors in grades, which were to be the sole evidence of ability or success of the college work considered in this study.

Chapter II established a background of history of engineering education and engineering drawing during the past one hundred years. The history of present day engineering education in the United States began shortly after the Civil War. The westward expansion of the United States, the invention of the reaper and sewing machine, application of electricity, development of steel, and attainment of greater speeds through refinement of the steam engine, all created a demand for a formally trained, technical engineer.

Even though there was this great need, and by 1870 over 100 schools of engineering had been started, these colleges were having trouble establishing themselves with industry and the universities. Graduate engineers were not accepted by the "practical" engineers who had "come up the hard way." Universities and faculties would not admit the technical and engineering faculty as a legitimate part of higher education.

Beginning in 1893, modern engineering education, as we know it today, began to be formed. In that year the American Society for Engineering Education was founded. Through the efforts of this Society during the past sixty years, the prejudices of the academic departments were gradually overcome and engineering took its place in the universities and colleges of the United States. Today enrollment in engineering in the colleges of the United States is exceeded only by that of teacher education and liberal arts.

The study, as presented in Chapter III, compares the students' grades and indicates relationships and correlations of his grades in engineering drawing with others of his college work. A total of 297 engineering graduates of the classes of 1950 and 1952 were considered; of these 104 of the graduating class of 1950, and 65 of the class of 1952 were eligible for use in the study.

Frequency distributions of grades in engineering drawing were obtained from the Instructor Grade Lists which are submitted at the end of each term for each course taught. Transcripts, in the form of data sheets, were made from the official records for each individual student used in the study. Grade point averages were calculated separately for engineering drawing, specialized engineering subjects within the majors, and overall four years college work.

Grade distributions in engineering drawing were compared. This revealed that while about 25% of students starting first year engineering drawing will complete their four years of college training in engineering, almost 60% of those receiving a grade of "A" during any one quarter of the three quarters will graduate and only 2.5% of those receiving grades of "D", "E", or "F" in a quarter will graduate.

After the means and standard deviations of the grades were calculated and compared for irregularities that might effect the relationships of the grades, coefficients of correlation were calculated for: (1) grades in engineering drawing with grades in specialized engineering courses, and (2) grades in engineering drawing with grades in all subjects. These correlations were calculated on groupings by majors within each graduating year, and for groupings of all within a graduating class.

While all coefficients of correlation were positive and of a level to be classified "substantially correlated," none were high enough to be termed "highly correlated." This would make the correlations of value for indicating group trends, but of doubtful use for predicting individual success.

CONCLUSIONS

1. Only about one-fourth of the students beginning first year engineering drawing will graduate in engineering with their class four years later.

2. The higher a student's grades in engineering drawing the better his chances of completing his four years work in engineering.

3. There was no difference in student's ability in engineering drawing, as indicated by grades, between the graduating classes of 1950 and 1952.

4. Regardless of the student's major department, there was no outstanding ability in engineering drawing shown by the students of any one department.

5. The more matured and experienced veteran enrollment seemed to have little effect on ability in engineering drawing as measured by student grades.

6. Grades in engineering drawing when correlated with grades in specialized engineering courses give a correlation ratio of approximately .50, which is interpreted as a "substantially significant" correlation.

7. Grades in engineering drawing would be useful for predicting trends of groups of students but not for predicting grades of individual students.

8. Grades in engineering drawing are just as useful in determining the student's success in his

complete college work as they are for predicting his success in specialized engineering courses.

RECOMMENDATIONS

1. A study should be made to determine the status of the 75% who did not complete their four year degree program in engineering.

2. In counseling students, faculty advisers should be made aware of the following:

(a) Only 25% of beginning students in engineering drawing will graduate.

(b) Only 2½% of students receiving grades of "D", "E", or "F" in engineering drawing will graduate.

(c) 60% of students receiving grades of "A" in engineering drawing, 43% of grades "B", and 21% of grades "C" will graduate.

(d) Grades in engineering drawing can be used to give a substantial indication of what students will do in specialized engineering courses and in their entire college work.

3. A follow-up study should be made of later classes at California State Polytechnic College.

4. Similar studies should be made at other colleges to see if the same levels of correlation existed under their curricula and methods of instruction.

5. Correlations should be made with the combinations of other courses, such as:

(a) Engineering drawing and mathematics, correlated with specialized engineering courses.

(b) Engineering drawing and physical science, correlated with specialized engineering courses.

(c) Engineering drawing correlated with first year college work.

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APPENDIX

GRADE POINT AVERAGES

AERONAUTICAL ENGINEERING GRADUATES 1950

STUDENT	GPA ENGR DRAW	GPA MAJOR ENGR WORK	GPA TOTAL COLLEGE WORK
AERO 50-1	3.00	1.45	1.28
AERO 50-2	1.67	1.48	1.40
AERO 50-3	3.07	2.27	1.96
AERO 50-4	1.67	1.90	1.71
AERO 50-5	1.67	1.76	1.56
AERO 50-6	1.67	1.60	1.42
AERO 50-7	2.00	1.92	1.49
AERO 50-8	1.00	1.49	1.49
AERO 50-9	1.00	1.31	1.14
AERO 50-10	2.00	2.15	1.71
AERO 50-11	2.00	2.12	1.85
AERO 50-12*	2.00	2.23	2.22
AERO 50-13	1.67	1.33	1.88
AERO 50-14*	2.67	2.15	2.00
AERO 50-15	2.00	1.67	1.28
	M = 1.93	M = 1.79	M 1.63
	σ = .56	σ = .33	

r= .478

*Graduated with honors

GRADE POINT AVERAGES

AIR CONDITIONING AND REFRIGERATION GRADUATES 1950

STUDENT	GPA ENGR DRAW	GPA MAJOR ENGR WORK	GPA TOTAL COLLEGE WORK
AC 50-1	1.67	2.36	1.98
AC 50-2	2.00	1.94	1.56
AC 50-3	2.00	1.71	1.58
AC 50-4	2.00	1.07	1.00
AC 50-5	1.33	1.52	1.77
AC 50-6	1.33	1.42	1.44
AC 50-7	1.00	1.36	1.31
AC 50-8	1.67	1.96	1.86
AC 50-9	1.33	1.53	1.39
AC 50-10*	2.00	2.02	2.13
AC 50-11	2.00	1.41	1.07
AC 50-12*	2.33	1.91	2.06
AC 50-13	1.33	1.15	1.11
AC 50-14*	2.00	2.46	2.27
AC 50-15	1.33	2.20	1.71
AC 50-16*	2.33	2.74	2.44
AC 50-17*	2.00	1.90	2.08
AC 50-18	1.33	1.32	1.33
AC 50-19	2.00	1.55	1.50
AC 50-20	3.00	1.44	1.61
AC 50-21*	2.67	2.57	2.41
AC 50-22	1.67	2.03	1.75
AC 50-23	1.00	1.12	1.20
AC 50-24*	3.00	2.23	2.10
AC 50-25	1.33	1.16	1.32
	M = 1.82	M = 1.76	M 1.68
	σ = .53	σ = .47	

r = .473

*Graduated with honors

GRADE POINT AVERAGES

ELECTRICAL ENGINEERING GRADES 1950

STUDENT	GPA ENGR DRAW	GPA MAJOR ENGR WORK	GPA TOTAL COLLEGE WORK
EE 50-1	2.00	1.88	1.77
EE 50-2	2.00	1.64	1.55
EE 50-3	2.33	1.69	1.70
EE 50-4*	2.00	2.78	2.56
EE 50-5	2.67	1.96	1.73
EE 50-6	2.00	1.53	1.87
EE 50-7	2.00	1.23	1.22
EE 50-8	2.00	1.57	1.50
EE 50-9	2.00	1.66	1.78
EE 50-10*	1.67	2.28	2.10
EE 50-11	1.67	1.65	1.59
EE 50-12	1.67	1.38	1.32
EE 50-13	1.33	1.76	1.70
EE 50-14	1.67	1.41	1.58
EE 50-15	2.00	2.02	1.93
EE 50-16	1.33	1.83	1.64
EE 50-17	0.67	0.89	1.04
EE 50-18	1.67	1.58	1.71
EE 50-19	1.00	1.08	1.10
EE 50-20	1.33	1.50	1.45
EE 50-21	2.33	1.98	1.82
EE 50-22	1.33	0.86	1.28
EE 50-23	2.00	1.57	1.59
EE 50-24	1.33	1.24	1.38
	M=1.75	M=1.62	M 1.63
	σ= .44	σ= .45	

r= .706

*Graduated with honors

GRADE POINT AVERAGES

ELECTRONICS AND RADIO ENGINEERING - 1950

STUDENT	GPA ENGR DRAW	GPA MAJOR ENGR WORK	GPA TOTAL COLLEGE WORK
EL 50-1	1.67	1.13	1.14
EL 50-2	2.67	2.00	1.75
EL 50-3	2.67	1.30	1.21
EL 50-4	2.33	1.91	1.78
EL 50-5*	3.00	2.14	2.20
EL 50-6	2.33	1.47	1.40
EL 50-7	2.00	1.73	1.75
EL 50-8*	3.00	2.05	2.10
EL 50-9	1.67	1.56	1.33
EL 50-10*	3.00	2.52	2.02
EL 50-11	1.67	1.12	1.26
EL 50-12	1.33	1.42	1.32
	M = 2.25	M = 1.70	M 1.60
	σ = .57	σ = .42	

*Graduated with honors

GRADE POINT AVERAGES

MECHANICAL ENGINEERS - 1950

STUDENT	GPA ENGR DRAW	GPA MAJOR ENGR WORK	GPA TOTAL COLLEGE WORK
ME 50-1	1.00	1.13	1.07
ME 50-2	1.33	2.28	1.60
ME 50-3	2.00	1.78	1.38
ME 50-4	1.00	1.44	1.24
ME 50-5	1.33	1.71	1.32
ME 50-6	1.33	2.52	1.74
ME 50-7	2.00	2.04	1.88
ME 50-8	1.67	1.58	1.26
ME 50-9	1.67	1.99	1.48
ME 50-10	2.00	2.02	1.67
ME 50-11	1.33	2.10	1.45
ME 50-12	2.33	2.41	1.94
ME 50-13	1.33	1.43	1.33
ME 50-14	1.33	2.04	1.86
ME 50-15	2.00	2.02	1.44
ME 50-16	1.00	1.76	1.50
ME 50-17*	2.33	2.37	2.00
ME 50-18	2.00	2.26	1.84
ME 50-19	2.00	2.16	1.95
ME 50-20	1.67	1.52	1.32
ME 50-21	1.67	1.91	1.39
ME 50-22	2.00	1.40	1.30
ME 50-23	1.33	1.17	1.17
ME 50-24	2.33	2.34	1.80
ME 50-25	2.00	1.80	1.56
ME 50-26	1.67	2.04	1.83
ME 50-27	1.00	1.82	1.42
ME 50-28	1.00	1.91	1.51
	M=1.63	M=1.89	M 1.55
	σ= .43	σ= .38	

*Graduated with honors

GRADE POINT AVERAGES

AERONAUTICAL ENGINEERING - 1952

STUDENT	GPA ENGR DRAW	GPA MAJOR ENGR WORK	GPA TOTAL COLLEGE WORK
AERO 52-1	2.00	1.37	1.24
AERO 52-2	1.00	1.59	1.18
AERO 52-3	1.67	1.34	1.18
AERO 52-4	2.00	1.82	1.86
AERO 52-5	2.67	1.97	1.54
AERO 52-6	1.33	1.05	1.05
AERO 52-7	3.00	2.32	1.95
AERO 52-8	2.67	2.06	1.62
AERO 52-9	2.00	1.47	1.25
AERO 52-10	0.67	1.16	1.00
AERO 52-11	1.67	1.65	1.40
AERO 52-12	2.33	1.76	1.33
AERO 52-13	2.33	1.96	1.63
AERO 52-14	2.67	1.81	1.83
AERO 52-15	2.00	1.77	1.47
	M = 2.00	M = 1.74	M = 1.44
	σ = .63	σ = .35	

GRADE POINT AVERAGES

AIR CONDITIONING AND REFRIGERATION ENGINEERING

1952

STUDENT	GPA ENGR DRAW	GPA MAJOR ENGR WORK	GPA TOTAL COLLEGE WORK
AC 52-1*	3.00	2.56	2.50
AC 52-2	1.33	2.26	1.98
AC 52-3*	3.00	2.14	2.36
AC 52-4	2.67	1.78	1.62
AC 52-5	2.00	1.48	1.57
AC 52-6	2.00	1.76	1.49
	M=2.33	M=2.00	M=1.92
	σ= .61	σ= .34	

*Graduated with honors

GRADE POINT AVERAGES

ELECTRICAL ENGINEERING - 1952

STUDENT	GPA ENGR DRAW	GPA MAJOR ENGR WORK	GPA TOTAL COLLEGE WORK
EE 52-1	2.67	1.90	1.63
EE 52-2*	1.33	2.55	2.18
EE 52-3	2.00	1.33	1.28
EE 52-4	2.00	1.29	1.28
EE 52-5	1.00	0.96	1.37
EE 52-6	1.33	1.26	1.30
EE 52-7	1.67	1.34	1.53
EE 52-8	1.67	1.82	1.93
EE 52-9	1.67	0.73	1.00
EE 52-10	1.33	1.14	1.16
EE 52-11	2.00	1.09	1.48
EE 52-12	2.00	1.92	1.95
EE 52-13	1.00	1.28	1.86
EE 52-14	1.00	1.36	1.41
	M=1.62	M=1.43	M=1.52
	σ= .46	σ= .45	

*Graduated with honors

GRADE POINT AVERAGES

ELECTRONICS AND RADIO ENGINEERING - 1952

STUDENT	GPA ENGR DRAW	GPA MAJOR ENGR WORK	GPA TOTAL COLLEGE WORK
EL 52-1	2.33	1.64	1.94
EL 52-2	0.67	1.29	1.37
EL 52-3	1.67	1.38	1.50
EL 52-4	2.33	1.16	1.21
EL 52-5	1.67	1.40	1.30
EL 52-6	2.00	1.86	1.91
EL 52-7	1.33	1.59	1.55
EL 52-8	1.67	1.33	1.35
EL 52-9	1.33	1.43	1.45
EL 52-10	1.00	1.50	1.40
EL 52-11	1.33	1.81	1.84
EL 52-12*	2.33	2.30	2.19
EL 52-13	2.00	2.08	1.92
EL 52-14	2.00	1.36	1.25
EL 52-15	0.50	1.00	1.03
EL 52-16*	3.00	2.34	2.16
	M=1.70	M=1.58	M=1.59
	σ= .64	σ= .39	

*Graduated with honors

GRADE POINT AVERAGES

MECHANICAL ENGINEERING - 1952

STUDENT	GPA ENGR DRAW	GPA MAJOR ENGR WORK	GPA TOTAL COLLEGE WORK
ME 52-1*	2.00	2.28	2.04
ME 52-2	1.67	2.19	1.87
ME 52-3	1.67	1.28	1.20
ME 52-4*	2.67	2.45	2.47
ME 52-5	2.33	2.28	1.92
ME 52-6	1.00	1.83	1.33
ME 52-7	1.00	1.11	1.38
ME 52-8	1.33	1.49	1.33
ME 52-9	1.33	1.56	1.23
ME 52-10	1.67	1.54	1.42
ME 52-11*	2.33	2.20	2.13
ME 52-12*	2.33	2.32	2.32
ME 52-13	1.67	1.95	1.73
ME 52-14*	1.67	2.10	2.06
	M=1.76	M=1.90	M=1.74
	σ= .49	σ= .41	

*Graduated with honors