A CORRELATIONAL STUDY OF THE RELATIONSHIP BETWEEN ACHIEVEMENT IN AN ENGINEERING COURSE, RETENTION IN ENGINEERING, AND THE METHOD OF PREREQUISITE INSTRUCTION

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CHAPTER I

PRESENTATION OF THE PROBLEM

Introduction

Freshman enrollment at the various engineering colleges throughout the United States declined significantly during recent years. Although there has been a substantial increase in 1973 and 1974, three years previously (1970, 1971, 1972) there was great concern expressed about the coming shortage of engineers. For example, 480 freshmen matriculated in the College of Engineering at Oklahoma State University for the fall semester of 1969, 475 for the fall of 1970, 304 for the fall of 1971, and 252 for the fall of 1972--a decline of 47 percent. Nationally, engineering enrollment decreased 24.5 percent from 1967 to 1972. This decrease in enrollment exists in the face of a prediction by the United States Labor Department and the Engineers Joint Council that the United States will be needing more engineers in the near future rather than fewer (18).

In addition to these declining enrollments, there is another problem which colleges of engineering have in common: there is a substantial number of freshmen engineering students who do not return to college for their sophomore year. Still others who do return to the university decide to major in an area other than engineering. Obviously, other colleges on the university campus lose students too, but traditionally there are relatively few students who transfer to an engineering college after their first year in college.

Thus, colleges of engineering throughout the country have been confronted with two similar problems--declining freshmen enrollment and the loss of potential engineers due to attrition. Both problems may cause a shortage of graduate engineers through 1980.

In light of this situation, one solution to this dilemma seems simple enough. Colleges of engineering should increase their enrollments. However, there are several reasons that make this alternative a difficult, if not an unrealistic, course.

Technology has become a "bad" word to certain ecologists and environmentalists. Aerospace companies, as well as other less visible industries, were put into an economic squeeze in the period from 1970 to 1972 due to a reduction in federal spending, and engineers and other physical scientists were terminated from their employment. While there were some geographic areas with serious employment problems, the mass media painted an extremely dark future for persons who had completed or were considering an engineering education. Thus, potential engineering students were encouraged to major in other disciplines. Along with the reported lack of employment opportunity, engineering schools must cope with the fact that over-all college enrollments are not likely to increase significantly during the next 20 years (42).

With these facts considered, the engineering college must choose another alternative, the reduction of attrition, in order to graduate sufficient numbers of engineers during the interim period. Engineering college administrators must ask themselves: "What can be done to retain a greater portion of those students who have matriculated at a college of engineering?" Thus, the administrators of the College of Engineering at Oklahoma State University have determined to address themselves to the attrition problem as an efficient method of mitigating the shortage of engineering graduates as well as for good educational practice.

Nature of the Problem

It has been suggested that one of the causes of attrition in the engineering college is academic failure or the fear or threat of academic failure. For example, only 14 of 59 students who transferred from the College of Engineering to another college at Oklahoma State University during the fall semester of 1972 had a cumulative grade-point-average equal to or greater than 2.0 (49).

If this failure of threat of failure can be reduced, and--conversely--if a high level of academic success can be made more easily attainable, then students might continue their enrollment in an engineering curriculum.

It is readily admitted that there might be several methods for achieving the goal of greater academic success, for there are seemingly many opportunities for students to learn in the school setting. Unfortunately, there are constraints that operate against the student. According to Bloom (5, p. 47), "the instructor expects a third of his pupils to learn well what is taught, a third to learn less well and a third to just 'get-by'." For example, only 33.6 percent of the freshmen who enrolled in the College of Engineering at Oklahoma State University in the fall semester of 1969 remained in continuous enrollment through the spring semester of 1973 (48). This datum tends to support Bloom's (5, p. 47) claim that only the first third of the students are "learning well what is taught."

Perhaps if academic success could be shared by more than just the "gifted" students (i.e., the first third), one could expect a greater proportion of an entering freshman class to be graduated.

Background for the Study

At Oklahoma State University the College of Engineering attempted to solve the attrition problem by creating an instructional program that would give the student both greater freedom and added responsibility for his own learning. This alternative instructional method was called Pre-Professional Individually Paced Instruction (PIPI) and was designed to encourage a high level of academic success. Ninety percent of the students who complete a given course are expected to achieve a grade of "A" or "B."

The basic content of the PIPI courses is comparable to what would be taught in the traditional classroom, but the student has a much larger and more active role in the process of learning. The student progresses through the requirements of a course by meeting specific behavioral objectives which are included in the instructions for the course. Self-assessments are included in the course materials which provide the student an opportunity for self-evaluation. When the student believes he has mastered a particular unit, he requests an instructor to evaluate his progress. The instructor administers a unit assessment, and if the student displays mastery of the unit--i.e., performing at the 90 percent level--he can begin work on the succeeding unit. If the student does not achieve mastery on a given unit, the instructor assists the student by private conference to identify those areas in which the student was weak, and after additional study of the unit, the student takes another unit assessment. There is no penalty for taking another assessment because PIPI is based on mastery rather than speed.

By using this system, emphasis is not placed on competition against one's classmates. Rather, the student is provided an opportunity to find a pace which is appropriate for his abilities and motivational level. The student is responsible to himself for his learning, and the course is completed when specified achievement levels have been reached. Yet the student is not left totally on his own resources, because instructors are available to facilitate learning and to direct students' individual study.

The PIPI curriculum consists of a group of courses totaling 40 semester credit hours, including written and oral communications, general chemistry, engineering physics, and mathematics through differential equations. Although the program was specifically designed for use by students enrolled in engineering, other students who were enrolled in other colleges of the university could also take advantage of this alternative to the more traditional classroom instruction. In either case, students may elect to take one or more of those courses listed in the PIPI rather than the traditional mode of instruction.

At the conclusion of any PIPI course, the student may choose to enroll in a sequential PIPI course or in the more traditional counterpart of the PIPI course. When a student completes all the courses offered via the PIPI program, he is obliged to take the remainder of his courses via the traditional system.

The two basic concepts of the PIPI program, "mastery-learning" and "self-pacing," make PIPI distinctively different from the traditional "lecture-laboratory-testing" method of instruction so common in American higher education.

"Mastery-learning" assumes that students learn course content more thoroughly than they might in the traditionally taught courses. Most students are expected to learn as well as the "first third" to which Bloom (5, p. 47) referred and the variable of time permits an intellectually weaker student to achieve on a plane with the stronger one by allowing sufficient time for mastering a given unit of learning.

"Self-pacing" assumes that all students will have an opportunity to complete a course at their own pace rather than at the pace established by the instructor for the entire class. Students are encouraged to complete a given course in one semester, but there are many students who finish in less than the complete semester. At the same time, there are instances when an "incomplete" grade is awarded, and the student may complete the course in the next semester. "Self-pacing" does not infer an indefinite period to achieve mastery. Rather, the student determines the pace at which he learns. "Self-pacing" should not be confused with inaction or a failure to work. Thus, a student who has sufficient time to complete a course of study at the mastery level will be apt to experience academic success.

McCollom (28) has concluded that a student who has completed one or more PIPI courses was more likely to remain enrolled in the College of Engineering for his second year than a student who did not choose to enroll in any of the PIPI courses. Furthermore, students taking PIPI courses are receiving higher grades than those students who are enrolled in the traditional counterpart. Admittedly, PIPI courses are built on the concept of good grades, but there is some evidence that academic success leads to more academic success (5).

One of the first conclusions one is apt to draw based on these data is that the PIPI courses were responsible for this higher retention. But obviously, this cannot be said without supporting research, and a step in this direction would be a study designed to relate the degree of success of PIPI students and the degree of success of non-PIPI students in an engineering course which is taught in the traditional manner during the sophomore year.

Statement of the Problem

The problem of this study was to determine the relationship between achievement in an engineering course, retention in engineering, and the method of prerequisite instruction.

Hypotheses to be Tested

The null hypotheses tested in the study are:

1. There will be no significant relationship between continued enrollment in the College of Engineering and the method of prerequisite instruction.

2. There will be no significant relationship between the incidence of withdrawing from courses during the freshman year and method of prerequisite instruction.

3. There will be no significant relationship between the letter grade earned (A, B, C, D, F, or W) in the "sophomore course" and the method of prerequisite instruction.

4. There will be no significant relationship between the method of prerequisite instruction and completion of the "sophomore course."

Definition of Terms

For the purpose of this study, the following definitions will be used:

Pre-Professional Individually Paced Instruction (PIPI) refers to a group of courses (i.e., communications, general chemistry, engineering physics, and mathematics from intermediate algebra through differential equations) that is based on the concept of "mastery-learning" and "self-pacing."

Mastery-Learning refers to a process of education in which the student is afforded the time he needs to master a given subject (i.e., earn a grade of "A" or "B" which is determined primarily by the number of units completed in an academic hierarchy rather than competency after a fixed period of time).

Self-Pacing refers to a flexible mode of instruction in which the student is responsible for developing his own study schedule and for establishing the amount of time (e.g., the number of weeks) required to achieve mastery of a course.

Hierarchy refers to the manner in which the PIPI courses are constructed. The student progresses through a course in a prescribed sequence to assure mastery of the simpler concepts before progressing to more difficult material.

Prerequisite Instruction refers to any of the pre-engineering courses which are offered both via the PIPI mode of instruction and via the more traditional "lecture-discussion-test" method of instruction.

Returning Student refers to students who return to the College of Engineering for their sophomore year to continue their study of engineering.

Sophomore Course refers to a one-semester sophomore-level engineering course entitled "Engineering Science--Mechanics of Rigid Bodies," which has as prerequisites the first course in general physics and differential calculus.

PIPI Subjects or PIPI students refers to students who have elected to enroll in one or more of the PIPI courses.

Non-PIPI Subjects refers to students who elected not to enroll in any of the various PIPI courses, but instead, chose to enroll in the counterpart to a PIPI course which is taught in the traditional manner.

Limitations of the Study

There will be no attempt to determine the cause of success or failure, nor is there intent to generalize beyond this study because there was no random selection of subjects to groups nor groups to treatments.

Assumptions of the Study

1. There is no meaningful difference in the intellectual abilities between those students who chose to enroll in PIPI courses and those who did not enroll in PIPI courses as measured by ACT scores and class rank upon graduation from high school.

2. The academic rigor of the sophomore-level engineering course, the quality of instruction, and the abilities of the students enrolled in the sophomore engineering course did not differ significantly for the four semesters in question.

Justification for the Study

In a recent (1973) study of first-year engineering students at Oklahoma State University, it was found that there were similarities in the achievement test scores as measured by the American College Testing Program (ACT) between the students who elected to take at least one PIPI course and those who did not enroll in that program (see Table I).

TABLE I

ACT SCORES FOR ENTERING FRESHMEN IN ENGINEERING 1971-1972[1]

	En	Ma	SS	NS	Comp
PIPI Students (N=75)	21.5	28.2	22.6	26.2	24.8
Non-PIPI Students (N=229)	20.5	27.2	22.5	26.3	24.3

[1]There are four sub-tests and a composite score expressed by the ACT. The sub-tests are En=English, Ma=Mathematics, SS=Social Science, and NS=Natural Science. According to the 1972-1973 edition of Using ACT on the Campus, the standard error of measurement for each of the sub-tests is 2.0 and the standard error of measurement for the composite score is 1.0. Standard deviations for the different tests and the composite score are respectively: 5.4, 7.0, 6.9, 6.3, and 5.4.

McCollom (28) reported an average high school class rank of the eighty-fourth and seventy-ninth percentile respectively, for another group of PIPI (N=23) and non-PIPI (N=71) students who enrolled in the College of Engineering in 1971.

Although there were these noted similarities in measures of intellect between the groups of PIPI and non-PIPI students, there were marked differences in the rate at which PIPI and non-PIPI students continued their study in the College of Engineering after the completion of the freshman year.

It was found that 63 percent of the students (N=75) who were enrolled in at least one PIPI course as freshmen continued in the engineering program during the following year, while only 51 percent of the students (N=229) who were enrolled in non-PIPI courses as freshmen continued in the engineering program during their second year (see Table II) (28).

TABLE II

RATE OF RETENTION OF STUDENTS WHO ENROLLED IN THE COLLEGE OF ENGINEERING FROM THE FRESHMAN TO THE SOPHOMORE YEAR 1971-1972/1972-1973

Enrollment Status Fall, 1972	PIPI Students Fall, 1971 (N=75)	Non-PIPI Students Fall, 1971 (N=229)
Engineering College	63%	51%
Another OSU College	9%	20%
Not Enrolled at Oklahoma State University-Stillwater	28%	29%

Based on these data, it can be said that students who enrolled in PIPI courses had a slightly better (i.e., 63 percent versus 51 percent) engineering retention rate than the non-PIPI students. It appears that the higher retention rate in engineering was attributable to a decrease in the rate of transfer from engineering to other Oklahoma State University Colleges (i.e., 9 percent versus 20 percent). The rate of students who were enrolled during 1971-1972 but who did not return to the University for their second year (i.e., 1972-1973) was nearly identical for both groups (i.e., 28 percent versus 29 percent).

There was no intent to make inappropriate statistical inference from these preliminary data. On the contrary, there is speculation that students who have completed at least one PIPI course may not continue to achieve as well, comparatively, in more advanced engineering courses when they must compete with students who have had the benefit of the instructional system used in the prerequisite courses that has been considered up to the present day to be quite successful.

It appears that PIPI may have some relationship to higher retention in engineering, but there is no evidence to support the "quality of learning" that one might assume would result through PIPI.

This research, then, is directed toward evaluating the PIPI model by determining (1) the success of PIPI students in a sophomore-level course relative to the success of non-PIPI students in the same sophomore-level engineering course and (2) the rate at which PIPI students continue in an engineering curriculum from the first to the second year relative to the rate of continued enrollment in engineering for non-PIPI students.

Summary of Implications of the Study

This study will investigate the degree of relationship that exists between the method of prerequisite instruction and continuation in engineering at Oklahoma State University from the first to the second year.

In addition, there is a need to assess the quality of instruction that occurs in the PIPI program. If PIPI students can compete successfully in a "sophomore course" in engineering with students who have benefited from more traditional types of prerequisite instruction, it may be inferred that the PIPI students are receiving adequate preparation from the PIPI program. Comparisons will be made between the method of prerequisite instruction and the level of achievement in the "sophomore course."

If significant relationships exist between the method of instruction in freshman-level courses and achievement in the "sophomore course" in engineering and/or if significant relationships exist between the method of instruction in freshman-level courses and retention in engineering from the first to the second year, then it can be said that enrolling and completing courses via the PIPI mode of instruction is a predictor of achievement in the "sophomore course" in engineering and a predictor of retention in engineering from the first to the second year.

Strong positive relationships may lead to an expansion of the PIPI program to include courses in engineering and additional studies of an experimental design to measure the efficacy of the two learning systems. Again, "cause and effect" cannot be inferred, but strong relationships between PIPI instruction and increased retention in engineering will provide some evidence that the College may have an "answer" to the problem of too few engineering graduates in the next decade.

Organization of the Study

Chapter I contains a definition of the problem, background for the study, definitions, assumptions and limitations. Chapter II contains a review of the related literature. Chapter III is concerned with research methodology and includes a description of the sample, procedures for data collection, and the statistical analysis to be utilized. Results of the study are presented in Chapter IV and in Chapter V, a summary of the study, including recommendations for further research, is discussed.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

This chapter includes a review of theoretical positions regarding self-paced and/or mastery-learning. Second, this section includes a review of research conclusions relative to the concepts presented in this study, "mastery-learning" and "self-pacing," both of which are incorporated in the group of courses referred to as Pre-Professional Individually Paced Instruction (PIPI). Finally, there is a section which discusses some of the common criticisms of individualized modes of instruction.

Theoretical Statements Concerning "Self-Pacing" and "Mastery-Learning"

A most dramatic comment that might describe the effectiveness of "mastery-learning" has been made by Block (3, p. iii) who stated that:

> One of the most powerful ideas beginning to shape educational views and practices is mastery learning. It assumes that all, or almost all, students can learn well and suggests explicit classroom procedures whereby all (up to 95 per cent) can achieve to high levels. Few recent ideas have produced more dramatic positive effects on student learning or generated more interest and school based research than mastery learning.

Bloom (5, p. 48) stated further that:

> Most students (perhaps over 90 per cent) <u>can</u> master what we teach. Our basic instructional task is to define what we mean by mastery of a subject and to discover methods and materials to help the largest proportion of our students reach it.

In other words, most students can master most learning tasks if the instructional method is appropriate.

Both Bloom and Block were referring to the concepts included in PIPI, "mastery-learning" and "self-pacing." They believe that nearly all students can learn what is expected of them by individualizing instruction.

Perhaps Dunn and Dunn (10, p. 49) best described the concept of individualizing instruction. Their description included the following principles. Individualization means that each student in a class may:

1. assume some responsibility for his own learning;
2. become an independent learner, capable of progressing without being dependent on others;
3. learn at a pace (rate, speed) which is comfortable for him;
4. learn through materials which are related to his perceptual strength;
5. learn on a level which is appropriate to his abilities;
6. relate the curriculum to his major interests;
7. learn in accordance with his own learning style (in small groups, alone, through media, at night, etc.);
8. be graded in terms of his own achievement and not in comparison with others;
9. feel a sense of achievement and thus be able to develop self-esteem and pride; and
10. select options from among a series of alternatives and participate actively in the decision-making areas of the learning process.

In addition to these features of "mastery-learning" and "self-pacing," it has long been a contention by some educational psychologists and theorists that success in the classroom contributes to additional successes in the classroom. Further, Bloom (4) suggested that success in school is an extremely important component in the development of one's feeling of self-worth. Thus, if a student's level of self-concept can be increased, he may have an even higher level of academic success in the future.

Bloom (5) concluded that adoption of "mastery-learning" and "self-pacing" models of instruction could lead to greater academic success by some students who are not now among those who have been identified as high achievers.

Empirical Validation of "Self-Pacing" and "Mastery-Learning"

There have been numerous studies conducted in the past several years which have attempted to establish whether answers exist regarding the most efficient yet practical method or methods of instruction. One of the most popular modes has been some variation of allowing the student a share of the responsibility for his success or failure by permitting him to work at his own pace and by providing him instructional materials which will accommodate "mastery-learning."

Oakland Community Junior College in Michigan introduced "mastery-learning" and "self-pacing" by establishing a "listening-center" where students had access to many of their courses via audio and/or slide presentations. In a study recently conducted at Oakland, 93 percent of the students enrolled in a social science program received a grade of

A, B, or C. In earlier years, only 64 percent of the students had achieved at that level for a similar group of courses (31).

Gentile (15, p. 117) applied "mastery-learning" and "self-pacing" principles to an introductory educational psychology course. Students read material, attended lectures at their will, held regular discussions with classmates, and--when the student believed he was competent--took a unit mastery test. The main purposes of the course strategy were:

1. to guarantee that all students mastered the course concepts;

2. to demonstrate how instruction which emphasized cooperative rather than competitive learning could be organized in the classroom; and

3. to maximize interactions among students, student proctors, and the teacher.

On One of the oldest (1926) efforts to study the effects of "mastery-learning" and "self-pacing" was conducted by Washburne (45) in the Winnetka, Illinois schools. This study contrasted achievement in Winnetka schools with achievement in other nearby surburban and private schools.

Students participating in the experimental program performed better on standardized achievement tests (except spelling) and in their first year of high school outperformed students from other elementary schools in English, mathematics, and social science.

Collins (8) conducted a study at Purdue University in which students enrolled in algebra or calculus courses were randomly assigned to either a "mastery" or "non-mastery" section of the course, with both groups receiving the same assignments and taking the same unit tests.

Approximately 70 percent of the "mastery" group received the grade of A or B while only 35 percent of the "non-mastery" group performed at that level. Furthermore, the grades of D and F were practically eliminated for the "mastery" group.

Scott (36), Stanley (38), Aft (1), and Tarquin and Blank (40) in different studies with engineering students concluded that individualized instruction was popular with the students. Favorable reaction was expressed by 80 percent or more of the students in each of the studies. Typical responses expressed opinions that the students enjoyed the course, but they felt they expended more effort than if the course had been taught in the traditional manner. These students were, in fact, expressing one of the tenets of PIPI (i.e., students are responsible for what they learn).

Not only is there an apparent growth in achievement in school subjects as a result of "mastery-learning" and "self-pacing," but some studies indicate a positive effect on self-growth. Ely (11), Ely and Minors (12), and Modu (29) reported that the increased contact with instructors, the higher grades earned, and the important role the student has in the learning environment may be responsible for improvement in self-concept.

Modu (29, p. 129) asserted that:

> . . . self-esteem could be changed even in late adolescence by an appropriate manipulation of cognitive achievement . . . Learning strategies which promote higher levels of achievement and changes in grading procedures may prevent losses in a student's self-esteem, thus helping to prevent severe emotional disturbance among college students.

Criticisms of the PIPI Method

Though the majority of the studies reviewed tended to support the concepts of PIPI, there is by no means unanimous acclaim of this mode of instruction.

Criticism leveled at "mastery-learning" and "self-paced" instruction has expressed concern that some students may receive higher grades than they would receive in "normal" classroom competition. Bloom (5, p. 49) responded to such claims by stating that the:

> . . . normal curve is not sacred. It describes the outcome of a random process. Since education is a purposeful activity in which we seek to have students learn what we teach, the achievement distribution should be very different from the normal curve if our instruction is effective. In fact, our educational efforts may be said to be unsuccessful to the extent that student achievement is normally distributed.

Emrick (13, p. 322) added that:

> . . . among the more exciting and promising trends currently emerging with educational innovations and reforms is a shift from traditional classroom instruction with its norm referenced testing procedures to more individualized instructional systems based on criterion-referenced procedures.

Probably the most mentioned negative aspect of PIPI-like courses are the problems incurred trying to overcome student procrastination. Weeks and Hayt (46, p. 55) conclude that self-pacing:

> . . . allows the student to progress to whatever rate he chooses, including zero, and consequently it allows the student with good intentions but poor motivation and self-discipline to fall seriously behind a normal schedule.

Sanford (35) and Feldman and Newcomb (14) have inferred that engineering students have a need for absolutes and prefer the teacher to have a dominant role in instruction (i.e., engineering students want direction). At the same time, engineers prefer to work by themselves and avoid groups.

While the PIPI courses do permit considerable individual work, English and speech taught in the PIPI method require some group activity. The instructor plays an important role in PIPI but probably could be called a "learning colleague" rather than a dominant figure.

Myers (30) reported that elementary students who had experienced PIPI-type instruction for three years had lower self-concept scores than those students who had experienced the same type of instruction for one or two years. Certainly, her work would lead one to look more closely at the conclusions presented by Modu (29) and Ely and Minors (12). Further, Taylor (41) criticized individualized learning systems on the premise that when students perceive what others in their class are learning, they are motivated to gain that knowledge also. Students in individualized courses learn independently and are isolated from a class. They do not provide stimulus for the remainder of the class nor are they stimulated by others.

Taylor also claims that because individualized learning takes place out of a social context, there is little social reinforcement which gives relevancy to the material learned. The result, Taylor asserts, is that the group learner is more likely to retain material at a higher rate over a longer period of time than the student who had some type of individualized instruction.

The most common criticism that PIPI has received at Oklahoma State University is the penalty that is paid by the procrastinating student. Students who do not study their PIPI courses on a regular basis often fall behind (i.e., their progress is so slow that they are not likely to complete the course in a one-semester period). Then, rather than success, there is only discontent with oneself, the course, and the PIPI "system."

The student who does not progress or who makes only limited attempts at accomplishing his work becomes disenchanted with PIPI, which may lead to even more procrastination. Though there is a provision, under certain circumstances, to permit students who are behind to have more than one semester to complete a course, students often believe this alternative is not acceptable and, at times, withdraw from the course, wasting the time, tuition, and the energy that have been invested.

At least some of these students who have not been able to complete the PIPI courses probably could have successfully completed a course taught in a more traditional manner. It is assumed that more direction from a teacher and an increased degree of structure (i.e., assigned homework and regular examinations) might encourage the "procrastinator" to give more attention to his academic responsibilities.

Conclusions

The learning theories proposed and research conducted regarding "mastery-learning" and "self-pacing" lead one to conclude that if educators ignored the normal curve and concentrated on the majority of students who are not among the gifted, it is possible that students who have not had high academic success in the past can achieve at the mastery level under the more favorable conditions of "self-pacing" and "mastery-learning."

Criticism is aimed at "self-pacing" and "mastery-learning" proponents who cannot prove their assertions nor explain the inconsistencies that result from attempts at empirical verification of the PIPI model.

Ely's work (11) attempted to identify "procrastination" which may result in screening potentially unsuccessful PIPI students, but the fact remains that no learning system is equally effective for all students.

Except for the Washburne (45) study concerning elementary students, there appears to be little in the literature regarding longitudinal effects of the "mastery-learning" and "self-pacing" paradigm.

The main thrust of this research is concerned with the ability of a mastery-trained student to compete with students who have not had mastery training. If the "mastery-learning" and "self-pacing" model of instruction is at least as effective as the more traditional mode, one would expect mastery students to compete on at least an equal basis in later courses, regardless of teaching method used, for which the PIPI or non-PIPI courses serve as prerequisites.

The secondary aim of this study is to determine the rate of retention as measured by the continued enrollment of students in engineering relative to the freshman student's choice of enrolling or not enrolling in one or more PIPI courses.

CHAPTER III

METHODOLOGY AND DESIGN

Introduction

The nature of this research precludes the use of randomization procedures. Therefore, the assumption of equality of the two samples must be supported by available data on the subjects. The ACT scores are a commonly used indication of intellectual level of college students. With respect to the two samples in this study the mean ACT scores were very similar (see Tables XXXIII and XXXIV).

The specific design of this research made four major determinations and required two different sample populations. One sample included those students who matriculated as freshmen in 1972-1973/1973-1974 while the other sample consisted of those students who completed the "sophomore course" during the period 1972-1973/1973-1974. Coincidentally, some students were in both samples. The intent was to make a determination about (1) continuation from the first to the second year in engineering relative to enrollment in PIPI courses, (2) the incidence of freshmen withdrawing from courses relative to enrollment in PIPI courses, (3) achievement in the "sophomore course" in engineering relative to enrollment in PIPI courses while a first-year student, and (4) the incidence of completing the "sophomore course" in engineering relative to enrollment in PIPI courses while a first-year student.

Description of the Sample

The sample considering retention in engineering relative to enrollment in PIPI (or non-PIPI courses) consisted of 533 entering freshmen students who matriculated in the College of Engineering at Oklahoma State University during 1972-1973/1973-1974.

Each entering freshman from these two periods was categorized in one of the following ways:

1. the student enrolled in a PIPI course during his first year and continued his enrollment in engineering the next year;
2. the student did not enroll in a PIPI course during his first year and continued his enrollment in engineering the next year;
3. the student enrolled in a PIPI course during his first year but did not continue his enrollment in engineering the next year; or
4. the student did not enroll in a PIPI course during his first year and did not continue his enrollment in engineering the next year.

Similar categories were determined considering those students, both PIPI and non-PIPI, who withdrew from one or more courses during the semester.

The several groups of students (i.e., PIPI and non-PIPI, PIPI and non-PIPI who withdrew from a course, and PIPI and non-PIPI who did not withdraw from a course) were compared to determine the rate of retention in the College of Engineering at Oklahoma State University from the first to the second year.

The second sample consisted of students who were enrolled in the "sophomore course" in engineering during the fall semester of 1972, the spring semester of 1973, the fall semester of 1973, and the spring semester of 1974. They were surveyed to determine which of them had completed at least one PIPI course prior to enrolling in the "sophomore course" in engineering.

The two groups of students, PIPI and non-PIPI, who had completed the "sophomore course" represent the sample on which this part of the study was based.

There were 94 sophomore students who had completed at least one PIPI course prior to enrollment in the "sophomore course" and 121 sophomore students who had not completed a PIPI course. All the students met the following criteria:

1. they were enrolled at Oklahoma State University prior to taking the "sophomore course" and thus had an opportunity to enroll in a PIPI course. Since freshman-level mathematics, chemistry, physics, and communications represent the PIPI courses, nearly all the sample completed their freshman year at Oklahoma State;

2. architects and others who had not completed a calculus-based physics course were systematically excluded from the sample; and

3. transfer students who had not completed courses at their original institution for which there was a PIPI course available at Oklahoma State University were included in the sample.

Data Collection

Several sources were utilized to accumulate needed data for the study. Official university enrollment as listed on the Student Information List provided by the University Registrar were perused to determine which of the freshmen students of 1972 returned to engineering the fall of 1973 and to determine which of the freshmen students of 1973 returned to engineering the fall of 1974. The respective dates for the lists were September 19, 1973, and September 3, 1974.

"Dean's Cards," which are official records of enrollments, were surveyed to determine which of the freshmen students entering in 1972 and 1973 had enrolled in one or more PIPI courses during their freshman year and which of the freshmen students had not elected to enroll in any PIPI courses. The resultant two groups became the sample to determine retention in engineering relative to PIPI or non-PIPI enrollment.

The second sample for achievement in the "sophomore course" was selected by utilizing Dean's Cards for the four semesters included in the study. After students enrolled in the "sophomore course" were identified according to the earlier enumerated criteria, their level of achievement in the "sophomore course" was determined by consulting instructor grade reports completed at the conclusion of each semester.

It was then necessary to determine which of the students who had enrolled in the "sophomore course" in engineering had completed one or more PIPI courses prior to enrollment in the engineering course. The two resulting groups became the sample to determine achievement in the "sophomore course" relative to the method of instruction prior to enrollment in the "sophomore course."

Statistical Analysis

Analysis of the data for the retention sample was accomplished by using the simple chi-square technique described by Bruning and Kintz (7) to determine the relationship between enrolling in one or more PIPI courses during the freshman year and continuing enrollment in engineering for the sophomore year.

Data are presented for each of the two years, 1972-1973 freshmen who returned in the fall semester of 1973 and 1973-1974 freshmen who returned in the fall semester of 1974 and for the combined enrollments of the PIPI and non-PIPI students for the two-year period.

Additional chi-square analyses are presented to determine relationships between retention in engineering and enrolling in more than one PIPI course, or in specific PIPI courses such as English, mathematics, chemistry, physics and combinations of these courses.

Data resulting from the study of achievement of students in the "sophomore course" relative to the method of prerequisite instruction are analyzed using the contingency coefficient or simple chi-square and phi coefficient described by Bruning and Kintz (7).

Additional contingency coefficients were computed to determine the relationship between the number of PIPI courses completed and achievement in the "sophomore course" in engineering and the relationships between the academic areas treated by the PIPI courses completed (i.e., English, mathematics, chemistry, or physics) and achievement in the "sophomore course."

All critical values of chi-square were tested for significance at the .05 level. Significant critical values permit rejection of the stated null hypotheses. Calculations were done on a Sperry-Remington SSR-8 hand-held calculator.

CHAPTER IV

ANALYSIS OF DATA

Introduction

This chapter presents the analysis of the data generated by the several chi-squares and contingency coefficients in order to test the dependence or independence of the predictive variable.

Several statistical tests were made relative to each of the hypothesis statements although rejecting or accepting the stated null hypothesis is based on the relationship postulated.

Analysis of Data and Presentation of Information Related to Hypothesis I

Hypothesis I: There will be no significant relationship between continued enrollment in the College of Engineering and the method of prerequisite instruction.

Table III describes the rate of retention of students who matriculated in the fall semester of 1972-1973 or 1973-1974 and a record of their continued enrollment in engineering for the second year. The students labeled "PIPI" elected to enroll in one or more PIPI courses during the first year of their studies.

Analysis of this retention data yielded a significant chi-square value of 8.12; thus, Hypothesis I could be rejected. A significantly greater proportion of those freshmen students who enrolled in one or more PIPI courses continued in engineering for the sophomore year than those who elected not to enroll in any PIPI courses (see Table IV).

TABLE III

RATE OF RETENTION OF STUDENTS WHO ENROLLED IN THE COLLEGE OF ENGINEERING FROM THE FRESHMAN TO THE SOPHOMORE YEAR 1972-1973/1973-1974

Type of Enrollment	Enrolled F72	Returned F73	Enrolled F73	Returned F74
PIPI	109	67 (61.4%)	119	85 (71.4%)
Non-PIPI	133	78 (58.6%)	172	88 (51.1%)
TOTAL	242	145 (59.9%)	291	173 (59.4%)

TABLE IV

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN 1972-1973/1973-1974

Type of Enrollment	Returned For Sophomore Year	Did Not Return For Sophomore Year
PIPI	152	76
Non-PIPI	166	139
TOTAL	318	215
Chi-square	8.12 (7.9 = significance at .005)	
Degrees of Freedom	1	
Phi Coefficient	.1234	

The analysis follows for each of the two years in question (i.e., 1972-1973 and 1973-1974) in Tables V and VI. There was no significant deviation from chance for the year 1972-1973 (i.e., the proportion of PIPI to non-PIPI students who returned for their sophomore year in engineering was no different than that expected by chance) but a significant chi-square value was obtained for the entering class of 1973-1974.

TABLE V

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN
1972-1973

Type of Enrollment	Returned for Sophomore Year	Did Not Return For Sophomore Year
PIPI	67	42
Non-PIPI	78	55
TOTAL	145	97
Chi-square	.198	(3.8 = significance at .05)
Degrees of Freedom	1	
Phi Coefficient	.0286	

Obviously, there is much disparity between the chi-square values for the two analyses. It was then determined to analyze the retention data relative to enrollment in PIPI courses from specific academic areas. The following chi-square analyses describe the relationships that existed between the method of instruction in certain freshman courses and retention in engineering.

TABLE VI

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN
1973-1974

Type of Enrollment	Returned for Sophomore Year		Did Not Return For Sophomore Year
PIPI	85		34
Non-PIPI	88		84
TOTAL	173		118
Chi-square	11.99	(10.8 = significance at .001)	
Degrees of Freedom	1		
Phi Coefficient	.2029		

Analysis of this retention data relative to enrollment in one or more PIPI mathematics courses yielded a significant chi-square value of 7.62. Thus enrollment in one or more PIPI mathematics courses can be considered as contributing to a large extent to the significant chi-square of 8.12 that permitted the rejection of Hypothesis I. Tables VIII and IX describe the relationships that exist between the variable for each of the two years in the study.

The data presented in Tables VIII and IX permit the conclusion that retention in engineering for the 1972-1973 freshmen students is independent of instructional method for all courses, but the engineering freshman of 1973-1974 who enrolled in one or more PIPI mathematics courses was more likely to continue in engineering for the sophomore year than the student who chose not to enroll in a PIPI mathematics course.

TABLE VII

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN WHO ENROLLED IN ONE OR MORE PIPI MATHEMATICS COURSES 1972-1973/1973-1974

Type of Enrollment	Returned For Sophomore Year	Did Not Return For Sophomore Year
PIPI	131	65
Non-PIPI	166	139
TOTAL	297	204
Chi-square	7.62 (6.6 = significance at .01)	
Degrees of Freedom	1	
Phi Coefficient	.1233	

TABLE VIII

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN WHO ENROLLED IN ONE OR MORE PIPI MATHEMATICS COURSES 1972-1973

Type of Enrollment	Returned for Sophomore Year	Did Not Return For Sophomore Year
PIPI	63	32
Non-PIPI	78	55
TOTAL	141	87
Chi-square	1.38 (3.8 = significance at .05)	
Degrees of Freedom	1	
Phi Coefficient	.0778	

TABLE IX

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN WHO ENROLLED IN ONE OR MORE PIPI MATHEMATICS COURSES 1973-1974

Type of Enrollment	Returned For Sophomore Year		Did Not Return For Sophomore Year
PIPI	68		33
Non-PIPI	88		84
TOTAL	156		117
Chi-square	6.79	(6.6 = significance at .01)	
Degrees of Freedom	1		
Phi Coefficient	.1577		

Enrollment in a PIPI calculus course was considered as another possible variable worthy of investigation. The following tables (i.e., X, XI and XII) are directed at determining the relationship that exists between enrollment in a PIPI calculus course and retention in engineering for the sophomore year.

The tabled data permits the conclusion that all three groups, 1972-1973 freshmen, 1973-1974 freshmen, and these two groups combined, return to engineering for their sophomore year at a rate significantly different than what would be expected by chance. Thus the predictive variable of enrollment in PIPI calculus is positively related to retention in engineering for the sophomore year.

Enrollment in a PIPI chemistry course was also considered as another variable to be considered. The following tables (XIII, XIV, and XV) describe the relationship that exists between enrollment in a

TABLE X

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN
WHO ENROLLED IN PIPI CALCULUS
1972-1973/1973-1974

Type of Enrollment	Returned For Sophomore Year	Did Not Return For Sophomore Year
PIPI	65	19
Non-PIPI	166	139
TOTAL	231	158
Chi-square	14.23	(10.8 = significance at .001)
Degrees of Freedom	1	
Phi Coefficient	.1923	

TABLE XI

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN
WHO ENROLLED IN PIPI CALCULUS
1972-1973

Type of Enrollment	Returned For Sophomore Year	Did Not Return For Sophomore Year
PIPI	30	3
Non-PIPI	78	55
TOTAL	108	58
Chi-square	12.12	(10.8 = significance at .001)
Degrees of Freedom	1	
Phi Coefficient	.2701	

TABLE XII

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN
WHO ENROLLED IN PIPI CALCULUS
1973-1974

Type of Enrollment	Returned For Sophomore Year		Did Not Return For Sophomore Year
PIPI	35		16
Non-PIPI	88		84
TOTAL	123		100
Chi-square	4.85	(3.8 = significance at .05)	
Degrees of Freedom	1		
Phi Coefficient	.1422		

TABLE XIII

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN
WHO ENROLLED IN PIPI CHEMISTRY
1972-1973/1973-1974

Type of Enrollment	Returned For Sophomore Year		Did Not Return For Sophomore Year
PIPI	21		13
Non-PIPI	166		139
TOTAL	187		152
Chi-square	.67	(3.8 = significance at .05)	
Degrees of Freedom	1		
Phi Coefficient	.0443		

TABLE XIV

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN
WHO ENROLLED IN PIPI CHEMISTRY
1972-1973

Type of Enrollment	Returned For Sophomore Year	Did Not Return For Sophomore Year
PIPI	8	9
Non-PIPI	78	55
TOTAL	86	64
Chi-square	.83 (3.8 = significance at .05)	
Degrees of Freedom	1	
Phi Coefficient	.0743	

TABLE XV

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN
WHO ENROLLED IN PIPI CHEMISTRY
1973-1974

Type of Enrollment	Returned For Sophomore Year	Did Not Return For Sophomore Year
PIPI	13	4
Non-PIPI	88	84
TOTAL	101	88
Chi-square	3.98 (3.8 = significance at .05)	
Degrees of Freedom	1	
Phi Coefficient	.1451	

PIPI chemistry course and retention in engineering for the sophomore year.

The only significnat chi-square value relative to enrollment in PIPI chemistry included data for the freshman class of 1973-1974 (see Table XV). It was difficult to assess any of the chemistry data as the PIPI samples were small. It might be noted, however, that fewer PIPI chemistry students from the 1972-1973 class returned to engineering than students who had not enrolled in PIPI chemistry. Again, caution should be used when making conclusions when so few students chose to enroll in PIPI chemistry.

The next consideration was to determine the relationship between enrollment in a PIPI physics course and retention in engineering for the sophomore year. Physics, either PIPI or non-PIPI, assumes a knowledge of differential calculus and each of the PIPI physics students had completed or were currently enrolled in differential calculus. Though it may seem a little reckless to compare PIPI physics students with the entire non-PIPI population, there is no other comparison that can be made because the non-returning students did not enroll in any physics course; they had transferred to other divisions of the University. Tables XVI, XVII and XVIII report the relationship that exists between enrollment in PIPI physics and retention in engineering.

The chi-square analyses relative to the PIPI physics were inconclusive due to the small frequency of PIPI physics students compared with the frequency of non-PIPI students. There were, however, no significant chi-square values resulting from analysis of PIPI physics returning to engineering for the sophomore year.

TABLE XVI

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN
WHO ENROLLED IN PIPI PHYSICS
1972-1973/1973-1974

Type of Enrollment	Returned For Sophomore Year	Did Not Return For Sophomore Year
PIPI	15	5
Non-PIPI	166	139
TOTAL	181	144
Chi-square	3.21 (3.8 = significance at .05)	
Degrees of Freedom	1	
Phi Coefficient	.0994	

TABLE XVII

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN
WHO ENROLLED IN PIPI PHYSICS
1972-1973

Type of Enrollment	Returned For Sophomore Year	Did Not Return For Sophomore Year
PIPI	6	2
Non-PIPI	78	55
TOTAL	84	57
Chi-square	.848 (3.8 = significance at .05)	
Degrees of Freedom	1	
Phi Coefficient	.0771	

TABLE XVIII

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN WHO ENROLLED IN PIPI PHYSICS 1973-1974

Type of Enrollment	Returned for Sophomore Year	Did Not Return For Sophomore Year
PIPI	9	3
Non-PIPI	88	84
TOTAL	98	87
Chi-square	2.56 (3.8 = significance at .05)	
Degrees of Freedom	1	
Phi Coefficient	.1179	

Finally, chi-square analyses were completed to determine the dependence or independence of the predictor variable of having enrolled in a PIPI English course relative to retention in engineering. Tables XIX, XX, and XXI describe these relationships.

None of the chi-square values relative to enrollment in a PIPI English course were significant. Retention in engineering for the sophomore year is independent of the instructional method.

Summary of the Data Related to Hypothesis I

Hypothesis I: There will be no significant relationship between continued enrollment in the College of Engineering and the method of prerequisite instruction.

TABLE XIX

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN
WHO ENROLLED IN PIPI ENGLISH
1972-1973/1973-1974

Type of Enrollment	Returned For Sophomore Year		Did Not Return For Sophomore Year
PIPI	52		36
Non-PIPI	166		139
TOTAL	218		175
Chi-square	.60	(3.8 = significance at .05)	
Degrees of Freedom	1		
Phi Coefficient	.0391		

TABLE XX

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN
WHO ENROLLED IN PIPI ENGLISH
1972-1973

Type of Enrollment	Returned For Sophomore Year		Did Not Return For Sophomore Year
PIPI	22		19
Non-PIPI	78		55
TOTAL	100		74
Chi-square	.31	(3.8 = significance at .05)	
Degrees of Freedom	1		
Phi Coefficient	.0428		

TABLE XXI

ANALYSIS OF RETENTION DATA FOR ENTERING FRESHMEN
WHO ENROLLED IN PIPI ENGLISH
1973-1974

Type of Enrollment	Returned For Sophomore Year		Did Not Return For Sophomore Year
PIPI	30		17
Non-PIPI	88		84
TOTAL	118		101
Chi-square	2.38	(3.8 = significance at .05)	
Degrees of Freedom	1		
Phi Coefficient	.1043		

Chi-square analysis of the data for the two years included in this study yielded a value of 8.12 with one degree of freedom. A chi-square value of this magnitude was significant at the .005 level. Thus, the null hypothesis was rejected, and it was concluded that enrolling in one or more PIPI courses was related to continuation from the freshman to the sophomore year in engineering.

The chi-square value for the entering class of 1972-1973 relative to retention in engineering was not significant while the value for the class of 1973-1974 was significant at the .001 level. Table XXII presents the findings of the study relative to enrollment in the several PIPI courses and returning to engineering for the sophomore year.

The rate of retention for the groups of students who entered in the fall semester of 1972 or 1973 was similar--145 of 242 or 59.9 percent of of the 1972 freshmen returned to engineering and 173 of 291 or 59.4 percent of the 1973 freshmen returned to engineering.

TABLE XXII

REVIEW OF FINDINGS RELATIVE TO ENROLLMENT IN ONE OR MORE PIPI COURSES

Name of Course	Matriculated 1972-1973/1973-1974	Matriculated 1972-1973	Matriculated 1973-1974
Mathematics	Sig	No	Sig
Calculus	Sig	Sig	Sig
Chemistry	No	No	Sig
Physics	No	No	No
English	No	No	No

Sig = chi-square significant at .05 level

No = chi-square not significant at .05 level

Analysis of Data and Presentation of Information

Related to Hypothesis II

Hypothesis II: There will be no significant relationship between the incidence of withdrawing from courses during the freshman year and method of prerequisite instruction.

There were 175 freshmen students who completed their freshman year while enrolled in the College of Engineering during 1972-1973. This group included 145 students who returned for their sophomore year in engineering and 30 students who transferred from the College of Engineering after the completion of their first year or who did not return to the University.

Similarly, there were 206 freshmen students who completed their freshman year while enrolled in the College of Engineering during 1973-1974 inclusive of 33 students who did not return to study engineering for their sophomore year.

Analysis of Table XXIII revealed that enrolling or failing to enroll in a PIPI course is not related to the incidence of withdrawing from courses. Students withdrew from courses, both PIPI and non-PIPI, at a rate independent of the method of instruction. Analysis of each year included in the study follows in Tables XXIV and XXV.

TABLE XXIII

ANALYSIS OF INCIDENCE OF WITHDRAWING FROM COURSES DURING THE FRESHMAN YEAR 1972-1973/1973-1974

Type of Enrollment	Withdrew From One Or More Courses	Did Not Withdraw From Any Courses
PIPI	67	106
Non-PIPI	69	139
TOTAL	136	245
Chi-square	1.27	(3.8 = significance at .05)
Degrees of Freedom	1	
Phi Coefficient	.0577	

TABLE XXIV

ANALYSIS OF INCIDENCE OF WITHDRAWING FROM
COURSES DURING THE FRESHMAN YEAR
1972-1973

Type of Enrollment	Withdrew From One Or More Courses	Did Not Withdraw From Any Courses
PIPI	25	56
Non-PIPI	30	64
TOTAL	55	120
Chi-square	.02	(3.8 = significance at .05)
Degrees of Freedom	1	
Phi Coefficient	.0113	

TABLE XXV

ANALYSIS OF INCIDENCE OF WITHDRAWING FROM
COURSES DURING THE FRESHMAN YEAR
1973-1974

Type of Enrollment	Withdrew From One Or More Courses	Did Not Withdraw From Any Courses
PIPI	42	50
Non-PIPI	39	75
TOTAL	81	125
Chi-square	2.79	(3.8 = significance at .05)
Degrees of Freedom	1	
Phi Coefficient	.1164	

Since the chi-square values derived from the statistical tests relative to the incidence of withdrawing from courses are not significant, one can conclude that withdrawing from courses during the freshman year for the two years included in this study was independent of the instructional method. Thus, the null hypothesis statement was accepted as stated.

Summary of the Data Related to Hypothesis II

Hypothesis II: There will be no significant relationship between the incidence of withdrawing from courses during the freshman year and method of prerequisite instruction.

The assertion made by critics of individualized systems of instruction that there is a higher incidence of withdrawal from courses among students enrolled in PIPI-like programs than in traditional instructional methods is questioned by this research.

Chi-square analysis of the data for the two years included in this study yielded a value of 1.27 with one degree of freedom. A chi-square of 3.8 was significant at the .05 level with one degree of freedom and would be required before the null hypothesis could be rejected. Thus, the incidence of withdrawing from courses in this study was independent of instructional method.

Analysis of Data and Presentation of Information Related to Hypothesis III

Hypothesis III: There will be no significant relationship between the letter grade earned (A, B, C, D, F, or W) in the "sophomore course" and the method of prerequisite instruction.

Analysis of the data to determine the relationship between the PIPI (N=94) and non-PIPI (N=124) students yielded an insignificant chi-square value of 3.75 with three degrees of freedom. Thus, the null hypothesis was accepted. Students who had completed a PIPI course were not more likely to earn a higher grade in the "sophomore course" than non-PIPI students.

Grades of A, B, and C were considered as separate achievement levels, but grades of D, F and W were compressed to one grade and considered as unsatisfactory. The grades of D, F, and W occurred sufficiently infrequent to exist as separate categories and using a PIPI concept, anything less than a C grade is indeed unsatisfactory.

TABLE XXVI

ANALYSIS OF ACHIEVEMENT IN THE "SOPHOMORE COURSE" AFTER COMPLETING ONE OR MORE PIPI COURSES

Type of Enrollment	Grade Achieved			
	A	B	C	UNSAT
PIPI	33	22	24	15
Non-PIPI	33	41	25	22
TOTAL	66	63	49	37

Chi-square 3.75 (7.8 = significance at .05)
Degrees of Freedom 3
Contingency Coefficient .1309

Additional analyses were completed to determine if there were significant relationships between specific PIPI courses and achievement in the "sophomore course."

Thus, completion of a PIPI mathematics course was not a significant predictor of achievement in the "sophomore course." Next, completion of the prerequisite calculus course was considered as a possible predictor of achievement in the "sophomore course." Much of the content of the "sophomore course" requires the student to understand as well as apply differential calculus. If the PIPI calculus course was, in fact, learned to "mastery," one would expect the students who had completed PIPI calculus to achieve in the "sophomore course" at a level consistent with "mastery-learning." But as Table XXVIII reveals, completing PIPI calculus was not a predictor of success in the "sophomore course."

TABLE XXVII

ANALYSIS OF ACHIEVEMENT IN THE "SOPHOMORE COURSE" AFTER COMPLETING PIPI MATHEMATICS

Type of Enrollment	Grade Achieved			
	A	B	C	UNSAT
PIPI	20	15	18	9
Non-PIPI	33	41	25	22
TOTAL	53	56	43	31

Chi-square 3.15 (7.8 = significance at .05)
Degrees of Freedom 3
Contingency Coefficient .1301

TABLE XXVIII

ANALYSIS OF ACHIEVEMENT IN THE "SOPHOMORE COURSE" AFTER COMPLETING PIPI DIFFERENTIAL CALCULUS

Type of Enrollment	Grade Achieved			
	A	B	C	UNSAT
PIPI	12	8	4	3
Non-PIPI	33	41	25	22
TOTAL	45	49	29	25

Chi-square 3.30 (7.8 = significance at .05)
Degrees of Freedom 3
Contingency Coefficient .1477

There were too few students in the sample who had completed PIPI chemistry or PIPI physics to use any test but simple chi-square. The analysis of these two courses relative to success in the "sophomore course" follows in Tables XXIX and XXX. Achievement in the "sophomore course" is indicated by "SAT" for a grade of A, B, or C and "UNSAT" for a grade of D, F, or W.

Since the chi-square values were not significant, it follows that completing the PIPI chemistry or PIPI physics course was not significantly related to satisfactory performance in the "sophomore course."

Finally, completion of PIPI English was analyzed to determine if this factor was able to predict level of achievement in the "sophomore course." Analysis of PIPI English follows in Table XXXI.

TABLE XXIX

ANALYSIS OF ACHIEVEMENT IN THE "SOPHOMORE COURSE" AFTER COMPLETING PIPI CHEMISTRY

Type of Enrollment	SAT	UNSAT
PIPI	16	3
Non-PIPI	99	22
TOTAL	115	25

Chi-square .06 (3.8 = significance at .05)
Degrees of Freedom 1
Phi Coefficient .0214

TABLE XXX

ANALYSIS OF ACHIEVEMENT IN THE "SOPHOMORE COURSE" AFTER COMPLETING PIPI PHYSICS

Type of Enrollment	SAT	UNSAT
PIPI	18	2
Non-PIPI	99	22
TOTAL	117	24

Chi-square .81 (3.8 = significance at .05)
Degrees of Freedom 1
Phi Coefficient .0760

TABLE XXXI

ANALYSIS OF ACHIEVEMENT IN THE "SOPHOMORE COURSE" AFTER COMPLETING PIPI ENGLISH

Type of Enrollment	Grade Achieved			
	A	B	C	UNSAT
PIPI	9	7	11	4
Non-PIPI	33	41	25	22
TOTAL	42	48	36	26

Chi-square 3.72 (7.8 = significance at .05)
Degrees of Freedom 3
Contingency Coefficient .1545

Thus, completion of PIPI English was not related to level of achievement in the "sophomore course."

Summary of the Data Related to

Hypothesis III

<u>Hypothesis III</u>: There will be no significant relationship between the letter grade earned (A, B, C, D, F, or W) in the "sophomore course" and the method of prerequisite instruction.

The 94 students who completed one or more PIPI courses and the 121 students who had not completed any PIPI courses were surveyed to determine their level of achievement in the "sophomore course" in engineering. The chi-square value associated with the analysis for this group was 3.75 with three degrees of freedom. A chi-square value of 7.8

is required to be significant at the .05 level. Thus, the stated null hypothesis was accepted.

Additional contingency coefficients and simple chi-square evaluations were done to include analyses of achievement in the "sophomore course" after completing specific courses utilizing the PIPI method. PIPI courses considered were (1) any mathematics course, (2) differential calculus, (3) chemistry, (4) physics, or (5) English. Thus, completion of any of the several PIPI courses was not related to the level of achievement in the "sophomore course" in engineering.

Analysis of Data and Presentation of Information Related to Hypothesis IV

Hypothesis IV: There will be no significant relationship between the method of prerequisite instruction and completion of the "sophomore course."

There were 94 students who enrolled in the "sophomore course" who had previously completed one or more PIPI courses. One of the assumptions of PIPI-type learning systems is that students who have experienced success in self-paced, mastery-learning courses develop a positive attitude toward academic success, and because of the hierarchial nature of self-paced curricula it is necessary to complete the courses to have success.

Hypothesis IV, then, was designed to test the hypothesis that students who have had previous PIPI experience would complete the "sophomore course," even though their grade in the "sophomore course" may have been unsatisfactory, they would not withdraw from the "sophomore course" but would remain as a student in the course.

The chi-square value for testing the hypothesis was not significant at the .05 level with one degree of freedom. Thus, the null hypothesis was accepted as stated.

TABLE XXXII

ANALYSIS OF WITHDRAWAL FROM "SOPHOMORE COURSE"

Type of Enrollment		Course Completed	Withdrew From Course
PIPI		88	6
Non-PIPI		111	10
TOTAL		199	16
Chi-square	.27	(3.8 = significance at .05)	
Degrees of Freedom	1		
Phi Coefficient	.0356		

Summary of the Data Related to

Hypothesis IV

Hypothesis IV: There will be no significant relationship between the method of prerequisite instruction and completion of the "sophomore course."

The chi-square value related to completion of the "sophomore course"--regardless of grade--and method of prerequisite instruction was not significant. Thus, completing one or more PIPI courses was not a useful predictor for determining which students would complete the "sophomore course." Completion of the "sophomore course" was independent of instructional method.

Summary

This chapter has presented the statistical analysis of the data collected for the study. Simple chi-square or contingency coefficient analysis of each hypothesis and analysis of the several subsets which, taken together, made up the hypothesis were accomplished.

The analysis attempted to test the dependence or independence of continuing in engineering for the sophomore year relative to having enrolled in one or more PIPI courses for one sample of students. Analysis for the second sample tested the dependence or independence of achievement in the "sophomore course" in engineering relative to the method of instruction in courses prerequisite to the "sophomore course."

The testing of the four hypotheses yielded the following results:

1. Students who enrolled in one or more PIPI courses during their freshman year were more likely to return to engineering for their sophomore year in engineering than those students who did not enroll in any PIPI courses.

2. There is no relationship between the rate at which PIPI or non-PIPI students withdraw from courses during their freshman year; thus withdrawing from courses is independent of instructional method.

3. There was no significant relationship between level of achievement in the "sophomore course" and method of prerequisite instruction; thus completing a PIPI course was not a useful predictor of achievement in the "sophomore course."

4. There was no significant relationship between completion of the "sophomore course" and method of prerequisite instruction; thus having completed one or more PIPI courses was not a useful predictor of which students would complete the "sophomore course."

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

The preceding chapters described the nature of the study, a description of the sample, method of analysis and rationale for accepting or rejecting the hypotheses. This chapter presents an overview of the study, a summary of each of the hypotheses, and recommendations for further research.

Overview of the Study

There is a great concern among engineering college administrators that there is not a sufficient number of students enrolling in the several engineering curricula to produce adequate engineering graduates for the future.

Since it was expected that university enrollments are likely to decline in the next 25 years, attention was given to the solution of the retention problem.

A "self-paced," "mastery-learning," group of courses was designed at Oklahoma State University. A preliminary study completed in 1971-1972 permitted the conclusion that PIPI students had higher rates of retention in engineering (48).

Hypotheses were constructed to confirm or deny the claim of less attrition for engineering students who enrolled in one or more of the

PIPI courses; to confirm or deny that PIPI students withdrew from fewer courses during their freshman year; to confirm or deny that students who completed at least one PIPI course would achieve at a higher level in the "sophomore course" in engineering; and finally, to confirm or deny that students who had completed one or more PIPI courses were more likely to remain in the "sophomore course" until it was completed.

One sample consisted of 533 freshmen who enrolled in engineering in 1972-1973 and 1973-1974, 228 of whom chose to enroll in one or more PIPI courses. The second sample consisted of 218 students who completed the "sophomore course" in one of the four semesters--fall, 1972 through spring, 1974. Chi-square techniques were applied to determine which of the relationships were significant.

Summary of the Findings

Four hypotheses were tested to determine the relationship between retention in engineering and the method of prerequisite instruction, and the relationship between success in a "sophomore course" in engineering and the method of prerequisite instruction.

Hypothesis I

Students who chose to enroll in one or more PIPI courses during their freshman year (1972-1973/1973-1974) were more likely to return to engineering for their sophomore year than those students who did not choose to enroll in one or more PIPI courses during their freshman year.

Hypothesis II

Students who chose to enroll in one or more PIPI courses during their freshman year (1972-1973/1973-1974) were not more likely to withdraw from courses during their freshman year than those students who did not choose one or more PIPI courses during their freshman year.

Hypothesis III

Students who completed one or more PIPI courses prerequisite to the "sophomore course" in engineering were not more likely to achieve at a higher level in that course than those students who completed the prerequisite courses in the traditional manner.

Hypothesis IV

Students who completed one or more PIPI courses prerequisite to the "sophomore course" in engineering were not more likely to complete the "sophomore course" than those students who completed the prerequisite courses in the traditional instructional manner.

Conclusions

The conclusion section of this study will be discussed in two segments. The first, relative to the problem of attrition; and the second, relative to achievement in the "sophomore course" in engineering.

Conclusions Relative to Attrition

There is statistical significance that permits the conclusion that students who choose to enroll in one or more PIPI courses are more likely to return to engineering for their sophomore year than those students who do not choose to enroll in a PIPI course.

There is, however, great disparity between the chi-square values for the two years that retention was studied. The chi-square value for the PIPI students entering in 1972-1973 relative to the non-PIPI students in the same year was .198, while the value for the 1973-1974 class was 11.99. In combination, the value was 8.12, which was significant at the .005 level.

The great disparity in the values caused the researcher to look beyond the problem statement, and a survey was made of ACT scores for the two groups (see Table XXXIII).

TABLE XXXIII

ACT SCORES FOR ENTERING FRESHMEN
1972-1973/1973-1974

Subtest	1972-1973 N = 246	1973-1974 N = 289
English	20.3	20.2
Mathematics	26.6	26.3
Social Studies	22.6	22.1
Natural Science	26.3	25.6
Composite	24.2	23.7

Assuming a random distribution of the scores there is no difference in these two groups when comparing ACT scores. Even assuming that more intelligent students are more apt to succeed in PIPI-type courses, there is no answer here because the scores were, if anything, lower for

1973-1974 than for 1972-1973.

The next step was to compare the scores of those students who enrolled in PIPI courses for the two years in question (i.e., 1972-1973/ 1973-1974), and again there appeared to be little, if any, difference (see Table XXXIV).

TABLE XXXIV

ACT SCORES FOR ENTERING FRESHMEN WHO ENROLLED IN ONE OR MORE PIPI COURSES 1972-1973/1973-1974

Subtest	1972-1973 N = 109	1973-1974 N = 118
English	21.1	22.1
Mathematics	28.3	28.7
Social Studies	24.2	24.7
Natural Science	27.6	27.9
Composite	25.6	26.0

There being no other direct measures that can be made, one can only assume why such a difference existed in the performance of the PIPI students. Perhaps it was due to more effective academic counseling prior to enrollment. Second, PIPI courses undergo revision annually, perhaps some substantive change during the second year encouraged success, and greater success caused greater content with one's major. Perhaps the teachers responsible for the various PIPI courses were more interested, more personable or more aware of the students needs and thus, greater success and ultimately greater retention resulted.

In reference to the second hypothesis related to the attrition sample, it was determined that PIPI students did not have a significantly higher incidence of withdrawing from courses than did non-PIPI students.

One of the criticisms of "self-paced," "mastery-learning" systems is the frequency of students withdrawing from a course or courses. This is usually attributed to procrastination on the part of the student in the PIPI-like course.

While this study did not relate to the topic of procrastination, it appears that students who enroll in PIPI courses are no more likely to withdraw from courses than are students who enroll in non-PIPI courses.

Conclusions Relative to Achievement in the "Sophomore Course"

There was no statistical evidence to support a claim that those students who had completed PIPI courses were likely to achieve at a higher level in the "sophomore course" than those students who had not completed any PIPI courses prior to taking the "sophomore course."

Further, there was no significant predictor of achievement in the "sophomore course" when considering specific PIPI courses completed by the PIPI students.

The most important conclusion to be gained from this portion of the study is that apparently PIPI students have had adequate preparation for the "sophomore course." This fact permits advisors, instructors, and others who deal with students in a counseling setting to make the suggestion that completing a PIPI-like course is a viable alternative to the more traditional mode of instruction.

In fact, some students may be better prepared and more satisfied in their engineering curriculum if they have an option of completing certain pre-engineering courses in a "self-paced," "mastery-learning" mode.

The second hypothesis relative to the "sophomore course" was aimed at the claim that students who complete PIPI-like courses are likely to complete a task even under less than optimum circumstances. Thus, one might expect students with a PIPI experience to have a significantly lesser incidence of withdrawal from the "sophomore course," but the hypothesis of no relationship was accepted. It should be pointed out that the incidence of withdrawal by both groups of students was very small.

Recommendations for Further Study

There have been numerous studies which have claimed that PIPI-like instruction is, in essence, "good" for everybody. It seems that additional studies should be completed to determine if, in fact, "goodness" is inherent in individualized instruction and further, if it is not "good" for everybody, what kind of personality is especially adaptable to PIPI instruction.

In addition, since this study was hampered by the inability to randomly select and assign students to groups, it is believed such a study must be accomplished to determine the efficacy of such systems.

Although it is difficult to separate the students from the learning system, we must identify the objectives for which we are striving in order to evaluate degrees of success for the student and/or the system.

If we can identify those competencies that are supposed to be achieved by the student in a given course, there is no reason one cannot test for these competencies.

Specific Proposals

It is proposed, therefore, that a study be designed to measure the effectiveness of the PIPI versus the traditional method of instruction. Examples of effectiveness might include (1) achievement in certain courses, (2) success in engineering, (3) scores on examinations administered to both PIPI and non-PIPI students after completing a certain course or any of several evaluation techniques.

Entering freshmen students should be randomly selected and randomly assigned to PIPI or non-PIPI groups to insure random distribution of possible confounding variables. The question of enrolling a student in more than one PIPI course is an additional variable. There is certainly a possibility that enrollment in more than one PIPI course during the same semester introduces a different set of variables than would exist if the student were only enrolled in one PIPI course.

Evaluating the level of achievement among those who enrolled in only one PIPI course would seem to be evaluating the effectiveness of a PIPI technique in terms of course content or material mastered, but enrollment in several PIPI courses concurrently may be sufficiently confounding that mastery of one course could be masked.

It would certainly be possible to measure the effectiveness of several PIPI courses by utilizing different groups to evaluate different academic areas. Thus, Group A-1 might be enrolled in PIPI calculus and Group A-2 in traditional calculus; Group B-1 in PIPI chemistry and Group

B-2 in traditional chemistry, etc. Other characteristics could also be included such as ACT scores, high school class rank, size of high school graduating class, or scores on some other pertinent instrument.

If it is difficult or impossible to select a satisfactory instrument to measure the effectiveness of each teaching technique, it is suggested that each group respond to the other's examinations or perhaps the professors responsible for the courses could agree on a common evaluation based on common objectives. Assuming randomization procedures are observed, significant differences that exist between the two groups could be attributed to the efficacy of the learning system or to some interactions within the system.

Other criteria could be used to determine differences between the two systems, but studies which use criteria other than mastery of content seem to be identifying the student's reaction to individual instruction rather than measuring what the system accomplished. That is, a student may be a more successful engineering student because of PIPI, although he may or may not be learning more than his peer who is enrolled in courses that are taught in a more traditional manner. It may be that the reaction of certain personalities to PIPI causes a positive attraction to one's studies and has little to do with learning course content to a level of mastery.

There may also be an interaction effect between some personality characteristics (e.g., intelligence, motivation, persistence) and achievement in many students. We know far too little about what motivates students to perform at higher or lower levels of achievement. PIPI may provide the medium which permits optimum frequencies of academic success for some students while traditional instruction may be more appropriate for other personality types.

Any further studies should include a general orientation session for the students who are participating in the study. Even at the risk of a confounding "Hawthorne effect," students enrolling in a PIPI course should be made aware of the nature of PIPI instruction and the dangers of procrastination. Most freshman college students have had 12 years to experience a "traditional" educational setting and, for the most part, have had reasonable success. One should avoid pushing them into a completely new and alien instructional system without providing a substantial introduction to the individualized learning system.

While we are interested in an instructional method, the impact the "method" has upon the student should not be ignored. He must be prepared to deal with a new kind of instructional bureaucracy. Conditions should be adjusted to encourage the students to overcome the inertia of getting started and thus the majority will achieve success. Perhaps practice sessions could be designed for use in the orientation session to teach the technique of learning in individually paced courses.

A second type of study might be concerned with the cost of PIPI instruction relative to traditional instruction methods. In these days of continuing pressure to be economical in higher education, it is an absolute that we must pursue any possibility of maintaining or lowering costs if it can be accomplished without negatively affecting the educational experience students expect and deserve. Keller (24) claims that under certain circumstances, individualized systems of instruction which are populated at optimum levels are less expensive than traditional systems. A study should be conducted measuring cost effectiveness versus output in the PIPI and non-PIPI systems to both evaluate and attract attention to this feature of PIPI-like instruction.

Ultimately, we must decide if PIPI does have inherent "goodness" or if it is appropriate for the majority of students. Assuming PIPI is a more efficient system of learning, we need to determine in future studies if it is better for some segments of the student population than for another. We also must consider the implications that studies of the suggested type may have on the future.

Certainly, no study evaluating PIPI on one campus should be construed to express "truth." The PIPI courses, the instructors, and the students are not static. Regular evaluation must be conducted to monitor the system as well as the learners.

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