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The influence of learning packages and independent study

on student achievement in engineering graphics

by

Arvid Ray Eide

A Dissertation Submitted to the

Graduate Faculty in Partial Fulfillment of

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INTRODUCTION

Background Information

The Department of Engineering Graphics at Iowa State University is a service department in the College of Engineering that teaches a number of courses related to graphic communication. Although the department's total responsibility includes different courses, its primary goal and major emphasis is the instructional responsibility for Engineering Graphics. The department teaches all engineering students a two-quarter sequence of drawing and design that is required by the college for graduation in an engineering curriculum.

Engineering students who attend the university are either transfer students or secondary school graduates. If the student is entering at the freshman level certain requirements are expected as established by the university as well as by the College of Engineering. For example, a required number of units in English, mathematics, physics and chemistry are necessary to begin an academic program as a first quarter freshman. University policy grants unrestricted admission to any student in the top fifty percent of his graduating class, but in point of fact, the average student in engineering is in the top 15 to 20 percent of his graduating high school class.

Most entering students have been exposed to many of the

required first year subjects prior to enrollment at the university. English, mathematics, physics and chemistry, as mentioned above, are typical examples of courses that entering freshmen have taken as secondary school students in preparation for one of the engineering disciplines.

The majority of students who begin a program of study have received little training in graphics prior to enrollment. Department statistics show that approximately fifty percent of all students have received no form of training whatsoever, whereas about thirty percent have received one semester of mechanical drawing in eighth or ninth grade. The remaining twenty percent come to Iowa State with various amounts of secondary school exposure to the subject area, but less than one percent exhibit a level of technical competence sufficient to pass a "test-out" examination that is available to all students.

These facts would seem to indicate that the majority of students have had little exposure to the area of graphic communication, but that they are well qualified academically to obtain that training without a great deal of difficulty.

All students, with the exception of those who try the "test-out" examination and pass, are expected to begin the graphics sequence with a first quarter course in fundamentals.

Basic Course

Engineering Graphics 161 is the basic course of a two-quarter sequence required for all students. It is a three credit course that meets three times each week for two hour combination lecture-laboratory periods.

Students enrolled in conventional sections are scheduled to attend each of these three periods every week. Since students are expected to spend approximately three hours for each credit hour received, additional work is expected outside of the regularly scheduled six class hours.

Students are required to purchase a textbook, problems book, and various components of drawing equipment prior to the first class meeting.

Faculty members are assigned sections which, on the average, range from 18 to 22 students. Both students and faculty are assigned to individual sections on a random basis.

All instructional faculty who teach the basic course use a departmental syllabus. This policy insures that uniform and consistent reading and problem assignments are followed by all sections. Various other departmental policies relating to topics such as attendance, make-up work, examinations, and grading also provide uniformity and consistency among the many sections.

The instructional pedagogy used by the different faculty members does vary. Due to the reasonably stable content of the basic course, however, a number of closed-circuit television tapes have been prepared over the past five years. Each classroom in the department is equipped with four television receivers that can be operated according to a pre-arranged playback schedule. The facility in this way provides any individual instructor the option of using a prepared closed-circuit program in the classroom if he so desires.

In addition to the TV facility there is also an overhead projector permanently installed in each classroom. It is mounted in the instructor's table at the front of the room and provides almost instant accessibility. This projector, coupled with a large amount of blackboard space, provides the classroom teacher a number of different instructional techniques.

An instructor in a typical classroom usually starts the period by presentation of new or critique and review of old material. He may solve a number of example problems aided by some form of graphical media or model.

A typical lecture would be 20 to 30 minutes in length, although it is not uncommon for some to extend considerably past that length of time.

Once the formal lecture is concluded the students are

assigned a number of problems to reinforce the topic area. Departmental policy encourages the student to remain in the laboratory until the end of the class period at which time a problem may be picked up for evaluation.

If a student is absent during a scheduled period he is expected to make up the work and submit late problems to the instructor. Departmental policy regulates the reduction in the grade he received based on his reason for absenteeism.

Daily problems or out-of-class home assignments that are collected for evaluation are typically graded and returned to the student the following period (48 hours). Many times, however, the topic area will have changed or the faculty member may not have finished the problem evaluation in time to return the graded assignment the next period, thus causing an additional delay in solution feedback.

Once the formal class lecture is complete the instructional staff members are then available for individual student help and direction. The amount of additional help required depends on the number of questions the individual students have regarding the problem assignments.

Need for the Study

There are several reasons that might suggest an in-depth

study directed specifically at the beginning or basic course in graphics.

Students entering the College of Engineering typically exhibit a high level of performance in most academic subject areas, as mentioned earlier. This would indicate an above average ability to comprehend moderate levels of technical materials. The problem is, however, many students come to the university with little, if any, training in the manipulative area of graphics. Since entering abilities and prior exposure differ it is logical to expect a variation in the amount of work done per unit time by any given student.

Another area of concern develops immediately after a student has enrolled in the engineering college. That problem is attrition. It is understandable and equally advisable that students with other interests or aptitudes leave the College of Engineering, but it is most important that the remaining students maintain a positive attitude regarding any engineer- ing related subjects that are taken during their freshman year.

Still another problem that will be a continuous source of reassessment is that of accountability. Since faculty sal- aries consume by far the largest percentage of expenditures it is logical to optimize faculty time while continuing to main- tain a predetermined standard of excellence.

With these areas of concern in mind it was believed that a system of instruction could be devised that might improve the existing method of teaching the fundamentals of graphics. The design would capitalize on a number of different instructional methodologies.

The concept of individualized instruction has a number of desirable features. Students could be allowed more latitude in completion of problems, differences in prior training could be accounted for, make-up work, supplemental assignments, individual help, as well as other benefits could be incorporated.

The utilization of television as a media to present graphic concepts, and yet retain the lecture for continued use on video tape should be considered. Television affords the opportunity of providing a well prepared yet concise presentation in many subject areas. This is particularly true in the graphics subject area because of problems in spatial relations and the difficulty associated with their visualization. It also suggests other possibilities, such as allowing students to play back programs at various times, repeating areas of study that caused some degree of difficulty, advancing at an accelerated rate, and others.

Another area that could be partially used to an advantage is the idea of prepared learning packages. These educational activity packages complement the areas of individualized in-

struction and use of audio-video instructional media.

Statement of the Problem

This study was designed to investigate and evaluate the effectiveness of an alternate method for teaching a course in the fundamentals of graphics. The technique combines prepared learning packages, audio-video television tapes, instant feedback, as well as an individualized approach to student learning.

The ultimate goal of the study was to determine if the combined approach might provide a positive result in the teaching of spatial, mental, and manipulative skills.

Secondary in concern, but areas of consideration, were questions regarding the attitude of the student after completion of the course, and also the feasibility of a more economical approach. In order to accomplish these goals it was necessary to:

(1) Plan and develop the learning packages which included the production of audio-video television tapes necessary to teach the basic course.

(2) Design an experiment in which a number of control students were assigned to conventional classes and other students were assigned to sections that would receive the experimental treatment.

(3) Develop instruments to measure entering and terminal performance of the control and experimental participants.

(4) Prepare an instrument capable of indicating the attitude of those students receiving exposure to the experimental treatment, not as a comparison, but as an indication of positive or negative feeling.

Objectives

The objectives of this study stated in general terms would be as follows:

(1) To determine if students who receive instruction by a combination of modules, audio-video tapes, and individualized instruction perform as well as students who receive instruction in a conventional manner.

(2) To investigate interrelations and correlations between entering and terminal variables.

(3) To determine if a performance predictability relationship exists between selected entering variables and terminal performance.

(4) To obtain a quantitative measure of attitude from students receiving the experimental treatment.

(5) To compare attrition from experimental sections with control and departmental statistics.

(6) To study the economic aspects and discuss the possibility of implementation on a larger scale.

Sources of Data

The collection of data for this study can be broken into three primary areas.

First, there are the independent variables that must be collected for both the experimental and control sections. These variables are necessary to more accurately determine the entering characteristics of all students who have been randomly selected for the study.

Six such variables were used and each is listed and briefly described below. The first four were measures obtained prior to enrollment in the course, while the last two were collected at the beginning of the course.

X_1 - High School Rank (HSR)   All students who apply for admission to Iowa State are required to submit an official transcript of their high school grades. This document indicates their percentile score relative to other members of that class. A low percentile rank indicates a high class standing.

X_2 - American College Testing Program (ACT)   The office of Admissions and Records expects each freshman enter-

ing the university to present an ACT score when he applies for admission. A student normally takes this test during his senior year in high school. It is a composite achievement score including English, reading comprehension, natural science and mathematics.

X_3 - <u>Minnesota Scholastic Aptitude Test (MSAT)</u>   This test is a composite score obtained from three sub-tests; reading comprehension, vocabulary, and verbal analogies. Students take this test on campus either during the summer or fall orientation.

X_4 - <u>Mathematics</u>   This test is designed to measure the student's ability to handle fundamental operations in arithmetic, algebra, trigonometry, and geometry.

X_5 - <u>Pre-Test</u>   This examination was designed to measure the student's entering level of knowledge in graphics. It was administered at the first class meeting, and each student was given as much time as required to provide answers to as many questions as possible.

X_6 - <u>Prior-Graphics</u>   Each student was asked to provide a chronological listing of all drawing or graphic related courses taken prior to enrollment in Engineering Graphics 161. With this information was included a statement regarding when the courses were taken and the grade that was received. This information was collected as part of the pre-test.

The second area involved a collection of data describing the dependent variables. These measures of performance were collected for all students participating in both the experimental and the control groups.

Y_1 – <u>Mid-Term Examination</u>   This measure was a two-hour examination that covered all work from the beginning to approximately midway through the quarter. It is a departmentalized series of examinations that are taken by all students enrolled in the basic course.

Y_2 – <u>Post-Test Examination</u>   This examination is given during final week and covers work for the entire quarter. It also is a two-hour departmentalized test.

Y_3 – <u>Course Grade</u>   This measure indicates a student's overall performance. It includes items such as daily work, quizzes, progress grades, etc. It is a measure of total combined performance.

A third area that provided a meaningful measure was the attitudinal survey. This instrument was completed by all students in the experimental sections at the end of the quarter. In order that it might include candid opinions the questionnaire was completed and submitted anonymously.

Hypotheses to be Tested

In addition to the statistical hypotheses that must be

stated and tested there are three important questions that require attention.

Question-1 Does the course design and methodology contribute to a positive attitude regarding the subject matter and its relation to the engineering discipline?

Question-2 Will the number of students who drop the course due to its structure and instructional methodology be less?

Question-3 Is the system financially economical, and would it be possible to extend the concept to a larger number of students?

The hypotheses to be formulated and tested in the statistical analyses of this study can be broken into four areas.

The Null Hypotheses in Regard to the Independent Variables

The following are detailed statements of the null hypotheses tested in regard to the six independent variables.

1. There is no significant difference between the mean HSR scores of the experimental group and the control group.

2. There is no significant difference between the mean ACT scores of the experimental group and the control

group.

3. There is no significant difference between the mean MSAT scores of the experimental group and the control group.

4. There is no significant difference between the Math scores of the experimental group and the control group.

5. There is no significant difference between the mean Pre-test scores of the experimental group and the control group.

6. There is no significant difference between the mean Prior-Graphics scores of the experimental group and the control group.

The Null Hypotheses in Regard to the Dependent Variables

The following null hypotheses were formulated and tested in regard to the dependent variables (examinations).

1. There is no significant difference between the mean scores of the experimental group and the control group on the mid-term examination.

2. There is no significant difference between the mean scores of the experimental group and the control group on the post-test.

3. There is no significant difference between the mean

scores of the experimental group and the control
group on the course grade.

The Null Hypotheses in Regard to a Factorial Analysis

The following set of null hypotheses were formulated and
tested in regard to a number of two-factor analyses. The
scores on all six independent variables were compared to
scores obtained on dependent measures.

For example, there are three null hypotheses for each of
six independent variables in relation to the mid-term examina-
tion.

Scores on the mid-term examination were either from the
experimental group or the control group which will be re-
ferred to as Factor A. Each independent variable was divided
at the median score into a high and low category called Factor
B. This basic design is illustrated in Figure 1 below.

| | | Factor A | |
		Experimental (a_0)	Control (a_1)
Factor B	High (b_0)	$a_0 b_0$	$a_1 b_0$
	Low (b_1)	$a_0 b_1$	$a_1 b_1$

Figure 1. The basic design of the two-factor design

To illustrate one set of null hypotheses from the eighteen sets tested the mid-term examination (Factor A) and the high school rank (Factor B) shall be used.

1. Mid-Term Examination and HSR Null Hypotheses

   1.1 There is no significant difference between the groups (Factor A) when the group mean scores on the criterion variable (Mid-Term) are compared.

   1.2 There is no significant difference between the two levels of Factor B when the group mean scores on the criterion variable (Mid-Term) are compared.

   1.3 There is no significant interaction between the groups (Factor A and Factor B) when the group mean scores on the criterion variable (Mid-Term) are compared.

There would be five other sets of hypotheses for each of the remaining independent variables and then six more sets each for the other two dependent variables. This makes a total of eighteen sets of null hypotheses for the two-factor analysis.

The Null Hypotheses in Regard to a Multi-regression Analysis

The remaining null hypotheses to be formulated and tested were in relation to the significance of independent variables as a measure of predictability in a multi-

regression analysis.

    1. There will be no significant contribution of any individual regression coefficients or any combination of regression coefficients in the determination of a predictability equation on course grade.

Limitations

Limitation placed on the study resulted from two different situations. First, since all students were computer assigned to sections it was inevitable that a number of non-engineers, non-freshman engineers, and also foreign students would be scheduled into both control and experimental sections. These students were allowed to remain in their respective sections, although they were not included in the statistical results. This point becomes significant when generalization of results are considered.

A second limitation placed on the study was the number of students who could participate. This resulted from equipment restraints such as the number of audio-video playback machines, tapes, receivers, etc.

REVIEW OF LITERATURE

Introduction

In an article written for "Education Research" a number
of years ago J. P. Powell (17) made this statement:

> "The activities of teaching, learning and examining
> in all areas of higher education have received remark-
> ably little attention from experimentalists. The idea
> that a belief stands in need of empirical support is
> often met with incredulous opposition. Men whose ac-
> ademic work is based upon rigorous testing of accepted
> ideas, tend to think it somehow indecent to apply some
> standard of inquiry to their own teaching and examin-
> ing practices. As a consequence, only a tiny minority
> ever bother to acquaint themselves with existing re-
> sults that are available."

A search of past and present literature reveals that
there has been a large amount of time and energy expended in
areas that are related to or classified as instructional in-
novation. Unfortunately, many of the results that are pub-
lished present only the idea, instrumentation, and methodol-
ogy used. Conclusions are drawn prior to some meaningful
evaluation of the original intent.

This illustrates the necessity of following some logical
procedures in the development of a research design. It pro-
vides direction to a sequence of events that produces meas-
urable results.

Literature that is written void of these procedures must
certainly be categorized as educational and informative, but

conclusions must be carefully considered.

This review will cite a number of instructional methods presenting various degrees of opinion and measured outcomes. It is, therefore, obvious that care should be exercised in generalizing unsubstantiated results.

Development of Personalized Instruction

The entire thrust of this study encompasses a number of different areas. Concepts such as closed-circuit television, learning packages, feedback and self-paced study are all secondary, however, to the more central theme of a personalized system of instruction.

The actual inception of much work being done today at the college level in personalized instruction began in early 1960's. An idea developed by Fred S. Keller and presented in an article written in 1965 entitled "Good-Bye, Teacher....." (11) was the spring board of much activity that followed.

Keller applied a new method of teaching students enrolled in a first-semester course of General Psychology at Arizona State University.

It was a course through which the students could move, from start to finish, at their own pace. Any particular individual would not be held back by other students or forced to go ahead until he was ready. The student might meet all

the course requirements in less than one semester, or more than one semester. How fast the student elected to go was his decision.

The work for the course had been divided into thirty units of content. Each unit was to be taken in a definite numerical order, and the students must show their mastery of each unit by passing a preparatory test or carrying out an experiment before moving on to the next unit.

Lectures and demonstrations of various types were presented and available to those that wished to attend. Examination material, however, was based on content presented totally aside from these lectures and laboratory demonstrations so attendance was not compulsory.

The teaching staff for the course included proctors, assistants and an instructor. The proctor was an undergraduate who had been carefully chosen. It was this individual's job to provide the students with study materials and also review all preparatory tests. Failure of a student to pass any given test on the first try, the second, the third, or even later would not be held against him.

All laboratory work was supervised by a graduate assistant. His responsibilities also included helping proctors with problems and questions that might have been too difficult for undergraduate students.

The instructor had as his principal responsibilities: (a) the selection of all study material used in the course; (b) the organization and mode of presenting the material; (c) the construction of preparatory tests and examinations; and (d) the final evaluation of each student's progress.

All students in the course were expected to take a final examination, in which the entire term's work was represented. With certain exceptions, the final examination came at the end of the term. Twenty-five percent of the student's grade was based on this final examination and the remaining seventy-five percent was based on the number of units of reading and laboratory work successfully completed.

In summarizing, those features that seem to distinguish Keller's approach most clearly from more conventional teaching procedures would be as follows:

(1) The go-at-your-own-pace feature which permits a student to move through the course at a speed commensurate with his ability and other demands upon his time.

(2) The unit-perfection requirement for advance, which lets the student go ahead to new material only after demonstrating mastery of that which preceded.

(3) The use of lectures and demonstrations as vehicles of motivation, rather than sources of critical in-

formation, and finally,

(4) The use of proctors, which permits repeated testing, immediate scoring, almost unavoidable tutoring, and a marked enhancement of the personal-social aspect of the educational process.

At approximately the same time Keller was developing and testing his ideas at Arizona State University Samuel Postlethwait et al. (18) was investigating a different approach to individualized learning at Purdue University. His idea was simply to place the emphasis on student learning rather than on the mechanisms of teaching. This method, which he called an integrated experience approach, required that the instructor first identify as clearly as possible those responses, attitudes, concepts and manipulatory skills that were to be achieved by the students.

The term "integrated-experience" was derived from the fact that a wide variety of teaching-learning experiences were integrated, with provision for individual student differences. Each experience was planned to present some important aspect of the subject. The program of learning itself was to be organized in such a way that the student could proceed at his own pace within prescribed limits. This technique was to allow students with various backgrounds and different levels of entering exposure to the subject material to fill in gaps

of information or omit portions that had been covered at a
previous time.

The inception of the integrated experience system first
started when Postlethwait prepared a number of audio tape re-
cordings to supplement his freshman biology classes at Purdue.
As student response to various instructional aids continued to
provide positive feedback additional items were added through-
out the semester. Response was so favorable to this supple-
mental material that it was decided to set up an experimental
section. The members of this experimental group received much
of their instruction by audio tape, although they did meet
with their instructor once a week to take quizzes and form
discussion sessions.

With continued experimentation Postlethwait developed his
approach to student learning into what he called four study
sessions.

1. Independent study session (ISS)

2. Small assembly session (SAS)

3. General assembly session (GAS)

4. Home study session (HSS)

The independent study session is a learning center
equipped with individual booths and under the constant super-
vision of an instructor. The student should be able to come
and go at his convenience, pacing his study to suit his abil-

ity and his other work schedule. Subject matter is presented
on a weekly basis terminated when the individual student feels
he has mastered the material. At this time the student takes
an oral quiz.

The small assembly sessions brings together a small num-
ber of students with an experienced discussion leader. It is
a scheduled session that meets each week. Occasionally this
time is used for testing, but it is also used for group activ-
ities, such as short field trips, problem analysis, single
concept films or any other activities that are well suited to
small group assemblies.

The general assembly session is intended to bring all
students enrolled in the course together in an auditorium one
hour per week on a scheduled basis. The major professor in
charge of the course normally conducts this session. The
hour assembly may include general directions and announce-
ments, long movies, guest lectures and other items of impor-
tance. A major effort of this session is directed toward mo-
tivation.

The fourth of Postlethwait's study sessions was that of
home study. The three previous sessions described were not
intended to replace the usual amount of outside study ex-
pected in a conventional course. Textbooks, notes, supple-
mentary reading and homework problems are typical examples
of the activities expected in this phase of Postlethwait's

"integrated-experience".

Keller and Postlethwait, with these two courses, established the foundation for a wide range of experimentation related to personalized instruction.

Instructional Systems and Material

Before additional examples are reviewed it would be appropriate to discuss in brief the work of Stuart and Rita Johnson (9). They have been active in the development of individualized instructional material, and have written a number of articles, as well as a book outlining an approach to the organization and preparation of such material.

To begin, the Johnsons divided the development of individualized material into a series of steps.

The first of these steps required that the course objectives be specified and analyzed. The two forms of analysis suggested are by types of behavior and by task analysis.

By task analysis the author suggested that the general course objectives be broken down into a series of sub-tasks. These sub-tasks will be more completely specific and, therefore, more meaningful.

Types of behavior can also be subdivided into domains; psychomotor, affective and cognitive.

The psychomotor classification scheme describes muscular responses at five levels of complexity: perception, set, guided response, mechanism, and complex overt response. Elizabeth Simpson (22) has an extensive analysis regarding performance of responses requiring muscular coordination.

The affective domain has been divided into five classes: receiving or attending, responding, valuing, organizing, and characterizing behavior. David Krathwohl (13) outlines in detail the problems that can appear by ignoring the attitudes and feelings of the learner.

Benjamin Bloom (3) classifies the cognitive category into six classes: knowledge or memory, comprehension, application, analysis, snythesis, and evaluation. This classification is arranged in terms of complexity. Its chief value to instruction is in helping to call the instructor's attention to a more complex set of objectives than mere memorization and recall.

The next step, once the instructional objectives are correctly formulated, is to establish the necessary criterion measures in order to distinguish minimum performance standards. Johnson insists that these instructional units must be incorporated into a logical design and that all specifications be carefully examined before what is actually needed by the instructor and the learner can be accurately determined.

Johnson also pointed out that any commitment to the method of instruction or media involved should be rigorously avoided until the objectives and criterion measures have been completely analyzed.

Next, in the sequence of events, is the actual design of the self-instructional package. This requires an extensive materials search followed by careful consideration of the types of media that will provide positive results.

The actual content of the self-instructional lesson should be centered around one unit of instruction only, and the characteristics of such a lesson are:

1. It can integrate several forms of material such as films, slides, filmstrips, etc.

2. It is self-contained.

3. It may be stored and used repeatedly.

4. It is individualized in that the student can take the lesson at his own convenience, proceed through a series of lessons at his own pace, and modify the sequence and/or content of instruction, depending on his needs and abilities and

5. The last, but an important characteristic, is the human portion of the system which consists of an instructor interacting with students, either individually or in small discussion groups.

Extending these ideas further, Banathy (2) demonstrates the use of a systems approach in the development of instructional material.

He points out that the nucleus of a system for learning is its purpose. It is purpose from which system objectives can be derived. Based on these objectives, the designer must determine whatever has to be learned in order to insure the attainment of objectives.

Next, states Banathy, the input competence of the learner must be assessed in order to see if he has already acquired capabilities that are relevant to his learning task. The differential analysis of learning task as opposed to input competence provides a set of actual learning tasks.

Only after these actual learning tasks have been identified and characterized can the system be designed. It is at this point that the designer must assign specific functions to specific components. He must, simultaneously, consider constraints and limitations of the overall system and optimize input to achieve the best possible output within the least possible time at the lowest possible cost. Decisions made on this basis lead to the design of an entire system of instruction.

Finally, feedback gained from output testing and system monitoring can be used to introduce adjustments and improvements.

Learning Packages

One concept that was central to Johnson's discussion was the idea of instructional units or packages. These units, sometimes called learning activity packages (LAP) contain a number of key ingredients which are significant to the over-all success of a personalized system of instruction.

Talbert (24) describes activity packages as a unit of in-struction built upon behavioral objectives, and that each package is a series of learning activities designed to enable students to meet those stated objectives. Each package should contain a diverse approach to mode, media, activity and content. Each student then would be able to choose the activity that helps him gain the understanding, knowledge, or skill required.

Talbert points out that a well designed activity package should contain three separate sources of evaluation.

First, the students will bring to the learning situation their own set of abilities, knowledge, and learning styles. This means that a pre-assessment of where he is should be made. It is conceivable that some students can already meet some or all of the objectives.

Second, the students need to be able to make self-assessments which will provide them immediate feedback. This

result produces positive reinforcement and encourages independent study.

The third source of evaluation is assessment of student progress by the teacher. Post-tests need to be administered to demonstrate the student's ability to perform the original objectives.

One study that was designed to test the significance of learning packages was developed by Bruce Meeks (16). The entire scope of the problem involved a number of different areas, but of singular concern to this study was his comparison of learning packages to more conventional methods of instruction.

Meeks used two different treatments in each of three classes. The treatments were: (1) an experimental treatment which used learning packages, and (2) a control treatment which used a conventional method of instruction. The subjects in each class were randomly assigned with all students receiving a pre and post test measure.

In summary, the results showed that the learning packages were significantly better than the conventional method of classroom instruction.

There have been a number of different attempts at developing units of study similar to the learning packages.

Jones (10) discussed a recent research study that was conducted by the American Institute of Research under funding

from Westinghouse. The group developed what are called
"teaching-learning units" (TLUS). These are individualized,
two-week units designed to guide the learner toward the
achievement of specified behavorial objectives.

Another study funded by the Kettering Foundation devel-
oped a self-guiding series of units called "Unipacs". They
are similar to TLUS in that they guide the learner toward a
particular objective.

In summary, it can be said that the development of a
basic unit of instruction designed specifically to meet cer-
tain behavorial objectives is an important consideration in
any system of personalized instruction.

Robert Mager (15) in his book on instructional objectives
illustrates the necessity of organizing a subject into com-
ponent parts as a prerequisite to a complete set of objectives
detailing exactly what is to be accomplished. In fact, in
many situations it is necessary to define those objectives so
carefully as to specify the level of comprehension to be ob-
tained.

Applications of Personalized Instruction

There have been many studies that are adaptations of the
original work done by Keller and Postlethwait. To illustrate

some of the things that have already been done, this section
will emphasize a review of examples that can be cited from
some of the physical sciences.

There is most certainly a need to individualize instruc-
tion in areas such as engineering, physics, etc., and to ac-
centuate this point Harrisberger (6), who was Head of Aero-
space and Mechanical Engineering at Oklahoma State University,
described self-paced instruction as the most revolutionary
concept in the past four thousand years.

He believes that to develop an effective self-paced
course one must start by first constructing "a hierarchy of
behavorial objectives". In other words, the entire course
structure should be divided into a group of minicourses or
units with each unit having a clearly stated objective. Fur-
ther more, these objectives must be described in performance
terms, each indicating what the student must do and how that
performance can be observed and measured.

Harrisberger illustrates by an analogous situation how
he parallels self-paced instruction with the successful
achievement of merit badges in the following paragraph:

> "To get the Eagle merit badge (A grade), a Scout has
> to demonstrate competence in 21 merit badges (mini-
> courses). Each merit badge has an instructional
> manual describing what the Scout must be able to do
> (performance objectives). It outlines practice and
> suggests ways to get help, emphasizing the practice
> exercises to do and the standards that have to be
> met when the Scout tries for a badge (competency

test). This system is total self-study.

> The Scout can get all the help he wants from any-
> one. He can take as long as necessary to get ready,
> and he can take the test when he thinks he can pass
> it. He can take the test over again until he can
> do it right, and he can take the test for as many
> badges as he is competent to earn, any time he is
> ready."

Harrisberger also suggests the necessity of flow chart-

ing activities to assure that first things are learned first.

This proper sequencing with carefully prepared objectives pro-

vides a solid base for course development.

Dr. Harrisberger continued by suggesting that a student

in completing a learning activity package should be provided

as many self-study aids as possible. In this way students

with different levels of ability or prior exposure can be

more totally accommodated.

The author's reaction to the idea that students taking a

course at their own pace with no scheduled classes will soon

degenerate to chaos and procrastination is quoted as follows:

> "This could possibly happen if the instructor does not
> pay attention to his role of programmer, counselor,
> manager, and chaplain."

In summary, Harrisberger lists a number of opportunities

and benefits as he sees them from the student's point of view.

1. The student can pretest through the course hierarchy

   until he reaches his level of proficiency. That is,

   he can begin where he is ignorant.

2. He can move at his own pace, with unlimited opportunity to practice and develop the skills required.

3. He can test his competency at any time and as often as he needs with immediate diagnostic feedback.

4. He has more opportunity for personal contact with his professor.

5. He is graded on the basis of achievement only.

6. It is a no-fail learning environment, with no penalty for not achieving. It is success-oriented, ego-building, morale-boosting and attitude enhancing.

Another individual that has done a considerable amount of work in the area of personalized instruction is Bill Koen (12). He developed a senior level nuclear engineering course at the University of Texas that was patterned after Keller's original design. His method, also called PSI (personalized system of instruction), divided the course material into units. Each unit contains a reading assignment, study questions, references, problems, and other necessary introductory material.

The student studies the units sequentially at the rate, time, and place he prefers. When he feels he has mastered the material, a proctor gives him a "readiness test" to see if he may proceed to the next unit. This proctor is a student who has been carefully chosen for his mastery of the

course material. If the student does not successfully complete the test, he is told to restudy the unit more thoroughly. Each time a student comes to be tested he receives a different test form. No matter how many times a student is required to retake a unit, his grade is not affected. All students who complete the course receive an A grade.

An attitudinal questionnaire was completed by the students in Dr. Koen's nuclear engineering class. The response to this self-paced course was highly favorable.

Koen suggests that PSI is successful because it is built upon well-established principles of learning theory. That is, students tend to repeat and enjoy behavior for which they are rewarded (i.e., positive reinforcements). They, likewise, tend to avoid and dislike behavior for which they are punished (i.e., negative reinforcements). PSI has been carefully "designed" so that a student is only positively reinforced - that is, he passes units, attends lectures, and is never penalized for not passing an exam.

Lord and Work (14), two members of the staff at Michigan Technological University, developed a course of self-paced study in statics and dynamics. Students enrolled in this program received instructions on the use of a programmed text and other information regarding the conduct of the course at their first class meeting. The students, at

this time, were provided a list of instructors' office hours
which were so arranged that every student had the opportunity
to see an instructor regularly for tutorial purposes.

The subject matter in the course was divided into units.
Quizzes were developed to test the student on each unit. A
score of eighty percent or higher was required before the
student was allowed to proceed to the next unit. If the stu-
dent received below eighty, or if he was not satisfied with
his quiz score, he could ask to be retested. The final grade
in the course was based on a weighted average of grades from
the last score on each unit quiz and the final examination.
Each student must have completed satisfactorily quizzes on
all units before being admitted to the final. Any student
who did not complete the course could continue without pen-
alty the following quarter.

Lord and Work agree that the primary advantage of self-
paced study is to allow the student to work at his own rate.
They believe that of equal importance is the fact that there
is a one-to-one teacher-student ratio in all interactions the
student has with his instructor.

Paradoxically, however, Lord and Work pointed out that
the particular aspect of self-paced study which gives a dis-
tinct advantage to this method of instruction also contains
its most serious pitfalls; namely, procrastination. A self-
paced course is, by its nature, the one subject that can most

easily be set aside.

Lord and Work found, however, that the majority of their students completed the work on schedule with a considerably higher grade distribution than conventional control sections.

The most significant observation to be made in conducting this self-paced course was the enthusiastic response of the students.

Another study conducted by Schwar and Winter (20) at Lafayette College in Pennsylvania developed a self-study computer programming course which was intended to maintain student interest as well as accomplish certain academic objectives. It was a two-credit, one semester course which employed a number of self-paced concepts. A programmed textbook was used and students were allowed to select either Fortran or Cobol, depending on their area of interest.

There were no formal class meetings except for an introductory lecture explaining the course structure and organization. There were regularly scheduled class hours but the students only attended if they had questions pertaining to the assigned work.

Schwar and Winter divided the course material into four blocks. Each block consisted of a two week time period set aside during which the student presented himself for an oral exam. The students were requested to pace their work during this two week period such that they were ready for examination.

The student, therefore, was free to arrange his study time within each two week block. This did not provide unrestricted flexibility since it did place restraints on completion of the course within a prescribed time period.

Schwar and Winter have found student response and interest to be high, but the time consumed by individual oral examinations was prohibitive.

Avner (1), who is chairman of mechanical technology at New York City Community College, decided to implement a form of self-instruction to students studying metallurgy in that school. Avner believed that students varied in their ability to absorb and understand material presented. He did not believe it was reasonable to expect all students to comprehend at the same rate. Means should be available for self-instruction, so that each student could proceed at his own pace in class preparation or reinforcement and review after the topic had been covered in class. The textbook alone, in this particular situation did not seem very effective because it did not provide adequate and immediate feedback to the students and appealed only to their visual sense.

With these thoughts in mind, Avner developed a series of sixteen programs covering the lecture material in the course. The programs consisted of 35mm slides and a stereo tape recording. One tape track carried the audio portion of the

program, while the other track carried the pulses that in-
dexed the slides. This audio-visual package was placed in
the library with programs and head phones available from the
librarian.

Avner emphasizes that a system of this design allows the
ability of the student to dictate the amount of time spent on
any given topic. The student can stop the tape recorder to
study a particular slide, and he can review selected portions
or the entire program as many times as he wishes.

The author provided results of student evaluations that
indicated a positive response from those that had completed
the course.

Hoberoch (7) who is on the staff in the Department of
Mechanical Engineering at the University of Texas, designed
a junior level course patterned after the PSI methods of
Keller and Koen. The course was entitled "Kinematics and
Dynamics of Machinery", and the fundamental concepts common
to PSI, as discussed earlier, were applied in this situation.

Two primary evaluations were made by Hoberoch. A com-
parison of grades received in the course and a student atti-
tudinal survey. As has been indicated in similar experiments,
the grade distribution was skewed in favor of A's with a
lower percentage of withdrawals. Also, student attitude
seemed positive and favorable. One student said, "This course

is great because for the first time in my curriculum I can take the time to really learn the material."

Hoberoch pointed out that two concepts crystalized very clearly for him as a result of applying the PSI concept of instruction. First, the course becomes better organized and prepared as a result of the instructor formulating his course objectives carefully, and second, many students learn more if a teacher "teaches" less and motivates more.

Related Research

In addition to the many books, articles, studies, and reports that have been published in the area of personalized systems of instruction there is also some pertinent research that needs to be mentioned.

Ratledge (19), a staff member in the Systems-Design Department at the University of Wisconsin - Milwaukee, received funding from the Carnegie Foundation to develop a form of student-paced instruction for freshman in Engineering Graphics. This course was planned and organized following an educational systems design developed by Wales (25).

The course, in its original form, was made up of three major topic areas. The students were provided an outline of reading assignments, and there was a large lecture session

followed by scheduled discussion classes, laboratory problems, surprise quizzes, and major exams.

The first step taken by Ratledge involved only a small number of students enrolled in a summer session. Each student received, in addition to a schedule, a set of objectives for each of eighteen units that subdivided the course. The live lecture was replaced with a tape/slide presentation. The class discussion session was shortened and an exam was prepared to follow each unit.

The next step, after some modification of tape/slide presentations and overhauling of the objectives, was to select two random experimental sections. One was taught as a part of the regular sessions, and the other was taught by the experimental procedure. Comparisons to be made included such items as unit exam grades, major exam grades, and time studies using student kept records.

Ratledge indicated that the experimental section experienced less than two percent failing grades, while the control section had just under thirty percent. On major examinations the two sections showed comparable grade spans and medians except the test section showed fewer failing grades.

The major difference in the two techniques, however, became apparent when the student records of time spent were compared. Results showed that the test section spent about

twenty-five percent less time than students functioning under the normal control situation.

Ratledge explained that the final step in the implementation of this new program was to expand the student-paced concept to the entire freshman class. This involved approximately three hundred students including different members of the instructional staff. The student was offered two options; (1) to progress at his own rate, faster or slower than the schedule, and (2) if the student believed it to be within his own ability, he could take a series of three test-out examinations.

In Ratledge's own words he said:

"The experience of the Systems-Design Department at the University of Wisconsin - Milwaukee shows that the application of the 'systems approach' to student-paced instructional techniques has demonstrated its value. Revised class organization, tape/slide presentations, student objective statements, as well as other ideas, have been applied to a course serving over three hundred students per year. The resulting improvements in grade distribution, time requirements, and cost have been highly satisfactory."

Another area of research that related directly to personalized instruction is many of the audio-tutorial studies that have been conducted. Studies concluded by Green (5), Stuck (23), and Hoffman (8) all indicate a positive reaction where audio-tutorial systems are compared with more conventional methods.

In contrast to this, however, a comparative analysis of

college teaching methods was made by the Center for the Advanced Study of Educational Administration at the University of Oregon. This organization conducted an in-depth study and systematic reanalysis of the data of almost 100 comparative studies of different college teaching methods. The results of this study were discussed by Dubin and Taveggia (4) in a book entitled "The Teaching-Learning Paradox".

This study concluded that there is no evidence of a significant difference in most comparative analysis of different teaching methods. Their point, therefore, was that increased attention should be directed to a cost-benefit analysis as opposed to strictly a teaching-comparative analysis.

If indeed, it could be stated that no differences exist among a wide range of teaching technologies, it would be safe to assume their respective educational benefits are equal.

This, suggests Dubin and Taveggia, could be consideration enough to turn more attention to a cost versus return analysis.

Summary

A review of the literature has illustrated that person-
alized teaching plays an important part in the overall in-
structional system of today's classroom.

The literature also demonstrates that the development of
any instructional system is a complex process involving a
carefully studied sequence of steps.

It is necessary to plan the entire course from beginning
to evaluation and redesign. This process of thoughtful anal-
ysis makes each step a meaningful move toward a more carefully
designed product. Considerable attention to items such as:
objectives, mode, media, feedback, evaluation, etc. has pro-
duced favorable results.

Keller and Postlethwait believed that instructional
systems should be well designed, but with the student's in-
terest considered an important criteria. Their initial work
in personalized systems of instruction has prompted many ed-
ucators to investigate similar programs in adjacent areas.

METHODS OF PROCEDURE

Introduction

The sequence of events necessary to prepare, conduct and analyze this study followed a scheduled timetable. Initial operations, which included preparation and organization of the study, were completed over the summer months of 1972. The collection of data occurred during fall quarter of '72, and the data were analyzed winter quarter of 1973. The study was conducted at Iowa State University in the College of Engineering with the cooperation of the Chairman of the Engineering Graphics Department.

Preparation of Material

The course content for Engineering Graphics 161 is established by the department's curriculum committee. Initially, therefore, it was necessary to ask that committee to prepare a detailed outline of the topics that were to be taught in the fall of '72.

This outline was then broken into a number of units or separate modules. For maximum flexibility it was decided to divide the individual units into two-hour (average) modules. Each learning package was next designed to contain four essen-

tial items:

(1) A listed statement of the objectives for that module.

(2) An audio-video instructional tape recording of the material in that module.

(3) A complete but concise outline of the instructional tape.

(4) A necessary number of problems to reinforce the subject matter.

Most of the equipment necessary to prepare the audio-video tape recordings was already available in the College of Engineering. Money for items such as tapes, production costs, etc., was supplied for use in the study by the Engineering Research Institute.

Room space to conduct the experimental portion of the study was furnished upon request by the Office of Space and Scheduling, and additional playback machines were borrowed from Engineering Extension to provide primary and standby capabilities during the experiment itself.

Selection of Sample

The population of students involved in this study was limited to Iowa State freshman engineers, as explained earlier. The computer, however, assigned on a random basis all students who were pre-registered in Engineering Graphics

161. This places non-engineers, non-freshman engineers and foreign students, as well as freshman engineers, randomly in all sections.

The actual profile of the classes was not changed in any fashion due to this problem. All students remained assigned to their respective classes such that the continuity of randomization would not be interrupted. Only freshman engineers, however, were considered in analyzing the data.

In the fall of 1972 there were a total of twenty-four sections of 161 with approximately twenty students in each section. Three of these sections were randomly assigned the experimental classroom, and three other sections were randomly placed in conventional classrooms. The instructional mode for the experimental sections was the integrated, module-TV methodology, while the control sections were assigned different instructional staff from a listing of all available faculty.

The teaching methods used by the different faculty members in the control sections were entirely that individual instructor's prerogative. Typically, the blackboard or overhead projector was the method of procedure, with grading, attendance, and other departmentalized policies being enforced.

Operation of Experimental Sections

The students in the experimental sections were each assigned three, two-hour blocks of time each week.

Although the instructional methods used allowed considerable individualization, these students were under several small but important constraints. As an overall rule students must complete all assigned problems in the course, although an exception to this is explained later, and in addition, each student must take major examinations no later than a pre-established date. This in no way prevents a student from taking all examinations at an earlier point in time, but it does not allow extended procrastination. As mentioned, most students were required to complete all problems in the course, however, if the student could exhibit an excellent understanding of subject material, as well as an excellent ability to do quality work, it was possible that the total number of required problems could be reduced. This situation could develop if a student has an exceptional ability or has had a considerable degree of prior training. In either case, a student-instructor generated decision could reduce the total number of problems required which tended to pattern or individualize the course material.

Class attendance was in no way required; daily problems were not to be submitted by a certain time period, nor were

students expected to stay in the laboratory to complete problem assignments. Individual students were encouraged to progress at their own speed by their instructor.

The notion of individualizing instruction concerns some people because of the inherent tendency on the part of students to naturally do required assignments first, putting off or procrastinating on others.

In this study the additional freedom allowed was intended to provide any given student a variable that he could control. For example, since all students do not enter at the same level, do not comprehend at the same rate, and do not execute a satisfactory problem solution in the same amount of time, then different students should be provided a variable amount of time to complete a given unit.

Good students were encouraged to work ahead, and missing a class for any reason was not followed by a penalty as long as the student finished the prescribed number of units prior to the end of the quarter. Although major examinations were given according to a preset schedule, the students were not penalized for work not complete at that time. The obvious implication, of course, is that they might not do as well on the examination if not properly prepared.

Any student who wished to take a major examination earlier than the minimum schedule simply informed the in-

structor so that a mutual time could be arranged.

Two particular techniques that were used in the study resulted in a majority of the students following the time sequence on the original assignment sheet. In other words, most students did not fluctuate by more than a unit or two the entire quarter.

A primary reason for this was the playback of tapes. The instructor scheduled a playback for all students who were in the classroom at five minutes after the scheduled period was to begin. Students who were not there could view the tape at other times, but it was simpler to be there at the beginning of the period.

A second technique that encouraged attendance was connected to the system of feedback used in the experimental sections. Each class was provided a complete set of answers to all the required problems. Exactly how this was used could best be explained by considering a typical period and module of instructional material.

All students received a syllabus at the beginning of the quarter. This provided assignments for the student to read prior to classroom attendance. Once the student was at the classroom laboratory he would take the assigned module from his notebook and watch the 15 to 20 minute audio-video taped problem. At the end of the taped lecture the student was free to work on the problem assignment where ever he so de-

sired. Typically, the student would remain in the classroom until he had completed the assigned problems. Once he had finished the problem he would check his solution against the prepared answer sheets. This provided immediate feedback regarding solution and, at the same time, afforded no embarrassment or negative attitude connected with feedback. If his solution was not correct he would rework and recheck until it was correct. Normally, if a student could work a particular problem then he had no question regarding solution. If the student could not work the problem he received as much individual help from the instructor as required.

Once the problem was completed the student turned it in to be evaluated, not for solution, but for quality or workmanship, lettering and presentation. Since these particular characteristics are not directly related to any given solution it is not critical that feedback be as immediate. Quality of workmanship, lettering and presentation do require constant attention, however, if gradual but eventual improvement is expected.

By not requiring that a problem be completed at a certain point in time, the students experienced more freedom in the solution of daily work. Each problem was an instrument to challenge the student's understanding of the unit of instruction. If the student understood the assignment he could work the problem and rapidly verify his solution in a short

period of time. This left him free to move into the next unit or wait until the next class period.

If the student did not understand the assignment and could not work the problem he had a number of different options available. He could reread the text assignment, he could watch the tape again, he could receive supplementary assignments, or he could meet with the instructor for as much personalized help as he required. The important variable, however, was time. The student could spend as much time as necessary within the framework of major examination constraints. This restricted extended procrastination, but still allowed a considerable amount of fluctuation. The student could control the amount of time necessary for him as an individual to complete a module of instruction.

Collection of Data

As mentioned earlier, major examinations were given at prescribed minimum times. It was entirely possible to take these exams at an earlier time, but impossible to take them later than the preset date on the assignment sheet.

There were three, two-hour examinations and a two-hour post-test. The second exams and the post-test in the experimental sections were identical to those used in the control sections.

All of these examinations, for both the experimental and control group, were graded by the same individual. The tests were mixed together, graded, and then separated into the appropriate sections again. This technique was an attempt to provide a uniform assignment of grades to examination papers, independent of experimental or control selection.

These data were used as two measures of the dependent variable. One additional dependent variable selected was the total score received in the course by individual students in each group.

The total number of students involved in the study was initially recorded at 39 in the experimental group and 52 in the control group. When non-freshmen, non-engineers, and foreign students were eliminated from the count it left a total of 34 and 43 in the experimental and control groups respectively.

Statistical Analyses

Once the data had been collected it was then possible to begin a complete statistical analysis. This process was facilitated by the allocation of computer time authorized by the College of Education.

The initial operation was to format and punch the data

on computer cards. All individuals who participated in the
study were assigned an identification number. This made it
possible to place the total collection of data points for
each individual on one card.

Since a detailed statement of the statistical hypotheses,
as well as a description of the variables involved were out-
lined in chapter one, it will not be repeated here, however,
a general account of the statistics involved is presented
below.

The first statistic to be processed was the null hy-
potheses in regard to the independent variables. This re-
sulted in calculations necessary to perform the t-statistic
comparing experimental and control variable means. This sta-
tistic determines if a difference actually exists in the
data, or if only random error associated with experimentation
was prevalent.

The same t-statistic was used to determine if differ-
ences existed when the means on the criterion variables were
compared.

These two statistical processes determined if there were
initial differences that needed to be adjusted, and if the
experimental method produced an increase in student achieve-
ment.

The next statistical determination to be performed was a

two-way factorial classification. This process enabled the investigator to examine various levels of performance by arranging the data into cells. Chapter one illustrated the different tests that were conducted and the null hypotheses that were tested. A total of fifty-four tests were made with the help of the digital computer.

These results were followed with a form of analysis referred to as multi-regression. This process was also performed with the aid of the computer. All of the independent variables were individually, as well as collectively, compared with each criterion measure to determine which had, if any, an influence on outcome.

A summary of these statistical results, together with the models restricted by indicated limitations, are presented in the next chapter on findings.

FINDINGS

Introduction

In order that the results of this study may be presented as clearly as possible a brief restatement of the objectives and hypotheses tested are listed as an introduction to this chapter.

The objectives as stated previously were:

(1) To determine if students who receive instruction by a combination of modules, audio-video tapes, and individualized instruction perform the same as students who receive instruction in a conventional manner.

(2) To investigate interrelations and correlations between entering and terminal variables.

(3) To determine if a performance predictability relationship exists between selected entering variables and terminal performance.

(4) To obtain a quantitative measure of attitude from students receiving the experimental treatment.

(5) To compare attrition from experimental sections with control and departmental statistics.

(6) To study the economic aspects and discuss the pos-

sibility of implementation on a larger scale.

Three of these objectives were formulated into a series of questions which will be presented later in this study. The remaining four objectives were answered by statistical determinations that can be divided into the following areas.

1. The analysis of independent variables

2. The analysis of dependent variables

3. A factorial analysis

4. A multi-regression analysis

Analysis of Independent Variables

There were six independent variables collected on each subject that participated in the experiment. As stated previously, the first four were available as a matter of entrance requirements or tests, and the last two were obtained from instruments administered at the beginning of the experiment. These independent variables (X) were as follows:

X_1 - High School Rank (HSR)

X_2 - American College Testing Program (ACT)

X_3 - Minnesota Scholastic Aptitude Test (MSAT)

X_4 - Mathematics (Math)

X_5 - Pre-Test

X_6 - Prior-Graphics

All participants of the study were assigned by computer scheduling. This procedure was a necessary restriction due to the impossibility of hand scheduling all first quarter freshman engineers. Although the process of computer assignment closely approximates randomization, certain restrictions on student schedules could influence the validity of the procedure.

A verification of randomness was satisfied by checking a number of independent variables to provide a measure of reassurance to the process of computer assignments.

Table 1 contains a summary of the mean scores and standard deviations for each of the six independent variables. The subscript "e" refers to the experimental group, the "c" indicates the control group, and $\overline{X}$ and S values in the table are independent variable mean scores and standard deviations, respectively.

Table 1. Summary of independent variable means and standard deviation (N - number of students)

Variables	N_e	N_c	$\overline{X}_e$	$\overline{X}_c$	S_e	S_c
HSR	32	37	18.78	14.78	15.00	10.65
ACT	32	37	26.94	27.46	3.30	2.34
MSAT	32	37	52.47	54.41	10.60	11.12
Math	32	37	26.22	29.35	9.82	7.19
Pre-test	32	37	15.13	14.54	14.11	16.99
Prior-graphics	32	37	3.47	2.86	5.20	3.26

These independent variable scores were compared by the computation of the t-statistic.

In general, this t-statistic may be used for testing the significance between any two sample means by either the separate group or pooled variance formulas. Both of these alternatives are restricted by a number of assumptions.

(1) Each sample must be drawn at random.

(2) The samples must be uncorrelated.

(3) The population from which each sample has been drawn must be normally distributed.

(4) The population must be homogeneous.

If it is possible to use the pooled t-statistic a stronger test will result due to the added degrees of freedom. One additional assumption must be met, however, before the pooled formula can be used.

(5) The variances of the two samples must be homogeneous.

So before a decision can be made regarding the type of t-statistic to be used the significance of the difference between the two estimated population variances must be compared.

This test is accomplished as indicated in equation 1 by dividing the greater of the two variances by the lesser of the two variances.

$$F = \frac{s^2_{greater}(N-1)}{s^2_{lesser}(N-1)} \tag{1}$$

The results of these calculations are presented in Table 2 below.

Table 2. Results of the variance ratio tests on the independent variables

Variables	F^a_{cal}	F^b_{table}	Level of Significance
HSR	1.98	1.78	Significant at 0.10
ACT	1.99	1.78	Significant at 0.10
MSAT	1.10	1.84	Not significant
Math	1.86	1.78	Significant at 0.10
Pre-test	1.45	1.84	Not significant
Prior-graphics	2.54	1.78	Significant at 0.10

[a] Calculated variance ratios.

[b] Determined at appropriate degrees of freedom.

With these results determined it is apparent that the mean MSAT and Pre-test scores can be compared using the pooled variance formula which is given in equation 2

$$t = \frac{\overline{X}_e - \overline{X}_c}{\left[s^2_p \left(\frac{1}{N_e} + \frac{1}{N_c} \right) \right]^{0.5}} \tag{2}$$

where $\bar{X}_e$ is the mean score for the experimental group

$\bar{X}_c$ is the mean score for the control group

N_e is the number of students in the experimental group

N_c is the number of students in the control group

S_p^2 is the pooled variance

The pooled variance in this formula can be calculated by the following equation

$$S_p^2 = \frac{\Sigma(X_{ei} - \bar{X}_e)^2 + \Sigma(X_{ci} - \bar{X}_c)^2}{N_e + N_c - 2}$$

where X_{ei} and X_{ci} are the i/th datum points in the experimental and control sections respectively.

To calculate a t-statistic for the remaining independent variables the separate group variance must be used. This formula is illustrated in equation 3

$$t = \frac{\bar{X}_e - \bar{X}_c}{\left[S^2(\frac{1}{N_e}) + S^2(\frac{1}{N_c}) \right]^{0.5}} \tag{3}$$

where S_e^2 and S_c^2 are the individual variances of the experimental and control variables respectively.

The following equation can be used to compute this variance.

$$S_z^2 = \frac{1}{N_z - 1} \Sigma(X_{zi} - \bar{X}_z)^2$$

where the subscript "z" could represent either the experimental (e) or control (c) groups.

Using the appropriate t-statistic a comparison can be made that will provide a statistical measure of the experimental and control group distribution for each of the six independent variables.

Table 3 is a summary of the results obtained from this comparison

Table 3. Results of the t tests on the independent variables

Variables	t_{cal}	Degree of freedom	t_{table}^a	Level of significance
HSR	1.258	35	2.030	Not significant
ACT	0.743	35	2.030	Not significant
MSAT	0.737	67	1.995	Not significant
Math	1.490	35	2.030	Not significant
Pre-test	0.155	67	1.995	Not significant
Prior-graphics	0.581	35	2.030	Not significant

[a]The table values are at the 0.05 level of significance.

With the results of these tests tabulated it is now possible to examine each of the null hypotheses previously formulated.

The Null Hypotheses in Regard to the Independent Variables

1. There is no significant difference between the mean
   HSR scores of the experimental group and the control
   group.

   Statistical results: There is insufficient evidence to
                         reject the null hypothesis.

2. There is no significant difference between the mean
   ACT scores of the experimental group and the control
   group.

   Statistical results: There is insufficient evidence to
                         reject the null hypothesis.

3. There is no significant difference between the mean
   MSAT scores of the experimental group and the control
   group.

   Statistical results: There is insufficient evidence to
                         reject the null hypothesis.

4. There is no significant difference between the mean
   math scores of the experimental group and the control
   group.

   Statistical results: There is insufficient evidence to
                         reject the null hypothesis.

5. There is no significant difference between the mean

pre-test scores of the experimental group and the control group.

Statistical results: There is insufficient evidence to reject the null hypothesis.

6. There is no significant difference between the mean prior-graphic scores of the experimental group and the control group.

Statistical results: There is insufficient evidence to reject the null hypothesis.

These results would indicate that the process of random assignment of subjects to the control and experimental groups was effective and that any differences determined in the end results must be attributed to an intermediate treatment.

Analysis of Dependent Variables

There were three dependent variables collected on each subject involved in the experiment.

Y_1- The mid-term examination

Y_2- The post-test or final examination

Y_3- The overall course grade

A summary of these results are presented in Table 4.

Table 4. Summary of dependent variable means and standard deviations

Variables	N_e	N_c	$\bar{X}_e$	$\bar{X}_c$	S_e	S_c
Mid-term examination	32	37	87.81	88.92	7.55	4.99
Post-test examination	32	37	90.81	88.24	6.35	6.45
Course grade	32	37	61.94	55.03	24.23	24.46

These results can be compared using the same approach that was applied to the independent variables. The initial step involved calculating the F ratio of variances as given by equation 1. The results tabulated in Table 5 indicate which t-statistic can be used in the comparison.

Table 5. Results of the variance ratio tests on the dependent variables

Variables	F_{cal}	F_{table}^{a}	Level of significance
Mid-term examination	2.29	1.78	Significant at 0.10
Post-test examination	1.02	1.84	Not significant
Course grade	1.02	1.84	Not significant

[a]Determined at appropriate degrees of freedom.

These results indicate that the separate group variance

formula previously given as equation 3 must be used to compute the t-statistic for the mid-term examination scores. The pooled variance given as equation 2 can be used to compute the remaining dependent variable scores.

Table 6 is a summary of the results of those calculations.

Table 6. Results of the t tests on the dependent variable means

Variables	t_{cal}	Degree of freedom	t_{table}^a	Level of significance
Mid-term examination	0.712	35	2.030	Not significant
Post-test examination	1.720	67	1.995	Not significant
Course grade	1.191	67	1.995	Not significant

[a]The table values are at the 0.05 level.

With the results of these tests tabulated it is now possible to examine each of the null hypotheses previously formulated.

The Null Hypotheses in Regard to the Dependent Variables

1. There is no significant difference between the mean scores of the experimental group and the control

group on the mid-term examination.

Statistical results: There is insufficient evidence to

reject the null hypothesis.

2. There is no significant difference between the mean

scores of the experimental group and the control

group on the post-test.

Statistical results: There is insufficient evidence to

reject the null hypothesis.

3. There is no significant difference between the mean

scores of the experimental group and the control

group on the course grade.

Statistical results: There is insufficient evidence to

reject the null hypothesis.

These results indicate that there is not a measurable in-
crease or decrease in learning due to the application of the
experimental treatment. This result will be considered in
more detail in the next chapter.

Factorial Analyses

A factorial analysis is a logical extension of the t-
statistic previously performed on the independent and depend-
ent variables. By using a two-way classification it is

possible to examine the variables in such a manner that extended insights are obtained.

A factorial design provides a method of analysis whereby the data can be grouped into cells. For example, $\bar{X}_{11}$, $\bar{X}_{12}$, $\bar{X}_{21}$, and $\bar{X}_{22}$ are cell mean scores as illustrated in Figure 2.

| | | Factor A: Group | |
		Experimental	Control
Factor B: Variable			
	High	$\bar{X}_{11}$	$\bar{X}_{12}$
	Low	$\bar{X}_{21}$	$\bar{X}_{22}$

Figure 2. Basic 2x2 factorial design

Factor A remains either the experimental or control groups, but Factor B can be any of the six independent variables. As an example to illustrate how the different variables were used in this study, let Factor B represent the independent variable HSR. In the experimental group HSR was then divided at the median into a high and low category. The scores on any one of the criterion measures (mid-term examination) that corresponded to these high and low HSR scores are the individual cell groups. Therefore, $\bar{X}_{11}$ would correspond to the mean score on the mid-term examination of

the top half of the students according to HSR in the experimental group.

The four cells need not have an equal number of subjects in each, but the computational procedures are simplified when they do. In this study, since the total number of students in the experimental group was only five less than the total number in the control group, a simplification could be made without altering the outcome. To balance the cells five control students were removed from the computational results of the 2x2 factorial analysis by a process of random elimination.

When these general arrangements have been made it is possible to test for significant differences between any of the following:

(1) Factor A when the group mean scores on the criterion variable are compared.

(2) Factor B when the group mean scores on the criterion variable are compared by level.

(3) The interaction between Factor A and Factor B when the group mean scores on the criterion variables are compared.

The first of the three tests above (1) should coincide with the t-statistic determined between the experimental and control groups when each of the dependent variables are considered.

The second test (2) should indicate if a statistical difference exists when the scores on the independent variables, ranked and divided into two levels separated by the median, are compared.

The third test (3) is a measure of the interaction between Factor A and B. For example, this test questions whether the effect of Factor A is the same at the two levels of Factor B or, stated differently, it is a measure of the effect of Factor A when B is at its higher level and the effect of Factor A when B is at its lower level.

This analysis will help indicate whether certain academic characteristics are more closely related to one form of instructional technique than the other.

In this experiment there were a total of eighteen factorial analyses. Each of these analyses provided for three hypotheses as stated above. The various independent and criterion variable combinations illustrated in Table 7 provided the total number of combinations that were examined.

Table 7. The independent and criterion variable combinations

Independent variables	Criterion Variables		
	Mid-term	Post-test	Course grade
HSR	1	2	3
ACT	4	5	6
MSAT	7	8	9

Table 7. (Continued)

Independent variables	Criterion Variables		
	Mid-term	Post-test	Course grade
Math	10	11	12
Pre-test	13	14	15
Prior-graphics	16	17	18

The mathematical model that was used in this statistical analysis is stated below.

$$X_{ijk} = U + A_i + B_j + (AB)_{ij} + e'_{ijk}$$

where X_{ijk} = the k/th observation of the (ij)th treatment combination

U = the grand mean

A_i = the true effect of the i/th level of Factor A

B_j = the true effect of the j/th level of Factor B

$(AB)_{ij}$ = the true effect of the interaction of the i/th level of Factor A with the j/th level of Factor B.

e'_{ijk} = random error or deviation corresponding to the k/th observation of the (ij)th treatment combination.

Each of the two-way classifications performed was tabulated in an ANOVA table such as the general example illustrated in Table 8.

Table 8. A general ANOVA table for a two-way classification

Source	d.f.[a]	SS[b]	MS[c]	F[d]
Treatments				
A	a-1	A_S	A	A/E
B	b-1	B_S	B	B/E
AB	(a-1)(b-1)	$(AB)_S$	AB	AB/E
Error	ab(n-1)	E_S	E	

[a]Degrees of freedom.

[b]Sum of squares.

[c]Mean squares.

[d]F-ratio.

where

$$A_S = bn \sum_{i=1}^{a} (\bar{X}_{i..} - \bar{X}_{...})^2$$

$$B_S = an \sum_{j=1}^{b} (\bar{X}_{.j.} - \bar{X}_{...})^2$$

$$(AB)_S = n \sum_{i=1}^{a} \sum_{j=1}^{b} (\bar{X}_{ij.} - \bar{X}_{i..} - \bar{X}_{.j.} + \bar{X}_{...})^2$$

$$E_S = \sum_{i=1}^{a} \sum_{j=1}^{b} (\bar{X}_{ijk} - \bar{X}_{ij.})^2$$

The column of mean squares (MS) is obtained by dividing the row sum of squares (SS) by the corresponding degrees of freedom.

For purposes of illustration, one of these factorial classifications will be presented in detail. Table 9 is an example of the ANOVA table illustrating the statistical results necessary to determine the set of three null hypotheses corresponding to the first combination given in Table 7.

Table 9. ANOVA table with HSR over mid-term examination

Source	d.f.	SS	MS	F
Total	64	503,774		
Mean	1	501,264		
Treatment (A)	1	30.25	30.25	0.80
HSR (B)	1	203.06	203.06	5.35^{*a}
Interaction (AB)	1	0.06	0.06	0.00
Error	60	2276.63	37.94	

[a]Table F ratio at 1 and 60 DF are 4.00 and 7.08.

These calculations result from using a criterion variable with Factor A and Factor B to determine main and interaction effects.

The tabulated F ratios are then compared with table values at 1 and 60 degrees of freedom.

When each of the eighteen combinations given in Table 7 is calculated and tabulated similar to Table 9 the results will provide the statistical information necessary to answer

a total of fifty-four null hypotheses. A summary table of these calculations are given in Table 10.

Table 10. Summary of all two-way classifications performed

Number	Symbol	Variation	Mid-term	F-Ratios Post-test	Co. grade
1	A	Treatment	0.80	2.17	0.78
2	B	HSR	5.35*	7.63**	16.35**
3	AB	Trt X HSR	0.00	0.22	0.53
4	A	Treatment	1.11	2.07	0.74
5	B	ACT	2.99	4.78*	10.45**
6	AB	Trt X ACT	0.14	0.01	2.33
7	A	Treatment	1.13	1.48	0.64
8	B	MSAT	4.00*	0.76	3.06
9	AB	Trt X MSAT	0.09	0.27	0.14
10	A	Treatment	1.46	2.37	0.77
11	B	Math	16.32**	13.29**	15.52**
12	AB	Trt X Math	5.78*	0.82	0.59
13	A	Treatment	1.08	2.03	0.65
14	B	Pre-test	1.56	3.30	4.24*
15	AB	Trt X P-T	0.01	0.32	0.00

*Significant beyond the 0.05 level.

**Significant beyond the 0.01 level.

Table 10. (Continued)

Number	Symbol	Variation	Mid-term	F-Ratios Post-test	Co. grade
16	A	Treatment	1.10	2.07	0.68
17	B	Prior-graphics	1.80	3.36	2.41
18	AB	Trt X P-Gr	0.70	1.54	4.41*

With the results of these tests tabulated it is now possible to examine each of the null hypotheses formulated in regard to the factorial design.

Criterion variable: HSR

1. There is no significant difference between the groups (Factor A) when the group mean scores on the criterion variables are compared.

    Mid-term   - There is insufficient evidence to reject the null hypothesis.

    Post-test   - There is insufficient evidence to reject the null hypothesis.

    Course grade - There is insufficient evidence to reject the null hypothesis.

2. There is no significant difference between the two levels of Factor B when the group mean scores on the criterion variables are compared.

    Mid-term   - Reject the null hypothesis.

Post-test   - Reject the null hypothesis.

Course grade - Reject the null hypothesis.

3. There is no significant interaction between the

groups (Factor A and Factor B) when the group mean

scores on the criterion variables are compared.

    Mid-term   - There is insufficient evidence

                 to reject the null hypothesis.

    Post-test   - There is insufficient evidence

                 to reject the null hypothesis.

    Course grade - There is insufficient evidence

                 to reject the null hypothesis.

Criterion variable: ACT

4. There is no significant difference between the

groups (Factor A) when the group mean scores on

the criterion variables are compared.

    Mid-term   - There is insufficient evidence

                 to reject the null hypothesis.

    Post-test   - There is insufficient evidence

                 to reject the null hypothesis.

    Course grade - There is insufficient evidence

                 to reject the null hypothesis.

5. There is no significant difference between the

two levels of Factor B when the group mean scores
on the criterion variables are compared.

      Mid-term   - There is insufficient evidence
                      to reject the null hypothesis.

      Post-test   - Reject the null hypothesis.

      Course grade - Reject the null hypothesis.

6. There is no significant interaction between the
groups (Factor A and Factor B) when the group mean
scores on the criterion variables are compared.

      Mid-term   - There is insufficient evidence
                      to reject the null hypothesis.

      Post-test   - There is insufficient evidence
                      to reject the null hypothesis.

      Course grade - There is insufficient evidence
                      to reject the null hypothesis.

Criterion variable: MSAT

7. There is no significant difference between the
groups (Factor A) when the group mean scores on
the criterion variables are compared.

      Mid-term   - There is insufficient evidence
                      to reject the null hypothesis.

      Post-test   - There is insufficient evidence
                      to reject the null hypothesis.

Course grade - There is insufficient evidence
to reject the null hypothesis.

8. There is no significant difference between the
groups (Factor B) when the group mean scores on
the criterion variables are compared.

Mid-term   - Reject the null hypothesis.

Post-test   - There is insufficient evidence
to reject the null hypothesis.

Course grade - There is insufficient evidence
to reject the null hypothesis.

9. There is no significant interaction between the
groups (Factor A and Factor B) when the group
mean scores on the criterion variables are com-
pared.

Mid-term   - There is insufficient evidence
to reject the null hypothesis.

Post-test   - There is insufficient evidence
to reject the null hypothesis.

Course grade - There is insufficient evidence
to reject the null hypothesis.

Criterion variable: Math

10. There is no significant difference between the

groups (Factor A) when the group mean scores on
the criterion variables are compared.

    Mid-term   - There is insufficient evidence
                           to reject the null hypothesis.

    Post-test   - There is insufficient evidence
                           to reject the null hypothesis.

    Course grade - There is insufficient evidence
                           to reject the null hypothesis.

11. There is no significant difference between the
groups (Factor B) when the group mean scores on
the criterion variables are compared.

    Mid-term   - Reject the null hypothesis.

    Post-test   - Reject the null hypothesis.

    Course grade - Reject the null hypothesis.

12. There is no significant interaction between the
groups (Factor A and Factor B) when the group
mean scores on the criterion variables are com-
pared.

    Mid-term   - Reject the null hypothesis.

    Post-test   - There is insufficient evidence
                           to reject the null hypothesis.

    Course   - There is insufficient evidence
                           to reject the null hypothesis.

Criterion variable: Pre-test

13. There is no significant difference between the
groups (Factor A) when the group mean scores on
the criterion variables are compared.

   Mid-term - There is insufficient evidence
          to reject the null hypothesis.

   Post-test - There is insufficient evidence
          to reject the null hypothesis.

   Course grade - There is insufficient evidence
          to reject the null hypothesis.

14. There is no significant difference between the
groups (Factor B) when the group mean scores on
the criterion variables are compared.

   Mid-term - There is insufficient evidence
          to reject the null hypothesis.

   Post-test - There is insufficient evidence
          to reject the null hypothesis.

   Course grade - Reject the null hypothesis.

15. There is no significant interaction between the
groups (Factor A and Factor B) when the group
mean scores on the criterion variables are com-
pared.

   Mid-term - There is insufficient evidence

to reject the null hypothesis.

Post-test   - There is insufficient evidence
to reject the null hypothesis.

Course grade - There is insufficient evidence
to reject the null hypothesis.

Criterion variable: Prior-graphics

16. There is no significant difference between the
groups (Factor A) when the group mean scores on
the criterion variables are compared.

    Mid-term   - There is insufficient evidence
to reject the null hypothesis.

    Post-test   - There is insufficient evidence
to reject the null hypothesis.

    Course grade - There is insufficient evidence
to reject the null hypothesis.

17. There is no significant difference between the
groups (Factor B) when the group mean scores on
the criterion variables are compared.

    Mid-term   - There is insufficient evidence
to reject the null hypothesis.

    Post-test   - There is insufficient evidence
to reject the null hypothesis.

Course grade - There is insufficient evidence
to reject the null hypothesis.

18. There is no significant interaction between the
groups (Factor A and Factor B) when the group
mean scores on the criterion variables are com-
pared.

Mid-term   - There is insufficient evidence
                  to reject the null hypothesis.

Post-test   - There is insufficient evidence
                  to reject the null hypothesis.

Course   - Reject the null hypothesis.

These results carefully examine the possible interac-
tions that could exist between entering variables and corre-
sponding performance measures.

From these results it is again apparent that there is
evidence to support a null hypothesis of no difference on
mid-term, post-test, and course grade measures when consider-
ing the control and experimental groups. This substantiates
the previous results and strongly suggest that the two teach-
ing methods are not statistically different.

These same results do indicate, however, that HSR and
mathematics are two independent variables that have an in-
fluence on the performance of the criterion variables. Those

students who graduated from a secondary school with a high class standing did significantly better than those with a low class rank. The same results are significant when identical reasoning is applied to scores in mathematics.

This suggests that HSR and mathematics are good indicators of performance in the basic graphic course.

Since all interactions are non-significant the resulting implication is that the experimental treatment had no significant effect on either high or low independent variable characteristics.

As an example, it is evident from Table 10 that there are no consistent significant interactions that would indicate the experimental treatment was better or worse for students with high or low scores on the mathematic entrance examination. This example could be extended to include all interactions in Table 10.

Regression Analyses

Another method of determining the significance of independent variables on the criterion measures is using regression analysis. By this technique it is possible to test the influence of different independent variables (X) on certain dependent variables (Y).

In this study two applications of regression analysis will be investigated.

(1) To determine if there is a relation between the independent and dependent variables.

(2) To determine if a prediction or forecast of achievement is possible.

The original intent in this part of the study was to consider only participants from the experimental group, but the digital computer made it possible to extend these results to include more combinations. The statistical results will be presented later in this section.

A discussion of regression analysis can best be accomplished by considering only two independent variables. The relations can then be extended from two to n variables.

When only two independent variables are considered the regression equation signifies a plane surface, and for any given values of X_1 and X_2 the individual values of Y must vary about that regression plane in a normal distribution with a zero mean and variance of σ^2.

The model equation for this example can be written as

$$Y = B_0 + B_1X_1 + B_2X_2 + E$$

where   Y = the dependent variable

           B_0 = numerical constant

B_1, B_2 = regression coefficients

E = random deviation

The prediction equation can be expressed as

$$\hat{Y} = b_0 + b_1 X_1 + b_2 X_2$$

with the values of b_0, b_1, and b_2 chosen so as to minimize $(Y-\hat{Y})^2$.

As the number of independent variables increase from two to n the problems associated with obtaining a solution to the above equations rapidly become more complex. If it is possible, therefore, to eliminate certain independent variables without significantly changing the results it is desirable.

In any multiple regression analysis a common question asked is: Which X-variables are most important in determining Y? Usually, no unique or fully satisfactory answer can be given, but several approaches have been tried.

Consider first the situation in which the objective is to predict Y or to explain the variation in Y. The problem would be fairly straight forward if the X-variables were all independent.

In practice, as in this study, correlations between the independent variables make the answer more difficult to determine. In most applications, X_1, X_2..., X_n are positively

correlated with each other and with Y. Therefore, it is not possible to simply run a linear regression of each X on Y.

Three different approaches to this problem are common.

(1) A trial-and-error technique whereby various combinations of the independent variables have been regressed on the same criterion variable. This process can then be repeated for different dependent variables.

(2) A method whereby all of the independent variables are regressed on Y and then a single independent variable judged the least important (non-significant) is eliminated and the process continued until all remaining variables are significant.

(3) A stepwise determination beginning with the variable that contributes the most and continuing until the addition of independent variables makes no significant contribution.

In this study both a trial-and-error (1) approach and the stepwise (3) technique was conducted, but since the latter was more successful its explanation and results will be presented.

The stepwise approach involves a number of sequential events. As an example, for purposes of explanation, the six independent variables will be regressed on course grade from the experimental group with the regression of other results

included at the end of this section.

The initial step in this analysis is to construct a correlation matrix. This is accomplished by calculating a correlation coefficient between each independent and dependent variable. Equation 4 was used to determine these values.

$$r = \frac{\sum xy}{\sum x^2 \sum y^2 \ 0.5} \tag{4}$$

where

$$\sum xy = \sum XY - \frac{\sum X \sum Y}{N}$$

$$\sum x^2 = \sum X^2 - \frac{(\sum X)^2}{N}$$

$$\sum y^2 = \sum Y^2 - \frac{(\sum Y)^2}{N}$$

The correlation coefficient (r) is a measure of the degree of closeness of the linear relationship between X and Y. Correlation coefficients can vary from -1 to +1 with zero implying no correlation whatsoever. Since the coefficient of correlation equals r for a given set of paired data (X and Y), then $100 \cdot r^2$ percent of the variation in the Y value can be attributed to the differences in X.

Correlation coefficients can be tested to determine if they are significantly other than zero. Conclusions are

Table 11. Correlation matrix for experimental data (N = 32)

	HSR	ACT	MSAT	Math	Pre-test	Prior-graphics	Mid-term	Post-test	Course grade	Grade point[a]
HSR	1.00[b]	-0.67**	-0.59**	-0.71**	-0.15	-0.06	-0.34	-0.47**	-0.43*	-0.59**
ACT		1.00	0.81**	0.80**	-0.01	-0.15	0.22	0.29	0.25	0.57**
MSAT			1.00	0.64**	0.06	-0.09	0.29	0.24	0.24	0.45**
Math				1.00	0.04	0.05	0.40*	0.50**	0.40*	0.67**
Pre-test					1.00	0.77**	0.23	0.28	0.29	0.11
Prior- graphics						1.00	0.33	0.38*	0.38*	0.18
Mid-term							1.00	0.82**	0.84**	0.70**
Post-test								1.00	0.87**	0.74**
Course grade									1.00	0.83**
Grade point[a]										1.00

[a] Grade point at the end of the first quarter.

*- Significant at the 0.05 level.

**- Significant at the 0.01 level.

[b] Table value at 0.05 (0.349) and at 0.01 (0.449).

normally drawn by considering the 5% and 1% significant levels.

Table 11 is a complete correlation matrix between the six independent variables and the four dependent variables.

Considering only the independent variables and the criterion variable (course grade), it can be seen from Table 11, page 88, that the "r" value between course grade and HSR was the highest. In this example, therefore, HSR will be the entering variable.

Once this fact was determined the next step was to compute and tabulate an ANOVA table. In an abbreviated form this analysis will involve the calculations shown in Table 12.

Table 12. General ANOVA table for multiple regression

Sources	d.f.	SS	MS	F
Total[a]	N-1	SS_{TOT}		
Regression	K[b]	SS_{REGR}	$\dfrac{SS_{REGR}}{K}$	$\dfrac{MS_{REGR}}{MS_{RES}}$
Residual	N-K-1	$SS_{TOT} - SS_{REGR}$	$\dfrac{SS_{RES}}{N-K-1}$	

[a]Total sum of squares corrected for the mean.

[b]Number of independent variables.

For a mathematical interpretation of the sum of square (SS) terms see Snedecor and Cochran (21).

When HSR is regressed on course grade the ANOVA given in Table 13 is obtained.

Table 13. Regression of experimental group results with HSR on course grade

Sources	d.f.	SS	MS	F
Regression	1	3432.28	3432.28	6.97*[a]
Residual	30	14773.59	492.45	

[a]Table F values at 1 and 30 d.f. are 4.17* and 7.56**.

Since there is only one degree of freedom for regression in this example, an F or t-test could be used to check the null hypothesis for statistical significance. The F-test will be used, however, since as the number of degrees' freedom increases to two or more only an F-test is appropriate.

The equation for the prediction of course grade (Y) by HSR (X_1) would be

$$\hat{Y} = b_0 + b_1X_1$$

where b_1 is the regression coefficient obtained by the optimization of the residual.

The null hypothesis could be stated as follows:

1. Null hypothesis, $b_1 = 0$.

   There is no significant contribution by the regression coefficient.

<u>Statistical results</u>: Reject the null hypothesis.

The next phase in the stepwise process is to examine the five remaining independent variables and compute their partial correlation coefficients. Equation 5 indicates the relationship of the dependent variable (course grade) to each of the remaining independent variables after considering HSR.

$$r_{12.3} = \frac{r_{12} - r_{13}r_{23}}{(1 - r_{13}^2)(1 - r_{23}^2)^{0.5}} \tag{5}$$

where the subscripts 1 - is the dependent variable (course grade)

    2 - is one of the five remaining independent variables

    3 - is HSR

The partial correlation coefficients for this example comparison are given in Table 14.

Table 14. Partial regression coefficients

Remaining variables	Partial correlation coefficients
ACT	-0.0024
MSAT	-0.0187
Math	0.1522
Pre-test	0.2563
Prior-graphics	0.3925

As evident from Table 14, Prior-graphics is the next most important entering variable.

This iteration would result in a new predication equation of course grade (Y) by HSR(X_1) and Prior-graphics (X_2) as follows:

$$\hat{Y} = b_0 + b_1 X_1 + b_2 X_2$$

where b_0, b_1, and b_2 are new values computed considering both independent variables.

Table 15 tabulates the ANOVA for this combination of variables.

Table 15. Regression of HSR and prior-graphics

Source	d.f.	SS	MS	F
Regression	2	5707.98	2853.99	6.62**[a]
Residual	29	12497.89	430.96	

[a]Table F values at 2 and 29 d.f. are 3.33* and 5.42**.

Once the regression coefficients and their standard error has been computed, individual F values can be computed for each independent variable. Table 16 contains these values.

Table 16. Calculated F values

Variable	F
HSR	7.147**
Prior-graphics	5.281*

These calculations provide the results necessary to test the following null hypotheses:

1. Null hypothesis $(b_1 = b_2 = 0)$.

   There is no significant contribution by either of the regression coefficients.

   Statistical results: Reject the null hypothesis.

   (Table 15).

2. Null hypothesis $(b_1 = 0)$.

   There is no significant contribution by the regression coefficient b_1.

   Statistical results: Reject the null hypothesis.

   (Table 16).

3. Null hypothesis $(b_2 = 0)$.

   There is no significant contribution by the regression coefficient b_2.

   Statistical results: Reject the null hypothesis.

   (Table 16).

At this point, the procedure necessary to accomplish a stepwise approach has been presented in detail through the first two complete iterations.

The remaining four independent variables must next be correlated with the independent variable after considering HSR and prior-graphics. These partial correlation coefficients are compared and the largest provides the third entering variable.

In this example mathematics would be considered next.

Following the previous iterations an ANOVA table and the appropriate null hypotheses would be formulated only to determine that mathematics does not contribute a significant regression coefficient.

The results of this example would thus indicate that when considering only the experimental group the independent variables that best predict the course grade were HSR and prior-graphics.

The prediction equation that results from the above computation can be expressed as

$$\hat{Y}_{CG} = 68.71 - 0.67X_{HSR} + 1.65X_{P.Gr}$$

The analysis and data just described was collected not only for the experimental group in the determination of course grade, but also for other combinations.

The following four Tables 17, 18, 19 and 20 are a consolidation of this data.

Table 17. Multi-regression of the independent variables on the mid-term examinations

Groups	Entering independent variables		
	First (1)	Second (2)	Third (3)
Experimental	Math (0.396)[a]	Pr-Gr(0.503)[b]	Not significant

Prediction equation $\hat{Y} = 78.58 + 0.29X_1 + 0.45X_2$

Control	HSR(0.447)	Not significant	Not significant

Prediction equation $\hat{Y} = 92.01 - 0.21X_1$

Combined[c]	HSR(0.388)	Pr-Gr(0.462)	Not significant

Prediction equation $\hat{Y} = 90.39 - 0.19X_1 + 0.37X_2$

[a] r value associated with the first variable.

[b] Cumulative r values for the first two variables.

[c] Experimental and control groups together.

Table 18. Multi-regression of the independent variables on the post-test examinations

Groups	Entering independent variables		
	First (1)	Second (2)	Third (3)
Experimental	Math(0.501)	Pr-Gr(0.616)	Not significant

Prediction equation $\hat{Y} = 81.10 + 0.31X_. + 0.44X_2$

Table 18. (Continued)

| Groups | Entering independent variables | | |
	First (1)	Second (2)	Third (3)
Control	Math(0.418)	Pre-t(0.503)	Not significant
Prediction equation $\hat{Y}$ = 75.05 + 0.40X. + 0.11X$_2$			
Combined	Math(0.403)	Pr-Gr(0.492)	Not significant
Prediction equation $\hat{Y}$ = 79.68 + 0.30X. + 0.43X$_2$			

Table 19. Multi-regression of the independent variables on the course grade

| Groups | Entering independent variables | | |
	First (1)	Second (2)	Third (3)
Experimental	HSR(0.434)	Pr-Gr(0.560)	Not significant
Prediction equation $\hat{Y}$ = 68.71 - 0.67X. + 1.65X$_2$			
Control	HSR(0.545)	Not significant	Not significant
Prediction equation $\hat{Y}$ = 73.55 - 1.25X.			
Combined	HSR(0.445)	Pr-Gr(0.521)	Not significant
Prediction equation $\hat{Y}$ = 67.35 - 0.84X. + 1.56X$_2$			

Table 20. Multi-regression of the independent variables on grade point at end of first quarter

| Groups | Entering independent variables | | |
	First (1)	Second (2)	Third (3)
Experimental	Math(0.672)	HSR(0.692)	Not significant
Prediction equation $\hat{Y} = 172.25 + 4.31X - 1.30X_2$			
Control	HSR(0.559)	Math(0.587)	Not significant
Prediction equation $\hat{Y} = 252.67 - 3.00X_1 + 1.94X_2$			
Combined	HSR(0.575)	Math(0.631)	Not significant
Prediction equation $\hat{Y} = 217.68 - 2.14X_1 + 2.91X_2$			

This data provides a new dimension to the previous results. It is now possible to see which independent variables become significant when considered collectively as opposed to individually.

Table 11 was a correlation matrix of both independent and dependent variables which illustrate a high correlation among the four dependent variables just considered. It is only logical, therefore, that the results of Tables 17, 18,, 19 and 20 be reasonably consistent.

These tables re-emphasize certain results that were previously determined. For example, HSR and mathematics are still significant predictors of certain criterion measures.

An additional variable becomes significant, however, when the data points are considered collectively. Prior-graphics is also an important variable when considered cumulative with other independent measures.

These tables also begin to give a quantitative measure of relative importance which is not possible to obtain when each variable is considered separately.

Table 20 is consistent with results that have been obtained by the Iowa State University Student Counseling Service. The prediction of grade point at the end of the first quarter is a function of the two independent variables HSR and mathematics.

The multiple r values that are included in parentheses after each independent variable in Tables 17, 18, 19 and 20 is the simple correlation between Y_i and Y.

If this value of r is squared (r^2) it is referred to as the portion of the explained variation by that particular variable.

By applying this reasoning it can be seen that only about 25 to 50 percent of the variability in the data can be accounted for by the independent variables used as predictors.

Student Attitude

One of the questions this study investigated was student

attitude. It was considered important to determine how the students reacted to the experimental form of instruction.

Many times in experiments involving human subjects a great many subtle influences can distort results. As an example, the term "Hawthorne effect" has come to refer to any situation in which the experimental conditions are such that the mere fact the subject is participating in an experiment tends to improve his performance. This effect rapidly declines, however, with time and over a twelve week period would have a negligible influence.

In most situations opinion is difficult to measure quantitatively, but an indication can be obtained by instruments such as student surveys.

If the survey is to invite an honest appraisal it should be conducted anonymously, but it is then difficult to correlate measures taken at different points in time.

All the students involved in the experimental group were asked to anonymously complete an attitudinal survey at the termination of the quarter. Students participating in the control sections were not included in this survey. It consisted of twenty-four questions with each student responding on a (0-9) scale as shown on the following page.

Strongly disagree (Poor)	Disagree, but not strongly (Acceptable)	Neutral feeling (Fair)	Agree, but not strongly (Good)	Strongly agree (Excellent)
0 1	2 3	4 5	6 7	8 9

The following summary is the averaged response of the 32 students in the experimental group based on the above scale.

Averaged response	Questions
<u>7.6</u>	1. The examinations in this course were an honest measure of your understanding.
<u>7.2</u>	2. The system of grading daily work (for quality only) made you try to improve your pencil and lettering abilities.
<u>7.9</u>	3. Quality of work is an important attribute for an engineer.
<u>6.9</u>	4. The system whereby you graded your own work for solution was a help in this course.
<u>5.6</u>	5. The textbook used in this course was helpful.
<u>5.8</u>	6. A textbook in this course was necessary as a supplement to the modules.
<u>5.4</u>	7. The objectives listed on the first page of each module were helpful.
<u>5.4</u>	8. Those objectives should either be improved or omitted.

7.6   9. The content of this course was something you consider fundamental to the education of an engineer.

8.2   10. The outlines of the daily work were helpful when doing laboratory assignments.

7.7   11. Those same outlines were helpful when studying for major examinations.

6.9   12. The problems assigned were an appropriate amount of work for a three credit course.

8.0   13. The TV tapes were well prepared.

3.5   14. The TV tapes were too long.

6.6   15. Rate the technical quality of the TV tapes (picture and sound).

8.0   16. How would you rate the TV tapes to more conventional lectures in other courses?

8.2   17. Your instructor provided you as much individual help as you required.

8.4   18. Compared to other teachers you have had, how would you rate your instructor?

7.7   19. The instructor was fair in his evaluations of your performance throughout the quarter.

7.6   20. This course has provided a necessary form of training for a future in engineering.

8.2   21. You favor the concept in this course of allowing students more freedom in the sense of completing assignments, etc.

<u>7.6</u>   22. You enjoyed taking the course.

<u>8.6</u>   23. If you could start again would you prefer this
         type of instructional situation, i.e., TV tapes,
         modules, open labs, etc., to the more conven-
         tional courses?

<u>8.1</u>   24. Give your overall opinion regarding this type of
         instructional system (everything considered).

The twenty-fifth question asked for additional comment.
All of the written responses were favorable with the exception
of one comment that suggested receiving some professional
assistance from WOI-TV in directing and producing TV tapes.

Most of the comments indicated, however, that the added
flexibility in the completion of assignments, the TV tapes,
the outlines, and the problem solutions were extremely help-
ful and beneficial to the overall learning process.

Student Attrition

A high percentage of the students who initially enroll
in an engineering discipline are quite capable of completing
one of the four year curricula.

Their first exposure to engineering, however, places
them primarily in areas such as mathematics, chemistry,
physics, and English. These courses are fundamental to the

education of an engineer, but provide little connection or association to their selected college.

These introductory remarks are not intended to imply that there are no contacts with the College of Engineering. A series of engineering seminars, engineering problems, advisors, student and professional organizations, peer associates, etc., provide a number of opportunities for exposure to the different disciplines.

Student attrition in all likelyhood will result from difficulty encountered from course work taken outside the College of Engineering. This does not eliminate, however, the possibility of students leaving engineering due to dissatisfaction from something taught from within the college.

Since Engineering Graphics 161 is the first three-credit course taken in engineering, it is not unrealistic to be aware and concerned about student transfers.

The primary question regarding attrition in this study was to determine if the instructional system used in the experimental group was of such a nature that students were changing sections or leaving engineering as a direct result of the experimental treatment.

To answer this question the number of students enrolled in 161 fall quarter was compared with the number of students who received a grade at the end of the quarter. From these

numbers a drop rate could be determined. Table 21 shows
these results as well as results from the experimental and
control groups.

Table 21. Attrition percentages

Course	Number enrolled	Number completed	Number dropped	Percentage
161 (Exp.)	34	32	2	5.9%
161 (Control)	43	37	6	13.9%
161 (Total)	320	280	40	12.5%

These numbers in no way suggest the students dropped due
to 161, but that for some reason dropped the course and there-
by received no letter grade. For example, one of the two
students who dropped the experimental course was doing ex-
ceptionally well in his freshman courses, but had to leave
school for personal reasons. The second student who dropped
was failing mathematics, chemistry, and English. This partic-
ular student was not adequately prepared to assume the ac-
ademic responsibility and dropped from school.

The percentages of Table 21 do not indicate that less
students drop engineering because of their exposure to the
experimental treatment. An implication of that type could
only be suggested after many more repetitions. The data

indicates, however, that the experimental treatment was not responsible for additional attrition.

DISCUSSION

Educational research is a complex science. It does not provide concise solutions that can be easily defined and precisely bound. To compound the problem even more, people are normally the participants of an educational study, and they are nearly impossible to control. It is for these reasons that cause and effect relations are hard to establish.

In this study, like many others, there were variables that could not be controlled. Individual students in both control and experimental groups were exposed to a multitude of external conditions beyond the control of the classroom teacher.

It is usually difficult to state, with a degree of certainty, conclusions obtained from educational research work. A study can, however, provide statistical answers to many questions that would otherwise be only value judgments. The process of following a well established procedure results in answers to important questions with a considerable degree of confidence.

In this study the questions that were to be answered started out as a number of objectives. The primary objective being to determine if a better way of teaching the basic graphics course could be devised. To this end a number of

techniques were combined to form learning packages that each student could complete by a form of independent study. These learning packages which included audio-video tapes and modules of instruction afforded the experimental students certain opportunities and variations not available to conventional classes.

The preceding chapter clearly indicated the results of this research design. These findings, although valuable in themselves, are not the entire story.

Many studies that have been conducted to compare one teaching method with another or even an existing program have failed to show a significant increase in achievement (4). This result is not predetermined, and only after the study has been completed can an introspective analysis provide additional insight.

The non-significant difference in the groups does raise an interesting question. If the experimental group was not significantly different from the control group, then how good is the control group?

The grade distribution for students enrolled in Engineering Graphics 161 for the year before the experiment was conducted showed that 15-20% of the students received an A grade, 40-45% a B grade, 25-30% a C grade, and less than 10% a D or F grade.

These statistics, together with a high department standard of excellence, produce results that are well within this university's range of expectation.

Another area that resulted in an interesting observation was that individual students, whether academically strong or weak, tended to do about the same in either the experimental section or the control section. This would indicate that the freedom of completing work independently did not seem to benefit students at either end of the academic scale.

To elaborate on this point it should be noted that an average student enrolled in 161 should expect to spend approximately nine hours each week completing assignments. If the student had some amount of prior training that time could be considerably shorter. If, on the other hand, a particular student had difficulty completing assignments due to course material problems or poorly developed skills then that student was allowed more time to obtain help and complete the assignments correctly.

This arrangement established time as a variable the student could control. Good students were encouraged to move forward faster than the average rate, while students who required more help were afforded additional time.

This procedure, as confirmed by the previous findings, did not seem to produce a higher level of learning by either

type of student. One possible answer might be that the exceptional students normally do not experience difficulty in any of their course areas, and as a result, find the necessary time to do quality work. The student who has trouble with content or exhibits poor skill and needs additional time is normally also having trouble with courses such as mathematics and physics. This classification of student requires more time in all of his academic areas, and if they are not willing to spend the added time the end result is lower achievement.

At this time there are two important secondary effects regarding the study that need to be explored.

The first, student attitude, is a point to be re-emphasized. Perhaps many forms of instructional methodology do not produce significant results, but the techniques involved can have a considerable influence on student reaction and opinion. Based on exposure to the course, students develop some degree of like or dislike for the instructor, the department, the college, and perhaps the individual's wisdom in selection of a career choice.

Most students who were enrolled in the experimental group were delighted to find a system of instruction designed for their benefit. A system whereby they could determine how and when to organize and utilize their time. It was surprising to determine that the majority of the students did not

deviate from a reasonably set schedule. Simply realizing that they had the freedom to come and go as they desired provided a reassuring asset.

The audio-video tapes and playback facility afforded each student the option of missing a class if he believed not attending would be to his advantage. For example, suppose a student had a major examination in another course and believed the additional time would optimize his effort. That student could arrange to view the tape at a later time and still receive the same lecture as the remainder of the class. Equally as beneficial was the fact the instructor was not called on to give that same lecture to one student. Approximately one-half of the students who missed classes for various reasons made arrangements to view the tapes prior to their absence. In fact, a few of the students even reviewed the tapes prior to major examinations.

Non-required attendance of this type might suggest that students would not attend class on a regular schedule, but this study showed that was not the situation. Attendance was as good or better than in conventional classrooms.

As the student surveys that were summarized in the previous chapter indicated, attitude regarding this method of instruction was very favorable.

Two general questions that remain to be discussed are

the economical considerations of this method of teaching, and
the feasibility of implementation on a larger scale.

Since the majority of funds associated with instructional
cost is salary, one aspect of this study dealt directly with
the question of instructor time spent in the classroom.

In the conventional classroom the faculty member spends
the majority of his time in the laboratory working with the
students. In the experimental group the faculty member spent
only 25% of the laboratory period in the classroom. The re-
maining 75% of that period was spent at his desk evaluating
student work. The technique of providing solutions for daily
problems made this economy of time possible. During the small
amount of time that was spent in the laboratory by the in-
structor there were few questions.

Since each student was responsible for a correct solution
to each problem the process of evaluation was made much sim-
pler. Each of the student's problems could be judged for
quality of workmanship in the period of time available.

The obvious possibility that exists by utilizing this
technique would be to increase the class size. If the
teacher-student ratio could be increased instructional cost
would be reduced.

Existing class sizes in conventional sections are approx-
imately 18 students. This number could be increased by fifty

percent and not require any additional time to accomplish present achievement levels. That statement is only true provided the tapes and instructional units are prepared.

The audio-video tapes and instructional modules do require an expenditure of faculty time, but once prepared they would demand only periodic attention.

The question of equipment has not been discussed, but that is small in relation to salary. For example, a cassette playback machine, three color receivers, and twenty-five, twenty minute cartridges could be purchased for around eighteen-hundred dollars. The equipment listed would serve approximately thirty students in a single classroom or about one-hundred students per week under existing work-load schedules.

The problems associated with one classroom and with one instructor are, however, far different than those problems dealing with a new system of instruction to teach 500 to 1000 students. For example, there could be a reluctance on the part of some instructors to use a series of tapes produced by others. In addition, there would be problems associated with the service and maintenance of audio-video machines and related equipment necessary to teach a larger number of students.

This study did not suggest or reveal any evidence that a

large scale production of the experimental program would, or
would not, be possible. The study did suggest, however, a
method of instruction that can produce an equal level of
achievement with a favorable student attitude in a more eco-
nomical matter. In conclusion, it would seem feasible to
suggest a continued development and gradual expansion of the
study. If it continued to indicate an economy of operation
coupled with a predetermined range of student achievement,
the system would eventually evolve to its appropriate level.

SUMMARY

This study was conducted to investigate an alternate method of teaching the basic graphic course to freshman engineers at Iowa State University.

The objectives of the study stated in general terms were as follows:

(1) To determine if students who received instruction by a combination of modules, audio-video tapes, and individualized instruction perform the same as students who receive instruction in a conventional manner.

(2) To investigate interrelations and correlations between entering and terminal variables.

(3) To determine if a performance predictability relationship exists between selected entering variables and terminal performance.

(4) To obtain a quantitative measure of attitude from students receiving the experimental treatment.

(5) To compare attrition from experimental sections with control and department statistics.

(6) To study the economic aspects and discuss the possibility of implementation on a larger scale.

To accomplish these objectives it was necessary to plan

and develop a series of graphic learning packages. Each package consisted of an audio-video tape and a module of instruction that could be used by the student in a form of independent study.

The experiment was designed such that one group of freshman engineers were randomly assigned to sections that would receive the treatment while other sections would act as control.

At the beginning of the study a number of measures were collected on all students that would be participants. These independent variables were primarily compiled to provide a profile of each student's academic achievement, but they also served as a check to substantiate randomization.

These independent variables were:

(1) High School Rank (HSR)

(2) American College Testing Program (ACT)

(3) Minnesota Scholastic Aptitude Test (MSAT)

(4) Mathematics

(5) Pre-test

(6) Prior-graphics

The criterion measures were collected during and at the end of the study. These dependent variables (mid-term examination, post-test examination and course grade) provided the evidence needed to make a series of tests.

The statistical results of these tests showed no significant difference existed between the control and experimental groups on any of the criterion measures.

The next determination was a factorial analysis designed to investigate relations between high and low independent variables when considered separately with each dependent variable. This analysis provided additional insight into the influence of each independent variable on student achievement in the course. Results indicated that HSR and mathematics are significant variables in relation to course performance.

This same analysis also afforded the possibility of interactions existing between high and low independent variables and experimental versus control grouping. The cross products in the factorial analysis revealed no consistent evidence to support a significant finding. It would appear that experimental and control methods of teaching did not differentiate between high and low achievers.

The relation of the independent variables to student course performance was also investigated in a multi-regression analysis. This technique accounted for the interrelation between independent variables in the process of determining a general prediction of performance. The multi-regression analysis also indicated a strong relation between HSR and mathematics in the prediction of performance. The analysis also showed that when the amount of prior-graphics was super-

imposed on HSR or mathematics, the general accountability was increased significantly.

At the termination of the study a questionnaire was filled out anonymously by each student that participated in the experimental group. The favorable results of this survey, coupled with a very low attrition, suggested that students had little objection, in fact, most would prefer a form of instructional methodology similar to that used in this study.

RECOMMENDATIONS FOR FURTHER RESEARCH

Recommendations aimed at extending this research study or initiating related studies are summarized as follows:

(1) Extend this study utilizing a larger sample size with the principal objectives being student attitude and economical considerations.

(2) Develop a series of measures capable of introducing the student into the basic course at the proper level. Students enter with a range of skills and prior training. A system of initial placement could be developed to allow more flexibility as to the amount of time a given individual needs to spend for a certain level of achievement.

(3) One of the objectives of a course in basic graphics is to develop drawing and freehand skills. A study could be designed to determine the extent of training necessary to accomplish desired standards of excellence.

(4) A series of follow-up studies could be conducted to measure retention of material in both experimental and control groups.

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APPENDIX A

The Experimental Group Assignment Sheet for Fall

Quarter, 1972.

Fall 1972 Assignment Sheet   Engr. Graphics 161

Wk	Min Date	Module #	Topics	Text References/ Pre-class Assignments
1	9-6	1	Int, Org, & Lettering	Unit 4, All Articles
	9-8	2	Sketching, S-View	Unit 3, Art 3.1-3.4
2	9-11	3	Sketching, Pictorial	Unit 3, Art 3.5, 3.6
	9-13	4	Instruments & Scales	Unit 5, All Articles
	9-15	5	Orth. Proj. of Points	Unit 6, Art 6.1-6.8
3	9-18	6	Orth. Proj. of Points	Unit 6, Art 6.9-6.12
	9-20	*	Examination	All Previous
	9-22	7	Orth. Proj. of Lines	Unit 7, Art 7.1-7.5
4	9-25	8	Orth. Proj. of Lines	Unit 7, Art 7.6-7.9
	9-27	10	Orth. Proj. of Planes	Unit 8, Art 8.1-8.6
	9-29	11	Orth. Proj. of Planes	Unit 8, Art 8.7, 8.8
5	10-2	12	Points & Lines	Unit 13, Art 13.1-13.5
	10-4	*	Mid-Term Exam	All previous
	10-6	13	Points & Lines	Unit 13, Art 13.7-13.9
6	10-9	14	Lines & Planes	Unit 14, Art 14.1-14.3
	10-11	15	Lines & Planes	Unit 14, Art 14.4, 14.6
	10-13	16	Lines & Planes	Unit 14, Art 14.12
7	10-16	17	Orth. Proj. of Solids	Unit 9, Art 9.1-9.5
	10-18	18	Orth. Proj. of Solids	Unit 9, Art 9.6-9.9
	10-20	20	Pictorials--Axon	Unit 10, Art 10.4-10.10
8	10-23	21	Pictorials--Oblique	Unit 10, Art 10.11-10.16
	10-25	*	Examination	All previous
	10-27	22	Section Views	Unit 11, Art 11.1-11.10
9	10-30	23	Section Views	Unit 11, Art 11.11
	11-1	24	Dimensioning	Unit 12, Art 12.1-12.10
	11-3	25	Dimensioning	Unit 12, Art 12.11-12.16

Homecoming (Noon Friday, November 3 - Noon Monday, November 6)

Wk	Min Date	Module #	Topics	Text References/ Pre-class Assignments
10	11-6	25	Dimensioning	Unit 12, Art 12.11-12.16
	11-8	26	Detail Drawing	Unit 26, Art 26.1-26.8
	11-10	--	Project Due/Review	

FINAL WEEK (November 13-17)

COURSE EVALUATION: 1st Exam   - 20%
                      M.T. Exam   - 20%
                      3rd Exam   - 20%
                      Final Exam - 20%
                      Daily Work - 20%

APPENDIX B

A Sample Instructional Module.

DEPARTMENT OF   INSTRUCTIONAL

ENGINEERING GRAPHICS   MODULE - 7

****

COURSE: ENGR. GRAPHICS 161

TOPIC: ORTH. PROJ. OF LINES - 1

REFERENCE: UNIT - 7

A-V TAPE: NO. 7

****

OBJECTIVES FOR MODULE - 7

A. By verbal, written, or graphical delineation be able to define and classify lines in space.

B. Be able to state the "Space Analyses" for any problem that can be represented by straight line segments.

C. Be able to graphically solve problems involving true length, point view, bearing and inclination. Also recognize the implied practical applications of fundamental principles.

D. Show an understanding of problem solution through the application and principles of rotation.

E. Develop an approach to problem solving that uses the following steps: 1) Recognize the problem, 2) Visualize in three dimensions the solution or necessary steps toward the solution (space analysis), and 3) Apply basic graphical principles to obtain desired solution.

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TOPIC OUTLINE FOR MODULE - 7

1. INTRODUCTION

    A. A basic understanding of lines in three-dimensional
        space provides us a simple tool for the solution to
        many problems.
    B. If points and the projection of points on various
        planes are understood, the extension of theory to
        lines is not difficult.
    C. A complete understanding of lines and their applica-
        tion to practical problems will make the upcoming
        lessons easier to comprehend.

2. DEFINITIONS

    A. A line can be defined as the path or locus of a
        point moving through space.
    B. For the present we shall study only straight line
        segments. Any line segment in space can be extended
        for the solution of problems (Fig 7-1).

Fig 7-1

3. CLASSIFICATIONS

    A. Horizontal - A line that is parallel to the horizontal
        plane.
    B. Front - A line that is parallel to the front plane.
    C. Vertical - A line that is perpendicular to the
        horizontal plane.
    D. Profile - A line that is parallel to the profile
        plane.
    E. Oblique - A line that is not parallel to any of
        the principal planes.
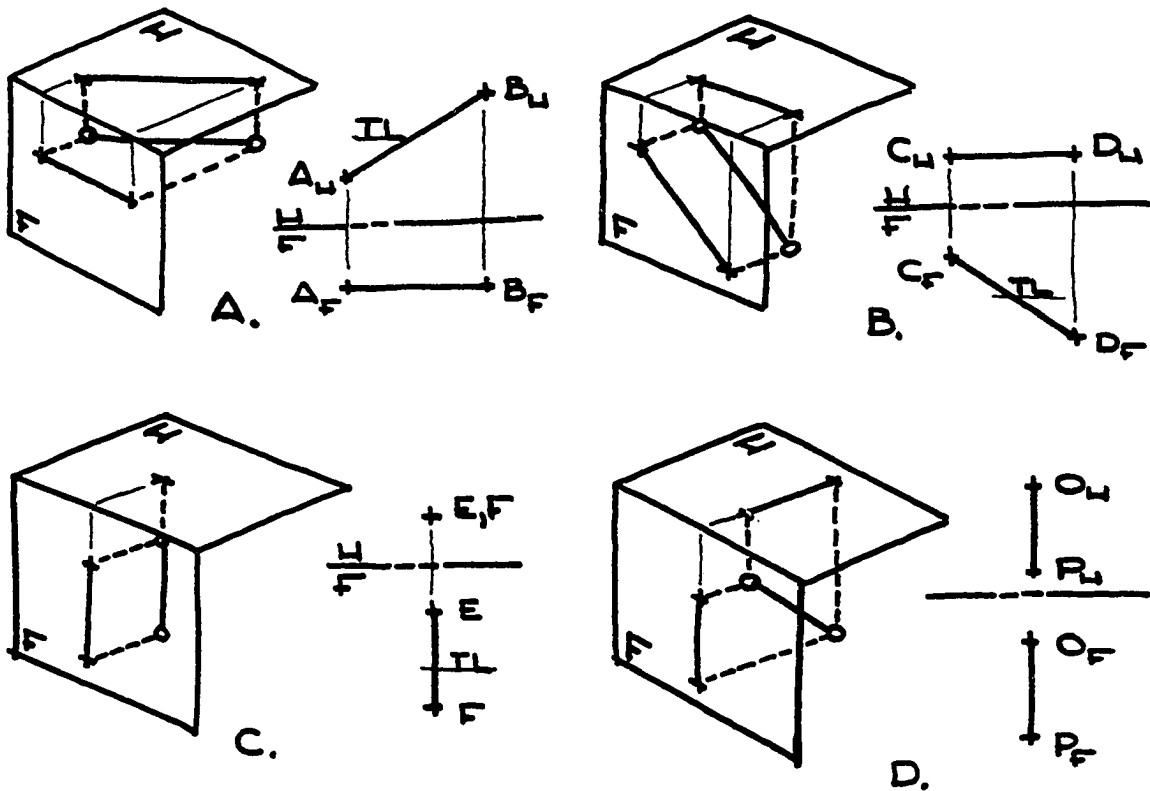
Fig 7-2

4. SPACE ANALYSES

   A. A space analysis is a statement of the visualiza-
      tion in three dimensions necessary to solve a
      particular problem.

   B. Be able to visualize the solution to problems in
      three dimensions.

5. TRUE LENGTH

   A. SPACE ANALYSIS: The true length (TL) of any line
      in space is found only upon a plane of projection
      parallel to the line.

   B. The location of the TL of line AB is shown on an
      auxiliary elevation view in Fig 7-3.

6. POINT-VIEW

   A. SPACE ANALYSIS: The view or projection of a line
      as a point is found only upon a plane which is per-
      pendicular to a true length projection of the line.

   B. The point projection of line AB is also shown in
      Fig 7-3. Notice the use of an auxiliary oblique
      view (2).

Fig 7-3

H & F - Prin Planes
  1 - Aux El
  3 - Aux Incl
2 & 4 - Aux Ob
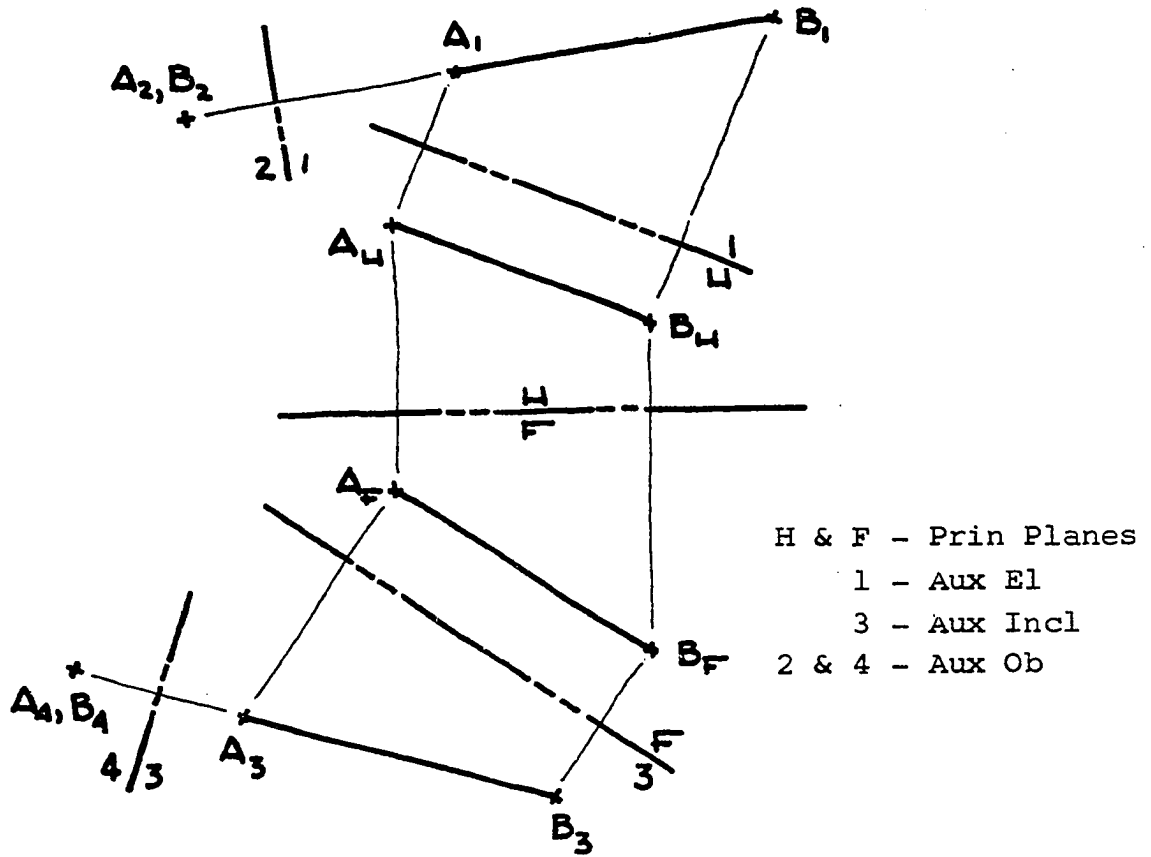
Notes:

1. Determine classification and T.L. Label the T.L. projection. Sketch an auxiliary view only when necessary.
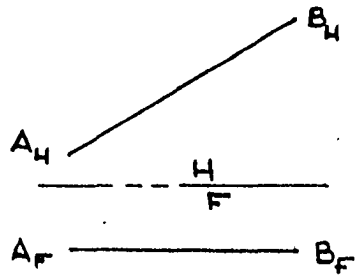
Classification _____
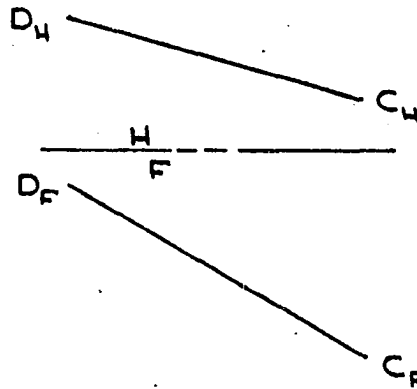
Classification _____
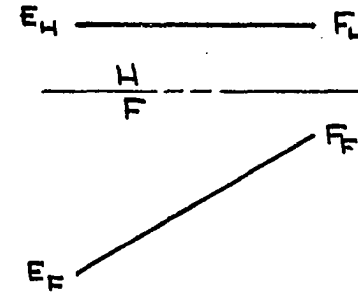
Classification _____

2. Sketch H and F projections of lines that fit the following specifications. Label T.L. Projections.

Horizontal line GH
1½ inches long
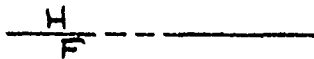
Profile line JK
1½ inches long
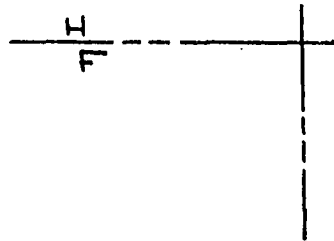
Vertical line MN
1 inch long

| SECTION : | NAME : | PROB# 7-A |
| DATE : | INSTR _ | GRADE _____ |

A_H ——————— B_H

$\dfrac{H}{F}$

A_F

B_F

C_H

$\dfrac{H}{F}$

D_H

C_F

D_F

E_H

$\dfrac{H}{F}$ F_H

E_F

F_F

H_H

G_H

$\dfrac{H}{F}$

G_F ——————— H_F

$+\ J_H K_H$

$\dfrac{H}{F}$

J_F

K_F

M_H

L_H $\dfrac{H}{F}$ M_F

L_F
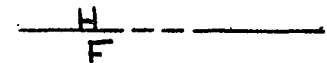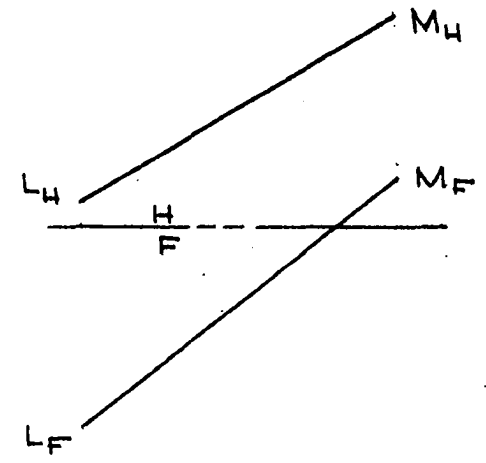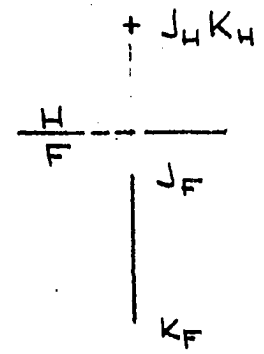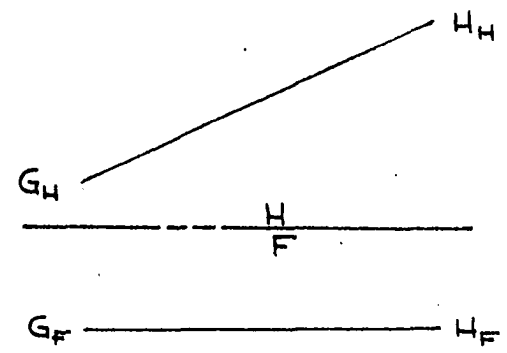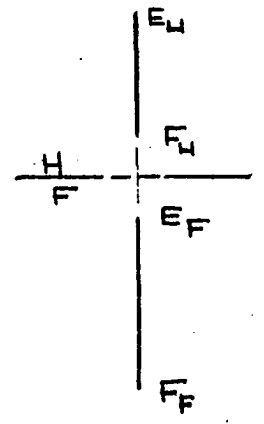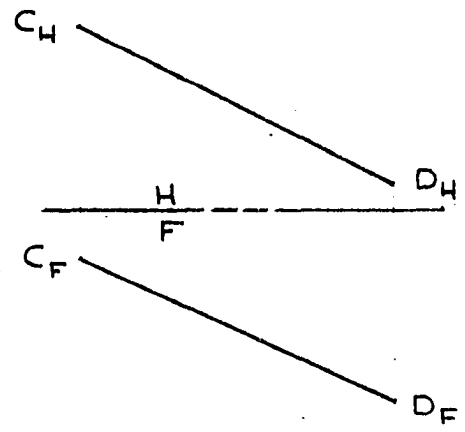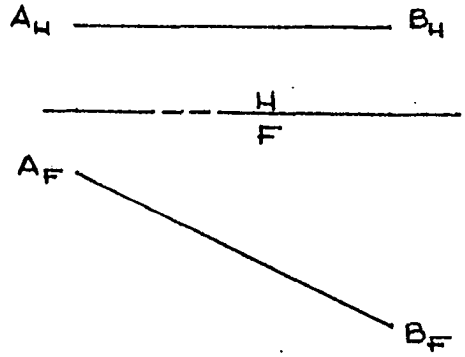
Sketch and label solutions for true length
and point view of the line. Do not measure
true length, just label (TL).

SECTION	NAME	PROB# 7-B
DATE	INSTR	GRADE

APPENDIX C

<u>Pre-test</u>

DEPARTMENT OF   NAME _____

ENGINEERING GRAPHICS   DATE _____

Part A. INFORMATION

1. Please list all schools you have attended starting with the ninth grade. (Include any college or other university.)

Name of School	Location	Years Attended
Example: Ballard	Huxley, Iowa	1968-72

2. What was the approximate size of your graduating class? ____

3. Was there any type of drawing (mechanical, etc.) offered at your school?

    (7-9) Yes No   (10-12) Yes No;   Circle.

4. List all previous training you have received in _any_ type of drawing. Be as specific as possible.

Name of Course	Length of Course	Year Taken	Grade Received

Part B.

Note: The questions below are designed to investigate the background and prior training of students entering this course. It is expected that many students will not know the answers. Read each question carefully and answer to the best of your ability. Please leave the question blank if you have no concept of its meaning. (Do not guess.) Your score on these questions will have nothing to do with your grade in this course.

1. Which of the following indicates a lead hardness? (Circle correct answer.)

    5G,   Z,   L,   1M,   3,   F,   4D

2. What is the purpose of guide lines?

3. If you wanted to scale down an object that was 3 x 4 ft. to fit an 8 x 10 inch paper what Architectural scale would you use?

4. What is the purpose or use of dividers in a drawing set?

5. Define "Orthographic Projection."

6. List the six principal planes of projection.

7. How can you distinguish an elevation view?

8. A vertical line is seen as a point on the _____ plane of projection.

9. What is meant by "true shape" of a plane?

10. How would you describe the orientation of the shortest connector between two non-parallel, non-intersecting lines in space?

11. Circle the words that do not apply to dimensioning: dimension lines, extension lines, leaders, contour lines.

12. List as many section views as you can think of.

13. Circle the word that does not fit: drill, ream, bore, counterspot, countersink, spot face.

14. What is section lining?

15. Lines are classified in five ways. Circle the non-correct classification. Front, horizontal, profile, inclined, vertical, oblique.

16. Which of the following is not a type of pictorial drawing? Oblique isometric, single view, or perspective

17. The slope angle of a line can only be measured in a(n)

_____ view with the line appearing in

_____.

18. What materials are needed for a sketch?

19. List three different types of sketches.

20. State the "Principle of Perpendicularity."

APPENDIX D

Mid-term Examination

135

IOWA STATE UNIVERSITY
ENGINEERING GRAPHICS 161

161/A1 - 10/72

MID TERM EXAMINATION

No books or reference
material may be used.
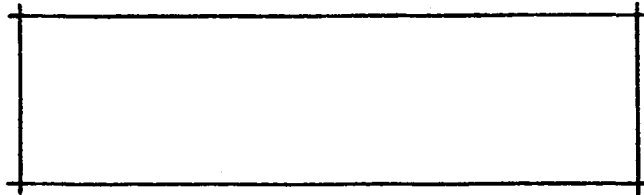
I. Page 1 (35%) _____   II. Page 2 (35%) _____

III. Page 3 (30%) _____   TOTAL (100%) _____

1. (10%) Using the Ames lettering guide, rule 3 sets of 3/16
   inch guide lines in the above box: Line 1- Your name,
   Line 2- Section___ Desk___, Line 3- The date.

2. (9%) Complete the following scale exercise:

   SCALE EQUATION   MEASUREMENT   RATIO

   $\frac{3}{4}" = 1'-0$

   $1" = 30'$

   1:24
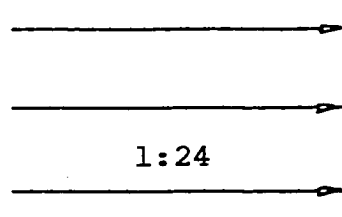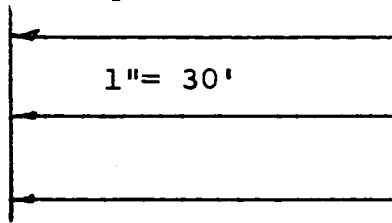
3. (4%) List the 4 essential
   elements of orthographic
   projection:

   _____

   _____

   _____

   _____
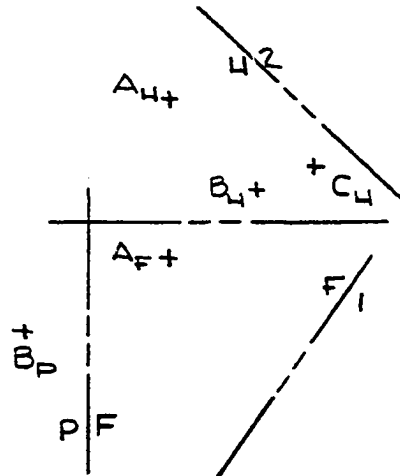
4. (10%) Project points A, B,
   and C to all indicated views.
   Point C is 1 inch below the
   horizontal plane.

5. (2%) Auxiliary view 1 is   Auxiliary view 2 is

   a(n) _____ view.   a(n) _____ view.

II. (35%) LINES AND PLANES   161/A2 - 10/72

1. (12%) Given the plane RST.   Name _____
   Showing all construction and
   labeling,

   a) Sketch the edge view of the plane.

   b) Sketch the true size view.

   c) Locate the slope angle of
      the plane.

   d) Show true length of line RS.

   e) Classify the plane. _____
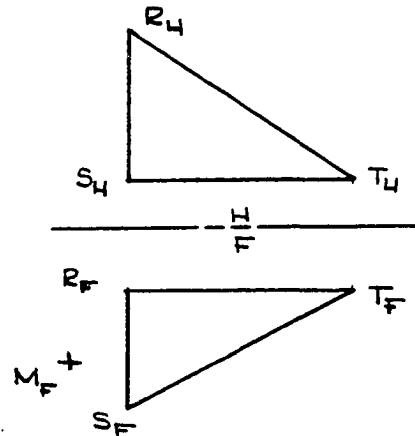
   f) Point M lies on the plane.
      Locate the horizontal
      projection of point M.

2. (3%) State two different delineations of a plane.

3. (12%) Given the H and F projections of
   a line AB. Showing all construction
   and labeling fully,

   a) Locate the bearing of line AB.

   b) Locate the true length view.

   c) Locate the slope angle of line AB.

   d) Is the slope angle positive or
      negative?

   e) Show a point view of the line.

   f) Classify the line. _____
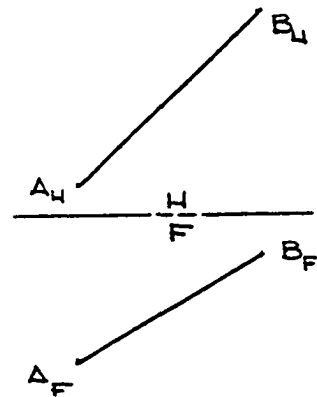
4. (3%) State the space analysis for finding the true slope
   angle of a line.

III. (30%) SKETCHING -
POINTS AND LINES

Name _____

1. (5%) State a 'Principle
of Perpendicularity'
between two lines

2. (5%) List in order five (5)
major steps in freehand
drawing.

1.

2.

3.

4.

5.

3. (10%) Solve freehand.
Estimate in inches the
shortest distance from
point '0' to the line
'AB.' Show connector
in all views.

DISTANCE _____

4. (10%) In the space below
make a pictorial sketch of
a roll of tape. Let the
outside diameter be twice
as large as the hole in the
middle.
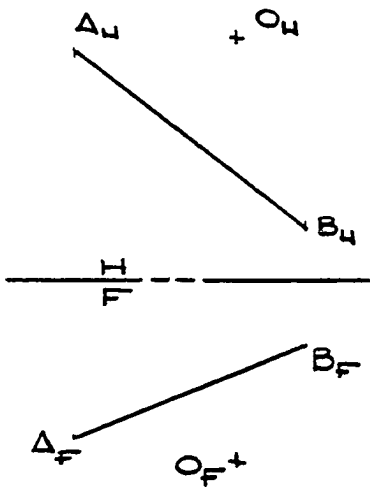
5. (5%) Sketch fully labeled
H and F views of:

a) Profile line
b) Front line
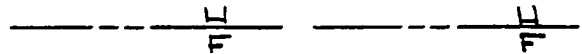
APPENDIX E

Post-test Examination

IOWA STATE UNIVERSITY   161/B1 - 11/72
ENGINEERING GRAPHICS 161

FINAL EXAMINATION   Name _____

No books or reference   I.   ORTHOGRAPHIC PROJECTION 25%____
material may be used.   II. SPACE GEOMETRY   25%____
All work freehand.   III. DETAIL DRAWINGS   25%____
                             IV. SOLIDS AND PICTORIALS   25%____

I. (25%) ORTHOGRAPHIC   TOTAL   100%____
   PROJECTION

1. a. (5%) Find the horizontal projec-
      tion of point D, which is on
      plane ABC.

   b. (10%) Find a true size and shape
      view of plane ABC. Label fully.
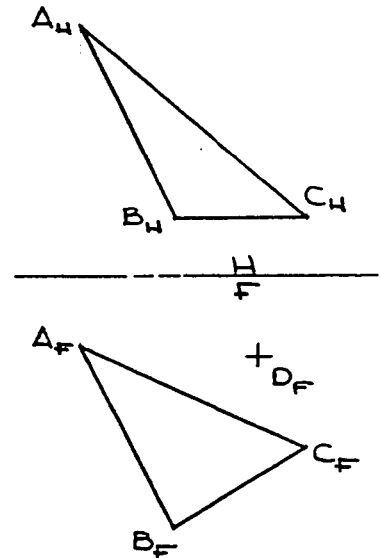
2. (10%) Find the bearing, length, and percent grade of line
   XY, using rotation.
   Label fully.   Estimate values:
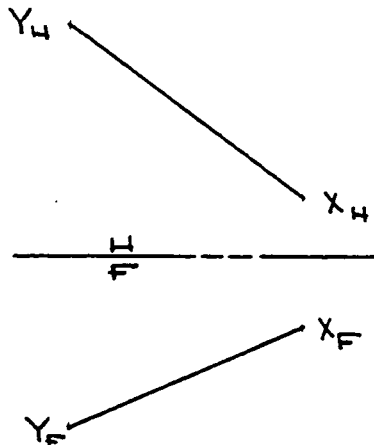
                                  Bearing_____

                                  Length_____

                                  Percent Grade_____

II. (25%) SPACE GEOMETRY   161/B2 - 11/72

Name _____

1. (4%) Given the H, F and P projections of the opaque planes ABCD and RST.
   a) Locate and label the line of intersection in the given views.
   b) Show correct visibility for the planes
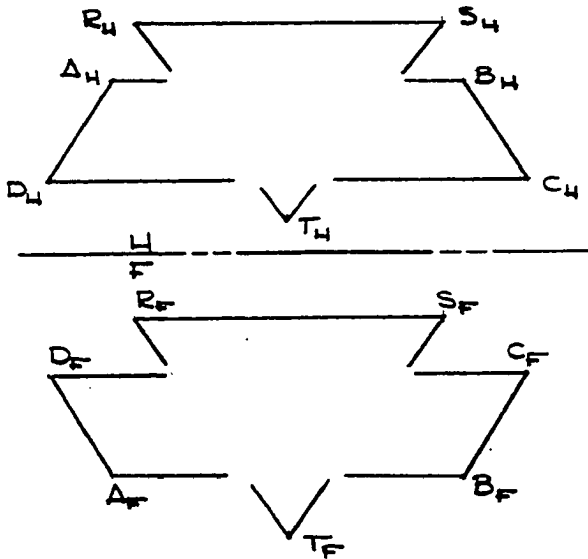
2. (8%) In the given views of the skew lines CD and EF, locate and label the,
   a) (4%) Shortest connector AB.
   b) (2%) Vertical connector VW.
   c) (2%) Locate and label the slope angle of the connector AB.
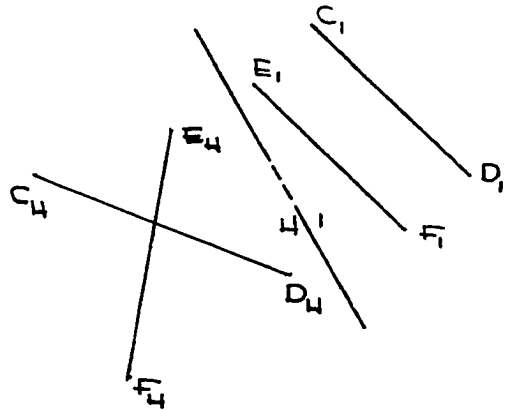
3. (5%) State the space analysis for finding the slope angle of a plane.

4. (4%) Locate the piercing point P of line QR and opaque plane ABCD. Show correct visibility. Show all construction. Label.
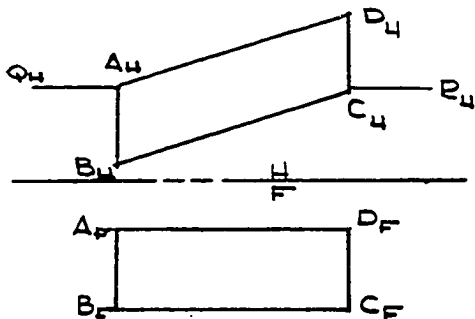
5. (4%) Sketch a projection showing the true angle formed by planes ABC and ADC. Label fully.
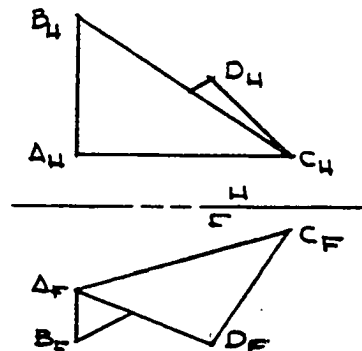
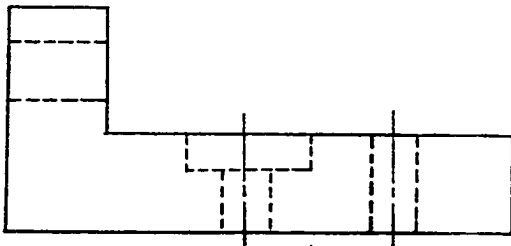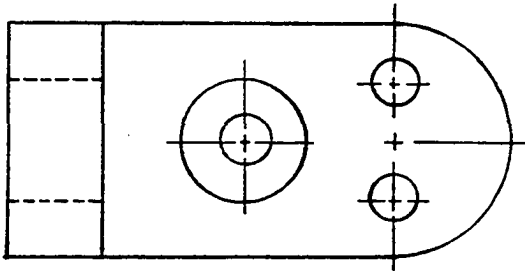III. (25%) DETAIL DRAWINGS   161/B3 - 11/72

Name _____

1. (4%) Explain why standards such as ANSI are important as applied to dimensioning.

2. (9%) Explain and illustrate with good sketches three different conventional practices.

3. (12%) Given three views of a steel bracket completely dimension this part for manufacture. Use S (size) and L (location) for dimensions.
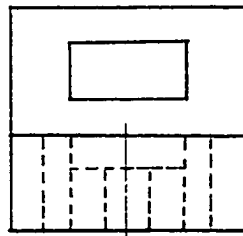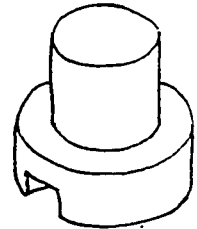
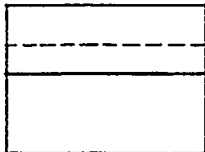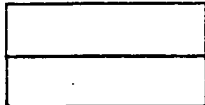IV. (25%) SOLIDS AND PICTORIALS   161/B4 - 11/72

Name _____

1. (5%) Discuss two advantages of   2. (5%) Sketch the
   oblique versus isometric pictorials   necessary ortho-
                                              graphic views of
                                              the given object.

3. (5%) Sketch five completely correct profile views for the
   given F and H views.

4. (10%) Sketch a suitable pictorial of the object shown.