To the Graduate Council:

I am submitting herewith a thesis written by D. Sharon Husch entitled "An Investigative Study of the Effects of Personalized System of Instruction (PSI) on High School Mathematics Students." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Curriculum.

R. Lewis Hodge, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

X

AN INVESTIGATIVE STUDY OF THE EFFECTS OF PERSONALIZED SYSTEM OF INSTRUCTION (PSI) ON HIGH SCHOOL MATHEMATICS STUDENTS

A Thesis

Presented for the

Master of Science

Degree

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D. Sharon Husch

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ABSTRACT

The purpose of this study was to compare lecture-recitation and PSI methods of teaching fractions at the high school level. The comparison was based on two variables: (1) performance of the students as shown by their academic achievement based on scores for the fractions part of a standardized test, and (2) the attitude of the students toward the method of instruction as measured by an attitude instrument which was administered at the time of the posttest.

This study was conducted in a Knoxville (Tennessee) public high school in the spring of 1980. It compared one PSI taught class of elementary algebra I-part II with two conventionally taught classes of elementary algebra I-part II on a unit in fractions developed by the researcher.

There were 34 students in the lecture classes and 16 students in the PSI class. Students in the PSI taught class were given a course description with information concerning course requirements, grading, and teacher-expectations of the students. The class was organized as set forth by Keller and Sherman in The Keller Plan Handbook. The lecture-recitation classes were treated in the usual way, i.e., taught by lecture, given homework, and then tested.

At the conclusion of the study, all students took a common posttest covering fractions and completed a

modified Akin attitude instrument. The findings of the study, as determined by a t-test for independent samples, were:

1. No significant differences were found among the mean posttest scores of the experimental and lecture-recitation classes at the .05 significance level. Therefore, the null hypothesis of no significant differences in the mean achievement scores of the two groups was not rejected.

2. At the .05 significance level, the attitude instrument produced no significant differences. Therefore, the null hypothesis of no significant differences in the mean attitude scores of the two groups was not rejected.

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CHAPTER I

INTRODUCTION

Gallup (20) has said that "we are teaching content to our students in an era when content becomes obsolete in less than a decade, and what we should be teaching students is how to learn how to learn; how to learn how to perceive; how to learn how to think about and solve those to-be-formulated problems; we should be teaching flexibility and variability, and creativity." Gallup states further that creativity can be taught because it is behavior. Behavioral analysis could provide one means for increasing the creativity in the world. Along with this, we would have the added benefit of conditioning our students to have a love for learning instead of a desire for a grade.

The Keller Plan or Personalized System of Instruction (PSI) is an individually-paced mastery-oriented teaching method that promotes achievement of the above mentioned behavioral objectives. PSI is an alternative to the more traditional lecture-recitation method of instruction. The PSI method is presently being used in many countries (America, England, Mexico, Venezuela, New Foundland, and Canada, to name a few) and in virtually every subject area. However, it has been used most extensively at the college level.

I. STATEMENT OF THE PROBLEM

This study was a comparative study of the lecture-recitation and PSI methods of teaching fractions at the high school level. The comparison was based on two variables: (1) performance of the students as shown by their academic achievement based on scores for the fractions part of the Shaw-Hiehle: Individualized Computational Skills Program Computation Test (Form A) 5-6 (58) which was used both as a pretest and as a posttest, and (2) the attitude of the students toward the method of instruction as measured by an attitude test (1) which was administered at the time of the final examination.

The study was designed to test the following hypotheses, using analyses of the variance:

1. There will be no significant differences in the mean achievement scores of the experimentally taught students and the lecture-recitation taught students.

2. There will be no significant differences in the mean attitude scores of the students who are taught by PSI and the students who receive the traditional type of instruction.

II. PROCEDURES AND SOURCES OF DATA

The study was conducted in an area high school. There were approximately 20 students in each of the 5 classes used for the purposes of this study. The Shaw-

Hiehle: Individualized Computational Skills Program Computation Test (Form A) 5-6 (58) served both as a pre-test and a posttest for all sections. The students' academic achievement was measured as a function of their test scores.

Students in the PSI taught classes were given a course description with information concerning course requirements, grading, teacher-expectations of students, and so on. See Appendix A for a copy of these instructions.

The lecture-recitation classes were treated in the normal fashion, i.e., taught by lecture, given homework, and then tested.

Selection of the Population

The population was selected from an area high school. The students had varying mathematical and intellectual abilities, according to the Knoxville City School System. The students' attitudes toward the subject ranged from highly positive to negative, as was reported by their classroom teacher. The population consisted of 93 tenth grade mathematics students who were enrolled in elementary algebra I-part II, geometry, and consumer mathematics classes.

Elements Needed for the Study

1. The following instruments were used:
    a. Section handouts
    b. Quizzes--four versions per section

c. An attitude instrument (Aiken) (1)

d. The Shaw-Hiehle: Individualized Computational Skills Program Computation Test (Form A) 5-6; Part II Common Fractions (58)

2. The following personnel were used for the program:

a. A teacher

b. Student-proctors

3. The following data were collected:

a. Scores on the pretest and posttest

b. Scores on the attitude instrument

III. IMPORTANCE OF THE STUDY

Ruskin (55) has said that a number of our students are finishing high school with little more than twelve to thirteen years of "accumulated ignorance." This study was designed to show that PSI could alleviate education's current problem of "accumulated ignorance" by providing the students with an opportunity to master subject matter rather than passing from one grade level to the next without having mastered the material of the present grade level.

According to Carroll (11),

$$\text{Degree of learning} = f\left(\frac{\text{time actually spent}}{\text{time needed}}\right)$$

and of this, Bloom (6) says that teachers experience normal grade distribution in the classroom as a direct

result of normal aptitude distribution in the classroom. Therefore, given the mastery-oriented learning method of instruction, each learner would have sufficient time to master an assignment, and aptitude would no longer play as important a role in achievement.

Block (5) states:

> In general three-fourths of the students learning under mastery conditions have achieved to the same high standards as the top one-fourth learning under conventional, group-based instructional conditions. In studies where a strategy has been refined and replicated, 90 percent of the mastery learning students have achieved as well as the top 20 percent of the non-mastery learning students. Mastery learning students also have exhibited markedly greater interest in and attitudes toward the subject learned compared to non-mastery learning students. Such dramatic cognitive and affective outcomes suggest that mastery learning cannot be ignored in the planning of future educational practices.

This study was performed in order to compare the traditional method of instruction to the Keller alternative of instruction at the high school level. The study sought to discover if this method of instruction could help rid us of the "accumulated ignorance" which Ruskin (55) addressed.

The researcher gathered data and analyzed the results to see if there were significant differences in the two methods of instruction. In addition to this, the study sought to answer such questions as:

1. What differences in student achievement are evident in the Keller method as opposed to the lecture method of instruction?

2. What differences in attitude are evident, if any, in the PSI taught classes?

3. What are some problems produced for the student and/or the teacher of a PSI taught class?

IV. BASIC ASSUMPTIONS

The following assumptions were present in this study:

1. Students could read and follow directions well enough to participate in the Keller method of instruction.

2. Quizzes and tests were constructed so that they would reflect fairness, validity, and reliability.

3. Proctors were capable of explaining information to the students.

4. Students were honest in grading sectionwork.

5. The attitude instrument used was accurate for determining students' attitude for the course.

6. The teacher did not bias the data by her presentation of the material.

7. The students did not bias the results of the study by their knowledge of participation in an experiment.

8. The sampling of students was diverse with regard to background, ability, and attitude toward the subject.

V. SCOPE AND LIMITATIONS

The study was performed on classes available to the researcher. This greatly inhibited the generalizability of the study. In addition to this problem, the option of students to drop out of the study at any time may have contributed to the loss of meaningful data. A further limitation was that of comparing a PSI unit in fractions developed by the researcher with a lecture-recitation class developed by the teacher of the classes under study.

VI. DEFINITIONS

Keller Plan or PSI: A system of instruction developed by Fred S. Keller in 1963 for use in college psychology courses. It has its basis in reinforcement theory. The students are given handouts defining objectives and setting assignments for necessary completion of each unit. A mastery level of 80%-100% is required in order to pass a quiz. The course is individually paced within the framework of the course, and in place of lectures, the student spends class time studying, taking quizzes, and seeking and receiving private tutoring from teachers or proctors.

Proctor: A student who has passed a quiz on a section and who desires to help fellow students with problem areas in that unit.

Section: A subdivision of the material of the course. The content of each section should represent about one to two day's work. Each unit is defined by the handout for that section.

VII. SUMMARY AND ORGANIZATION OF THE STUDY

In summary, the researcher implemented a PSI program in high school mathematics classes in order to establish some validity to claims of many contemporary educational researchers, namely that PSI promotes mastery over grade achievement.

Chapter II is a review of the literature relevant to the Keller Plan and to individualized K-12 mathematics instruction.

Chapter III is concerned with the design of the experiment and the techniques employed to carry out the study.

Chapter IV is a summary of the findings and an interpretation of the data.

Chapter V deals with conclusions and recommendations with regard to the PSI method of instruction and today's educator.

CHAPTER II

REVIEW OF RELATED LITERATURE

I. INTRODUCTION

According to Keller (32) Personalized System of Instruction (PSI) is not new in its attempts to require mastery learning. He points out that the military has used this approach in promoting persons from one level to the next level. To become an Eagle Scout in the Boy/Girl Scouts of America, a mastery of each division of material is necessary. When a test is failed, the scout has the opportunity to spend more time on that unit before attempting to pass the test a second time. The requirements for each merit badge are synonymous to the small units of material to be covered in the academic subjects taught by the Keller Plan. One might compare the awarding of the Eagle Scout Award to the final grade of a course. The scout studies at a self-prescribed rate and must master all sets of material before receiving the final award--becoming an Eagle Scout. Likewise, the student taught by PSI must master each unit in order to complete the course.

This mastery procedure is used in the teaching of Morse Code to those persons wishing to obtain radio operator's licenses. Mastery of a prescribed amount of material is required. The material is presented in small units. The student studies at her/his own rate, and upon

mastery of each portion of the material, she/he proceeds to the next level. Upon completion (and mastery) of all materials, the applicant is awarded her/his license.

Keller (32) witnessed this mastery-oriented, individually-paced learning in non-academic areas during World War II, but he ". . . did not then appreciate that a set of reinforcement contingencies which were useful in building simple skills . . . might also be useful in developing the verbal repertories, the conceptual behaviors, and the laboratory techniques of university education. It was not until a long time later . . . that [he] came to such a realization."

II. HISTORY

PSI began in 1962 when two North American psychologists, J. Gilmour Sherman and Fred S. Keller, and two Brazilian psychologists, Carolina Martuscelli Bori and Rodolfo Azzi, were assigned the task of establishing a department of psychology at the newly founded University of Brasilia. The teaching method that resulted from their collaboration is the Keller Plan or Personalized System of Instruction (PSI).

This plan was first used at Columbia University in the winter of 1963. The course taught was a short-term laboratory course in psychology. The basic procedure of this pilot study was implemented at Brasilia during the following year by professors Bori and Azzi. The course

was a short-term introductory psychology course with 50 students. The teaching method was received enthusiastically by the students, as well as the university administration. All who completed the course were judged to have an excellent mastery of the course material. The only objections to the method of instruction were those voiced by the professors who enjoyed lecturing to their students and who were unable to lecture in the PSI taught courses.

The Brasilia venture was abruptly ended in the middle of the second semester due to a political upheaval at Brasilia which resulted in the resignation or dismissal of 200 or more teachers. However, it is reported by Keller (32) that members of the original psychology department have taken positions elsewhere and are using PSI in their course instruction. Although PSI was not started until 1963, similar methods of teaching date back as early as 1919 when the public schools of Winnetka, Illinois, began using an instructional method that was very similar to PSI in its main features (37). Since that time, various programs utilizing some form of individualized instruction have developed across the nation and abroad; however, it was not until the early 1960's that individualized instruction developed firm roots. Keller and his colleagues were among the first to apply the concepts of individualized instruction systematically in higher education.

Some of the individualized learning programs at the elementary and secondary level which were developed in

the mid-1960's are Individually Prescribed Instruction (IPI), a project at Pittsburg (20), Stanford's Computer Assisted Instruction (CAI) (2, 60), PSSC Physics, SMSG in mathematics, and ISCS for general science. All these programs are pre-college courses which break the material into small units, sometimes allow students to travel at their own rate, but lack the unit-perfection feature of PSI.

According to Keller (32) there are five features which distinguish PSI most clearly from conventional teaching procedures. They include the following:

(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 advancement, 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 information.
(4) The related stress upon the written word in teacher-student communication; and, finally:
(5) 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.

Some universities (17, 22) allow more than one semester to complete courses while others impose "doomsday contingencies"--either the student reaches a certain point in the material by a deadline or she/he drops the course (24, 25). The lectures and demonstrations are provided to enhance the student's knowledge. Attendance is

optional, and no examination is based upon these lectures. In order to be able to attend the lectures, the student must have mastered a prescribed amount of material.

Proctors

According to Farmer et al. (18), the use of proctors is essential to the success of personalized instruction. The indispensable functions of proctors have been described in detail by Keller (32). The most important tasks of the proctors include: (1) the careful scheduling of reinforcing events which, to be effective, must immediately follow the desired variant of student's behavior; and (2) increasing the chances that the desired variants will appear in the individual student's repertoire of behavior. A study was carried out at Queens College of the City University of New York involving varying percentages of proctoring of the units of the course. The clearest conclusion to be drawn from the results is that some proctoring (25% or more) is both necessary and sufficient to improve a student's rate of progress. While serving as a proctor, the students achieved a mastery of the material with less exposure and in less time (18).

With the proctor performing all of the duties once done by the instructor of the courses, the teacher is left with the tasks of answering questions, treating the unique, and adding the artistry that cannot be predicted. The system frees her/him from treating the mundane and

repetitious so that she/he can have the time to deal with the creative (60).

PSI Organizations

In June, 1971, the first issue of the PSI Newsletter was published. Its purpose was to promote communication of developments in PSI technique and applications. Donations from individuals and institutions paid the printing and mailing expenses. PSI Newsletter was issued four times a year, and was written by Ruskin and Sherman, members of the psychology department, Georgetown University, Washington, D.C. By October, 1973, Georgetown University had received some grants from the Fund for the Improvement of Post-Secondary Education and from the Carnegie Corporation of New York and a Center for Personalized Instruction at Georgetown University was under construction. The primary function of the Center for Personalized Instruction was to collect and distribute research reports by publication of the PSI Newsletter, sponsoring workshops and national conferences, and the eventual publication of the Journal of Personalized Instruction which began in March, 1976. The Journal of Personalized Instruction began where the newsletter left off and appeared March, 1976, quarterly, through September, 1978 and Spring 1980. Some financial problems caused a delay of the 1979 issues of the journal, and a recent conversation with a member of the Center of Personalized Instruction staff indicated that the Center

was temporarily closed due to a lack of funds. The staff member was unable to tell the researcher if the Center would be reopened in the future.

III. COMPARATIVE STUDIES

Many comparative studies have been done in the area of PSI versus lecture-recitation taught classes. Refer to Table II-1 for a summary of the comparative studies which have appeared in the literature since the conception of PSI. The listings are alphabetical and include the subject area in which the comparison of the two teaching methods was made. In addition to the comparative studies which have been reported in the literature, Berry (4), Ferster (19), Gallup (20), Green (22), Nelson and Scott (46), Cooper (13), and Leo (38) have reported their use of PSI in the classroom. The reports by the above authors were descriptive in nature.

Nearly all reports have shown superior performance by PSI taught students. Kulik (36) summarized 75 studies which compared PSI with lecture-discussion teaching. He found that PSI improved student achievement in college courses in 57 of 61 studies. Of the other four studies, three found conventional methods of instruction superior, and one study found no significant difference in the two teaching methods. Kulik further reported that 48 of the 61 studies reported statistically significant differences in favor of the PSI taught classes. It was noted that

TABLE II-1

ALPHABETICAL LISTING OF AUTHORS COMPARING PSI AND CONVENTIONALLY TAUGHT CLASSES AND THEIR RESPECTIVE FIELDS

Author	Field
Austin and Gilbert (3)	Physics
Born et al. (8)	Psychology
Breland and Smith (10)	Mathematics
Cole (12)	Psychology
Corey and McMichael (14)	Introductory psychology
Ewing (17)	Mathematics
Hammer (24)	Business
Haver (25)	Mathematics
Herring (26)	Mathematics
Hess (27)	Psychology
Hoberock (29)	Mechanical engineering
Hoberock et al. (30)	Engineering
Kagle (31)	English
Knightly and Sayre (33)	Library science
Koen (34)	Engineering
Kontogianes (35)	Mathematics for elementary education majors
Kulik et al. (37)	Science
Lewis and Wolf (39)	Chemistry
Liguori (40)	Business mathematics
McKean et al. (41)	Mathematics and statistics
McMichael and Corey (42)	Introductory psychology
Moore et al. (43)	Biology
Newton and Abraham (47)	Economics
Philippas and Sommerfeldt (48)	General physics
Pollack and Roeder (49)	Government
Protopapas (50)	Biology
Riner (52)	Freshman mathematics
Roth (54)	Digital systems
Schoen (57)	Mathematics
Sheppard and McDermot (59)	Introductory psychology
Steele (61)	Mathematics
Taylor (63)	Political science
Tietenberg (64)	Economics
Witters and Kent (66)	Anthropology

students who scored below average on the Scholastic Aptitude Test (SAT) performed in PSI taught classes like those students who had above-average SAT scores. Further, PSI improved student ratings of the instruction. Ten of 11 studies found students rating PSI as the superior method of instruction. Twenty-seven studies compared the withdrawal rates of PSI and lecture-recitation sections. Seventeen studies reported higher withdrawal rates in the PSI courses; however, the rate of withdrawal in the PSI classes was 13.8% compared to 10% for the conventionally taught classes.

Grade Performance

Many reports have shown superior performance in PSI taught students. However, it is probably worth noting at this point that almost half of the studies done in mathematics found no significant difference in the students regardless of the method of instruction which was utilized in the course. Herring (26) raised several concerns with this finding, namely, (1) success in physics and engineering when taught by PSI might be due to the abilities and attitudes of those students, i.e., these students should be of high ability and positive attitude by virtue of the fact that they are in that program, and (2) in courses relying heavily on the written word and rote learning, the student may cope better with the PSI method of instruction than students in mathematics.

Table II-2 lists the percentage of A's resulting in some PSI taught classes. Note the considerable increase of grades at the A level when PSI is utilized.

These researchers report a decrease of D's and F's earned by the PSI taught students. Nearly all authors report that their grade distributions no longer look like the traditional bell-shaped curve. One might picture the grade distribution of a PSI taught class and a traditionally taught class as being represented by Figure II-1.

TABLE II-2

THE PERCENTAGE OF A'S GIVEN IN VARIOUS PSI TAUGHT COURSES

Researcher	Percentage of students receiving A's
Berry (4)	80
Born et al. (8)	70
Born and Herbert (9)	50
Cole (12)	35
Farmer, et al. (18)	56
Haver (25)	38
Hess (27)	45
Hoberock (29)	82
Hoberock et al. (28)	70-90
Keller (32)	45
Knightly and Sayre (33)	90
Koen (34)	74
McKean et al. (41)	20 and 50
McMichael and Corey (42)	50
Myers (45)	97
Nelson and Scott (46)	54
Protopapas (50)	34
Sheppard and McDermot (59)	33

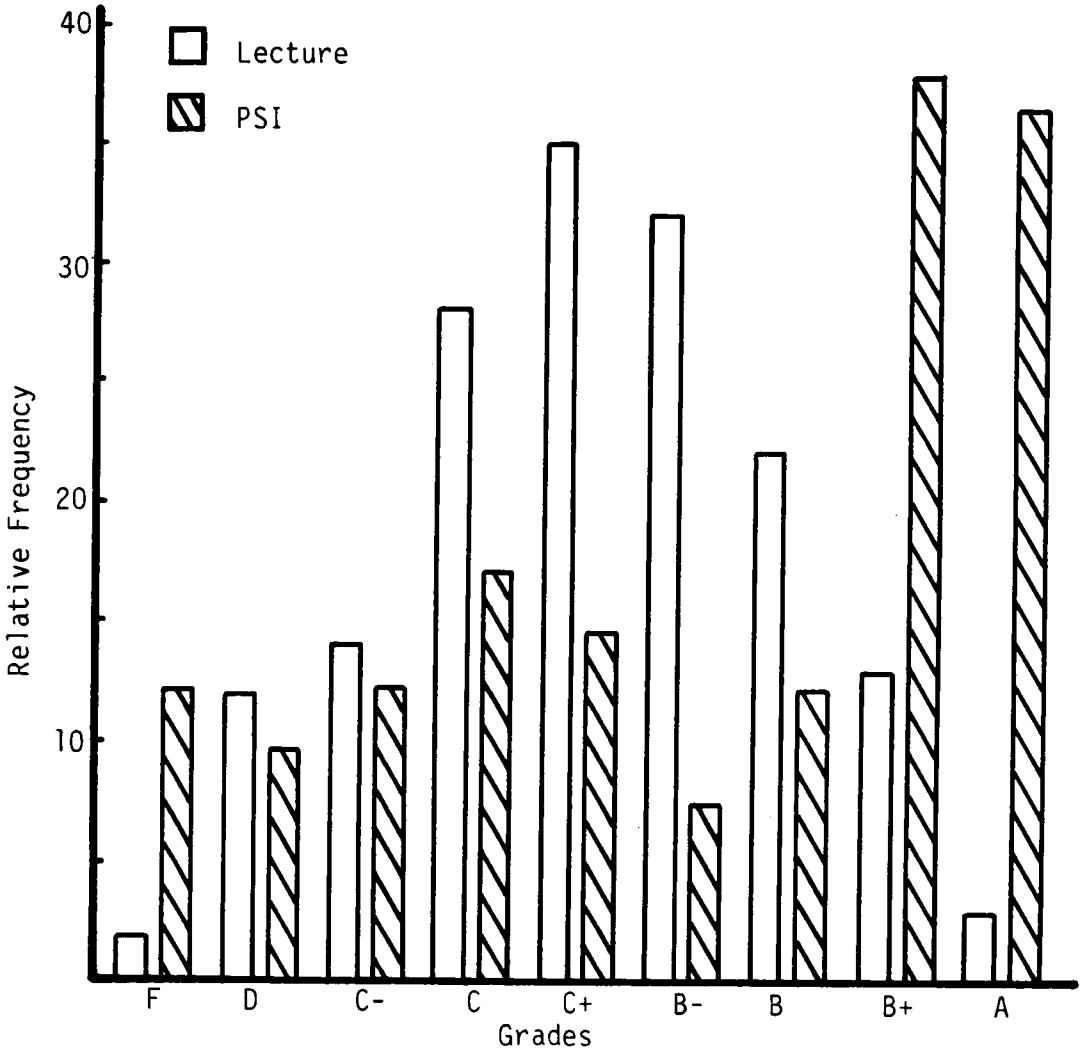


Figure II.1. Representative grade distribution of a PSI class and a lecture-recitation class.

With the PSI teaching method, students who are presumably inferior may show up better or just as well as the presumably superior students who were taught by the more conventional procedures (36). In a truly PSI taught course with no time limit, it would appear that there should be no reason for any student to attain less than an A in any class. The student would be allowed to work at a rate commensurate with her/his ability, thereby allowing her/him to take the needed and necessary time to master the material. However, most universities do put time limits on their students, and not all students are motivated to study hard enough to learn the material well enought to achieve an A. An indication toward that latter fact might be an observance of the drop-out rate experienced by PSI taught sections of the various courses. Many researchers have reported drop-out rates much higher for PSI taught courses. Some students do not want to spend time learning all quarter that they feel they can "cram for" the night before an examination in order to barely pass. Personal interviews with The University of Tennessee, Knoxville students enrolled in the competency-based mathematics courses revealed an attitude ranging from highly positive to highly negative. The primary complaint was, "Why should I study that hard when I can cram the night before an exam and learn just enough to pass?" Educators should consider what this implies about our present educational system.

Retention

There is evidence that students taught by PSI learn more and retain the knowledge longer. Studies done by Hoberock et al. (30), Leo (38) and Corey and McMichael (14) indicated that students who were taught by PSI retained the knowledge they learned longer than students who were taught by the lecture method of instruction. Table II-3 shows data gathered in the Corey and McMichael (14) study. The mean test scores of both the original PSI group, original lecture group and the sample groups that were rested 10 months later are indicated in this table. Notice that the sample PSI group had a higher mean test score 10 months later than did the original lecture group. Further, the test scores of the PSI students decreased only 12% while the test scores of the lecture taught sample decreased 20%.

TABLE II-3

COMPARISON OF RETENTION OF MATERIAL IN PSI AND LECTURE CLASSES

	Mean score	Mean score of sample	Mean score of those retested
Original PSI	78.2	78.9	69.4
Original lecture group	65.1	57.7	54.0

Attitudes

Most studies comparing PSI taught students with lecture-recitation taught students concentrated their efforts mainly on grade performance; however, a few studies made at the college level also reported on attitudes of the students towards the two teaching methods. Koen (34), Sherman (60), Lewis and Wolf (39), and Myers (45) reported highly favorable student attitudes toward PSI taught courses. Kulik (36) reported that 10 of 11 studies which he summarized found that students rated PSI over lecture-recitation taught classes.

Among the reasons stated most frequently by the students favoring PSI over lecture classes were: (1) self-pacing, and (2) no penalties for failures on section quizzes. Personal interviews with The University of Tennessee, Knoxville students found similar attitudes from those students who had positive attitudes towards PSI taught classes. Some students reported negative attitudes towards PSI, complaining that the PSI course was more time-consuming than conventionally taught courses. Schoen (57) reported similar findings, i.e., negative attitudes from PSI taught students due to the large amount of work required in the PSI classes.

Although no studies compared PSI taught students with lecture-recitation students in high school mathematics in regard to attitude, it is worth noting that several authors have stated that attitude towards the subject area

plays a crucial role as to whether the child learns. Creswell and Hudson (16) stated that the ". . . manner in which mathematics instruction is implemented (including materials used) may be a significant factor in how well students master basic concepts . . . ."

Why Does PSI Work?

According to Koen (34),

> PSI is successful because it is built upon well-established principles of learning theory. To illustrate the sophistication of PSI, let us compare it with the usual classroom technique using one elementary principle of psychology--that is, an organism tends to repeat and enjoy behavior for which it is rewarded; it tends to avoid and dislike behavior for which it is punished. The objective of the teacher is to encourage a student to learn and to enjoy learning. PSI has been carefully "designed" so that a student is only positively reinforced (he passes units, attends lectures, is not penalized for not passing an exam, has a chance to get an A up until the last day of class, etc.); he is never negatively reinforced. Contrast this with a conventional system in which a student wagers one-fourth of his grade at each hour examination--a failure from which there is no reprieve.

With this and a philosophy of mastery and a striving for excellence how can it possibly not work? Although PSI may appear to be the panacea, it is not infallible.

Problems

Sherman (60) discussed some of the problems of PSI. Inherent in the system are logistical problems (with everyone self-paced there is a need for a large area to take tests, proctor students, and study, if the student

wishes to study in the classroom). Students fall behind, some procrastinate--actions which require incompletes and additional paperwork for the administration. Professors work harder; students work harder; and there is the expense of additional staff to run a PSI course. Furthermore, the almost prohibitive production time for materials burdens the support system.

Of all of these problems, procrastination on the students' part is considered the most pressing. Hess (27) has suggested a few ways of curbing this problem, which are as follows: (1) keep a cumulative record for each student and plot her/his progress in the student's presence, (2) establish a "doomsday contingency," (3) have proctors contact those persons who are more than a week behind the expected progress; and, finally, (4) schedule the final examinations so that students may finish the course early if they wish. Sherman (60) has suggested letting the students proctor as a way to solve the procrastination problem. The professor proctors the first students who master the unit, and they in turn proctor the remainder of the class. This not only solves the money and manpower problem but also improves the quality of knowledge of the subject gained by the students who participate as proctors. Sherman (60) used students from his course to proctor and reported,

> While some students who were not proctors received over 90 on the final, no proctor fell

> below 90. Seven of the 32 proctors scored 100 on the final--a score not attained by any student who went through the course without proctoring.

Sherman (60) says ". . . the proctors learn more than anyone . . . ." This feature also has the added bonus of appealing to the bright students and keeping them from getting bored.

PSI at the Elementary and Secondary Level of Instruction

To date, there does not appear to be more than a handful of papers written on attempts at using PSI at the elementary and secondary school level. An ERIC search under the descriptors: Personalized System of Instruction, Keller Plan, PSI, mastery learning, self-pacing, contingency management, performance based education, competency, and individualized instruction intersected with mathematics, algebra, geometry, junior high schools, high schools, senior high schools, and secondary grades produced only 43 prints. None of these entries dealt directly with PSI in the elementary, junior high, or senior high mathematics programs. A manual search of the following journals: School Science and Mathematics, The Mathematics Teacher, The Arithmetic Teacher, Journal of Research in Mathematics Education, and Journal of Personalized Instruction using the same descriptors, as well as instruction, teaching methods, and other similar descriptors produced very little information in the particular area of PSI in the elementary or secondary schools.

Competency-Based Curriculum

Competency-based curriculum (CBC), a method of instruction which is similar to PSI in most of its features, was recently implemented in the Washington, D.C. schools. The Winter 1978 issue of the Journal of Personalized Instruction contained a special section devoted to the competency-based curriculum which the Washington, D.C. schools have adopted. The curriculum materials were developed and used in 29 pilot schools in the system during the 1977-1978 school year. These schools field-tested the materials in reading, English/language arts, and mathematics. The school year 1978-1979 was considered to be the first year of actual implementation of the competency-based curriculum in the school system. There will be a continued effort to develop the curriculum materials in all primary subject areas in order to incorporate CBC in the schools in all areas by 1981. Reed (51), the superintendent of schools for the District of Columbia, reported that the school system chose to have a competency-based curriculum starting at the primary level rather than waiting to have competency-based testing prior to high school graduation. Competency-based teaching is the current practice of 30 states as mandated by the state legislature or local school board policy. Reed further states that, "This concept (CBC) has as a basic assumption the belief that all children can learn and that the best possible

program is one that insures that they do learn." Guines (23), associate superintendent, reported "that significant achievements have been made thus far" with the CBC program. Werner and Ruskin (65) pointed out the similarities and differences of CBC and PSI. The two basic differences were as follows:

1. PSI is a system of instruction originally designed for single-classroom implementation while CBC is a systemwide public school curriculum.

2. Instructional techniques and strategies vary throughout the curriculum in CBC as opposed to the dependency on the written word in PSI.

On the other hand, both methods of instruction have the mastery requirement and a teacher-paced or student-paced features. In the situation where students are required to attend classes, the PSI feature of lectures used only for motivational purposes must be somewhat augmented. Werner and Ruskin (65) reported that many teaching methods were used in the CBC, including group instruction and audio-visual instruction.[1]

A further search of the PSI Newsletter uncovered some notices and articles involving uses of PSI in

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[1]A recent conversation with a member of the staff at the Center for Personalized Instruction, Washington, D.C., indicated a lack of written information at the present as to the success of the CBC program. Due to a lack of funds the Center for Personalized Instruction is closed, and it is not yet known whether the center will be reopened.

mathematics teaching. Bobinski (7) reported on the use of PSI in an algebra I course taught to eighth and ninth grade students at Krueger Junior High School, Michigan City, Indiana. The class used the Holt algebra series which had a bi-level pacing chart marked "A" for minimum and "B" for maximum. The students were allowed to choose their own level of intensity and pacing. Each day some class time was spent in group instruction which was followed by a period when students worked individually or in small groups. The students who worked alone scored the highest, worked the fastest, and became the proctors. Bobinski (7) said "it is significant to note that no student enrolled in the class failed to complete at least the minimum requirements at the end of the school year, . . . [and] 12% of the students enrolled in the class had finished the basic course in algebra I and were working with algebra 2 materials at the end."

Two more reports in the PSI Newsletter were descriptive in nature. Cox (15) wrote about the Independent Learning Schools (ILS) in San Francisco, California. The ILS is totally individualized from grades K-12 in all academic areas. His students place from four to five grade levels behind to five or six ahead. ILS is a totally PSI method of instruction and has had a high degree of success. It is interesting to note that Cox reported that the school is thought to be "suspect" because of its high degree of success.

Sachs and Taylor (56), members of the staff of the Mathematics Learning Center (MLC) at the National Technical Institute for the Deaf (NTID), reported on the use of PSI in the center. NTID students come from a varied background and possess a large range of mathematics ability and maturity. The basic task of the school is to provide post-secondary technical training for its students in order to enhance their employability. The responsibility of attending the center and progressing in mathematics is totally left to the student. The center is open 12 hours/day and staffed by 8 full-time instructors, 8 part-time instructors, and 12-15 student assistants. MLC subscribes to the features of PSI in its instruction. This was a descriptive article reporting on the procedure used at the MLC.

Other reports were given on the use and success of PSI employed in other areas such as spelling, English/language arts and science. However, for the purposes of this study, the researcher was primarily concerned with a search for the use of PSI to teach mathematics in the elementary or secondary schools.

Individualized Instruction in Elementary and Secondary Schools

Suydam and Weaver (62) listed 14 dissertation abstracts concerning individualized instruction at the grade school level of instruction. Of the 10 studies comparing individualized instruction to the traditional

method of instruction, 4 found significant differences favoring individualized instruction, 2 favored the traditional method and 4 had no significant differences. In 30 articles reviewed by Hirsch (28) only 5 reported significant differences in favor of individualized instruction, 2 reported significant differences in favor of conventional methods, and the remaining 23 articles found no significant difference in favor of either treatment.

With research findings like this, it is difficult to entice teachers to try PSI at the elementary and secondary school level. However, it is necessary to realize that individualization is only part of the PSI mode of teaching. One of the major problems PSI faces deals with people modifying the program, experiencing failure, and then reporting failures in PSI implementations.

When Not to Use PSI

Is PSI the method in which all courses at all educational institutions should be taught? Probably it is not the best method for every teacher and every class. Green (21) states 15 reasons why a teacher may wish not to use the Keller Plan. They are as follows:

1. Mastery is not the object of your course.
2. There is no adequate test for your course.
3. Your subject changes too fast.
4. You have 500 students, no help, and no time off to prepare materials.
5. Your students can't read, at least not well enough to do without lectures.
6. You are legislatively required to lecture for a large number of hours.

7. You don't have the energy to try something new at this time.
8. Good teaching isn't rewarded at your school.
9. You can't get undergraduate tutors for love, credit or money.
10. One undergraduate cannot judge proficiency in your subject on the part of another undergraduate.
11. Your administration will not tolerate a large fraction of A's.
12. You object on principle to specifying detailed objectives in your course.
13. You cannot specify objectives in your course.
14. You are too soft-hearted to withhold a privilege from a student who has not earned it.
15. You are satisfied with your present method.

CHAPTER III

PROCEDURE AND DESIGN FOR THE STUDY

I. THE STUDY: AN OVERVIEW

This study was conducted in a Knoxville (Tennessee) city high school in the spring of 1980. It compared one PSI taught class of elementary algebra I-part II with two conventionally taught classes of elementary algebra I-part II on a unit in fractions which was developed by the researcher. The comparison was made on three variables: (1) the pretest scores, (2) the posttest scores, and (3) the responses by the students to an attitude instrument.

The PSI fractions unit was field-tested by the author in a ninth grade general mathematics class in the fall of 1979. The researcher has used a variation of PSI in her teaching for the past six years and was convinced that PSI would allow students to experience the mastery in mathematics which is necessary for advancement from one level to the next level in mathematics.

A teacher in an area high school was recruited to teach both the PSI and conventionally taught classes of mathematics. The study was conducted the last two weeks of the school year. The teacher and some of her students served as proctors, and the researcher served in the capacity of consultant.

II. THE STUDENT POPULATION

Five high school mathematics classes were selected for the purposes of this study. Three classes were chosen to participate as experimental classes, and two classes participated as the conventionally taught classes. These classes were consumer mathematics, algebra I, and geometry classes and were taken by students who varied in mathematical ability, motivation, and socio-economic background. Some students took these courses in order to satisfy the Tennessee state requirement of one Carnegie Unit of mathematics for graduation, while other students took these classes as prerequisites for higher level mathematics courses.

Sixteen students in a PSI taught elementary algebra I-part II class were compared with 34 students in two conventionally taught elementary algebra I-part II classes. Two classes, a consumer mathematics class and a geometry class, numbering 22 and 19 respectively, were taught by the PSI method of instruction. Since there were no consumer mathematics and geometry classes available to the researcher for a comparative study, these two classes were treated descriptively and will be reported in Chapter IV. All students volunteered to participate in the study.

III. THE PROCTORS

Proctors in the PSI taught classes were students who had mastered a particular section of the fractions unit as indicated by a class poster. The primary responsibility of each student-proctor was to serve as a tutor for any fellow student experiencing difficulty in any section. The student who needed help consulted the classroom poster, chose a student who had mastered the section in question, and asked for help. The teacher could also be asked for help, although her duties consisted primarily of grading section quizzes.

IV. THE STUDY SECTIONS

No textbook was used in this study. Sections were designed by the researcher to include introductory exercises in fractional parts, equivalent fractions, and the four binary operations on fractions. Problems for the different sections were taken from various junior high school textbooks (44, 53) and designed by the researcher. Supplementary and enrichment materials for the sections were collected from various sources during the past seven years that the researcher has been teaching mathematics.

There were 12 sections in the fractions unit: an introductory section on fractional parts which did not have a section quiz and 11 sections each having 4 versions of

a quiz. The titles of the sections are as follows:

0. Introduction: Fractional Parts
1. Equivalent Fractions
2. Mixed Fractions
3. Addition of Similar Fractions
4. Addition of Unlike Fractions
5. Subtraction of Similar Fractions
6. Subtraction of Unlike Fractions
7. Subtraction of Similar and Unlike Fractions Involving Borrowing
8. Multiplication of Proper Fractions
9. Multiplication of Mixed Fractions
10. Division of Proper Fractions
11. Division of Mixed Fractions

Each section, excluding the introductory section, consisted of a handout made up of an explanation for the section, sample problems, and approximately 20 problems to be worked by the student. An answer sheet for each section was provided for the student to check her/his work upon completion of each section and prior to her/his taking of the section quiz.

V. THE PSI CLASSES

On the first day of the experiment, an explanation of the project was given to all students by their teacher. A duplicated sheet of instructions explaining the nature

of the course was given to each student in the PSI taught classes. A copy of this informational sheet can be found in Appendix A. The students were allowed to ask questions. A pretest was administered. The pretest/posttest can be found in Appendix B.

The second day of class the students began the fractions unit. The 50 minute class time was spent in working problems, seeking help and taking section quizzes. The students took the handout for each section, studied the examples, worked the problems and supplemental materials, checked the work they had done, sought help (if it was needed), and took a section quiz. If the student worked 8 of the 10 problems on the quiz correctly, she/he proceeded to the next section. However, if the student did not have 80% of the problems worked correctly, she/he sought help from the teacher or a student-proctor and took another quiz for the section. The student could take as many quizzes as was necessary for the 80% proficiency requirement. No student took more than four quizzes on a given section. Upon completion of all 12 sections, the student was given the same Shaw-Hiehle test (58) as a posttest. The attitude instrument was completed at this time.

Distinction Between Treatments

The research was designed in order to compare the PSI method of instruction with the lecture-recitation method

of instruction in high school mathematics on a certain unit of study. The conventionally taught students were given the standardized test as both a pretest and a post-test. Otherwise, they were taught fractions in the traditional lecture method of instruction. None of the PSI materials, other than the pretest and posttest, were used with this group. The teacher presented fractions in her personal manner of teaching and the students were allowed to work outside of class. The experimental group adhered to the five features of PSI which are described in Chapter II.

Section Quizzes and Grading

Students were required, by the state, to attend classes; therefore, they did not come to class only to take the quizzes as is done at the college level of PSI instruction. The students requested section quizzes as they felt they were ready for them. Then the student completed the quiz, the teacher graded the quiz in the presence of the student. If a minimum of 80% was attained on the quiz, the student was allowed to begin the next section's work. However, if less than 80% was attained by the student, she/he was directed to review the material, seek help in problem areas, and take another quiz. There was no limit to the number of section quizzes a student could take in order to achieve the 80% mastery of a given section, and the number of required quizzes in order to

achieve the 80% mastery of each section had no bearing on the final grade for the unit.

Section quizzes consisted of four to five problems from previously completed sections and five to six problems from the new section. The questions on the section quizzes were problems similar to the problems given in the section handout and worked by the student. Four versions of the quiz were constructed by the researcher. All quizzes for any given section were constructed at the same degree of difficulty.

Progress Checks

Each student had a chart (see Appendix C) which indicated at a glance the progress of that student. This chart also allowed the teacher to determine the number of quizzes per section that each student had taken in order to achieve the 80% mastery level.

A class chart indicated the number of sections completed by each student. Students who were having difficulty with a particular section consulted the class chart to find a proctor.

Self-pacing

The students were allowed two weeks to complete the fractions unit. This progress should have been at the rate of slightly more than one section/day. The completion of this unit brought the bonus of completion of the course-work for the year in the mathematics class in which the

student was enrolled in the high school. Some students were highly motivated by this bonus and finished the course of study in six to seven days. Some students procrastinated and did not finish all sections of the unit by the end of school.

Posttest

The standardized test (58) was given as an exam on the fractions unit. It consisted of eight problems involving addition, multiplication, subtraction, and division of proper and mixed fractions. It was necessary to know how to deal with equivalent, improper, and mixed fractions in order to score well on the test. The test was given to each member of the PSI class as she/he completed the unit of work. The entire class of traditionally taught students were given the test rather than individually tested. A copy of this test can be found in Appendix B.

VI. THE LECTURE CLASS

Two elementary algebra I-part II classes, which consisted of 34 students, were chosen to participate in the experiment as lecture-recitation taught classes. They were informed of their part in the study.

The conventionally taught group of students were given the same standardized test as a pretest, presented the material by their teacher, and given and same standardized test as the examination or posttest. Only the pretest,

posttest and attitude instrument were used from the PSI materials in order to compare the two types of instruction. All materials presented in class and all homework problems were provided by the classroom teacher. The lecture classes and the PSI taught classes covered the same topics in fractions.

Attendance was mandatory as dictated by the state; however, participation in the experiment was totally voluntary. A student could request not to be a participant in the study at any time, but no student so requested; however, a few students in the PSI taught classes failed to take the posttest. This automatically eliminated them from the study.

VII. COMPARABILITY OF CLASSES

One class was chosen for the PSI taught class and two classes were chosen for the lecture classes. The high school students attended a school which reportedly has the most diverse population of students of all the Knoxville city schools. The students had varied backgrounds, interests, and ability levels.

To further insure a large degree of comparability, a t-test for independent samples was performed on the pretest scores.

VIII. ATTITUDE INSTRUMENT

At the time of the posttest, an attitude instrument designed to measure the attitude of the students toward the method of instruction used for the unit was administered. A t-test for independent samples was performed on the data to test the hypothesis: There will be no significant differences in the mean attitude scores of the students who are taught by the PSI method and the students who receive traditional type of instruction.

CHAPTER IV

PRESENTATION AND INTERPRETATION OF DATA

I. INTRODUCTION

Chapter IV presents the data collected in this study and the analyses performed on the data with respect to comparability of the sections, the two null hypotheses, and the reliability and validity of the instruments used in obtaining the data.

II. THE CLASSES

The PSI method of instruction was used in three tenth grade high school mathematics classes--one elementary algebra I-part II class, a geometry class, and a consumer mathematics class. The lecture-recitation method was used in two elementary algebra I-part II classes. The schedule of the classes and the method of instruction employed in each class can be located in Table IV-1. The elementary algebra I-part II classes are discussed in an experimental way. The consumer mathematics and geometry classes were treated descriptively and will be dealt with separately at the conclusion of this chapter.

The number of students registered in each class participating in this study is summarized in Table IV-2. The elementary algebra I-part II classes will be listed

TABLE IV-1

SCHEDULE OF CLASSES AND METHOD OF INSTRUCTION

Period	Class	Method of instruction
1	Elementary algebra I-part II	Lecture
2	Consumer mathematics	PSI
4	Elementary algebra I-part II	PSI
5	Geometry	PSI
6	Elementary algebra I-part II	Lecture

TABLE IV-2

ENROLLMENT IN THE CLASSES

Period	Class	Enrollment
1	EA-L	18
2	CM-PSI	22
4	EA-PSI	18
5	G-PSI	19
6	EA-L	16

as EA-L for the lecture class and EA-PSI for the PSI taught class. The consumer mathematics class and geometry class, both taught by the PSI method, are listed as CM-PSI and G-PSI, respectively.

III. COMPARABILITY OF CLASSES

On the first day of the experiment, the Shaw-Hiehle standardized test (58) was given to the students of the five mathematics classes that participated in this study. Table IV-3 summarizes the mean test scores and standard deviation (SD) for the classes. In order to compare the PSI taught students with the traditionally taught students, the data from the two traditionally taught classes were combined into one group of data.

TABLE IV-3

MEAN TEST SCORES AND STANDARD DEVIATION

Experimental classes	Mean test scores	SD
EA-L	63.529	28.6
EA-PSI	63.125	34.4

A t-test for independent samples was performed on the data in Table IV-3 in order to determine whether a significant difference in the mean pretest scores existed.

The hypothesis under test was: There is no difference in the mean pretest scores of the students enrolled in EA-L and EA-PSI. The results of the analysis are shown in Table IV-4.

TABLE IV-4

ANALYSIS OF T-TEST OF MEAN PRETEST SCORES

df	t-value
48	.068

At the .05 significance level, given the degrees of freedom shown in the analysis, a value of $t \geq 1.960$ was necessary to reject the null hypothesis. Therefore, the hypothesis is not rejected and the two classes, EA-L and EA-PSI, appear to be comparable at the beginning of the study.

IV. COMPARABILITY OF THE CLASSES AT THE END OF THE STUDY

One of the characteristics of the PSI taught classes in the studies performed on the college level was the high drop-out rate. Since this study was performed on high school students who were mandated by the federal government to attend school, the drop-out rate was experienced only

by the students who were absent for the posttest. Students could ask not to be included in the study; however, no student so requested to be excluded.

Table IV-5 indicates the enrollment, drop-outs (as defined above), and the net enrollment by classes for the elementary algebra I-part II classes. All analyses of data for both the pretest and the posttest were performed on the net enrollments of the classes.

TABLE IV-5

ENROLLMENT, DROP-OUTS, AND NET ENROLLMENT BY CLASSES

Category	EA-L	EA-PSI
Enrollment	34	18
Drop-outs	0	2
Net enrollments	34	16

V. THE POSTTEST

At the end of the study, the Shaw-Hiehle test (58) was once again administed to each class. The mean test score and standard deviation (SD) as experienced by each class is indicated in Table IV-6.

TABLE IV-6

MEAN POSTTEST SCORES AND THE STANDARD DEVIATION

Class	Mean score	SD
EA-L	84.41	22.39
EA-PSI	79.378	25.85

A t-test for independent samples was performed on this data to test the hypothesis: There is no difference in the mean posttest scores of the lecture-recitation taught classes and the PSI taught classes. Table IV-7 summarizes these results.

TABLE IV-7

ANALYSIS OF T-TEST ON THE POSTTEST SCORES

df	t-value
48	.673

At a .05 significance level, a value of $t \geq 1.960$ is necessary in order to reject the null hypothesis. Therefore, the hypothesis cannot be rejected.

Reliability and Validity of the Pretest/Posttest

The reliability of the Shaw-Hiehle test was determined by performing an even-odd correlation test. This test yielded a correlation coefficient of .8275. At the .05 significance level, a value of $r \geq .1946$ is necessary to show reliability at df = 100. Therefore, the test was determined to be reliable.

The researcher, in conjunction with the teacher who carried out the experiment, judged the pretest/posttest to be valid for the purposes of this study. The test was judged to have good content validity, i.e., having both good face validity and good sampling validity.

VI. THE ATTITUDE INSTRUMENT

Following the posttest, the students were administered an Attitude Instrument (AI) which was designed to measure the students' attitude toward mathematics and the method of instruction used in their course. A Likert scale for recording attitude was used for each item. To examine a copy of the Attitude Instrument, turn to Appendix D.

Many researchers reporting on PSI versus lecture-recitation taught classes report that students' attitudes are much more positive towards the subject and the method of instruction when PSI has been employed. Aiken (1) has stated that attitude plays a crucial role in learning

mathematics. Therefore, one of the goals of this study was to compare the attitude of students toward both the course content and the method of instruction.

The Attitude Instrument was administered in order to study the responses of the students. This was done in order to learn if the responses reflected any significant differences in attitude of the two groups.

The responses for each statement were "Strongly Agree," "Agree," "Undecided," "Disagree," and "Strongly Disagree." The responses were scored 4, 3, 2, 1, and 0, respectively. Table IV-8 shows the mean attitude scores and standard deviation for the attitude instrument, and Table IV-9 displays the results for the t-test for independent samples.

TABLE IV-8

MEAN TEST SCORES AND STANDARD DEVIATION FOR THE AI

Class	Mean score	SD
EA-L	40	6.43
EA-PSI	43	4.69

TABLE IV-9

T-TEST VALUE FOR MEAN TEST SCORES ON THE AI

df	t-value
48	1.25

No significant difference occurred at the .05 level of significance. A $t \geq 1.960$ was necessary to reject the null hypothesis: There will be no significant differences in the mean attitude scores of the students who are taught by PSI and the students who receive traditional type of instruction.

An item analysis was performed on seven statements in the Attitude Instrument which dealt with the PSI course itself. These statements were:

1. "This course held my interest." (Statement 5 on the AI.)

2. "The teaching methods used were not appropriate for this course." (Statement 6 on the AI.)

3. "Compared to other courses I have had, I enjoyed this course less." (Statement 7 on the AI.)

4. "If I were going to take another mathematics course, I would not want to take one taught in this manner." (Statement 11 on the AI.)

5. "I would not recommend to my best friends that they take this course." (Statement 12 on the AI.)

6. "I could have made a better grade in this course if it had been taught differently." (Statement 19 on the AI.)

7. "Overall, this course was not a good one." (Statement 23 on the AI.)

Table IV-10 depicts the mean attitude scores for each individual statement and Table IV-11 summarizes the results of the t-test for independent samples which was performed on each set of data. At the .05 significance level, a $t \geq 1.960$ for the degree of freedom indicated is necessary to reject the null hypothesis that there is no difference in the attitude of students toward the two teaching methods. Therefore, the null hypothesis is not rejected for any of the seven statements.

TABLE IV-10

MEAN ATTITUDE SCORES FOR EACH INDIVIDUAL STATEMENT

State-ment	Mean score (PSI)	SD	Mean score (L)	SD
5	2.45	1.16	2.6	1.38
6	.94	.71	.6	.68
7	1.3	1.09	1.3	1.37
11	1.3	1.17	1.2	1.31
12	1.0	1.0	1.0	1.15
19	1.1	.83	1.1	1.05
23	.8	1.06	1.3	1.45

TABLE IV-11

T-TEST VALUES FOR STATEMENTS ON THE AI

Statement	df	t-value
5	48	.4068
6	48	1.640
7	48	0
11	48	.2760
12	48	0
19	48	0
23	48	1.388

VII. DESCRIPTIVE STUDY

The PSI method of instruction was utilized wtih the consumer mathematics (CM) and geometry (G) classes at the same time as the experiment was carried out in the elementary algebra I-part II classes, as described earlier in this chapter. All materials used with these students were identical to the materials used with the experimental group as described in Chapter II. As there were no geometry or consumer mathematics classes available to the researcher for a comparative study, these two classes were treated for descriptive purposes only.

Table IV-12 displays the mean pretest and posttest scores for the two classes.

TABLE IV-12

MEAN PRETEST AND POSTTEST SCORES AND STANDARD DEVIATION FOR THE CONSUMER MATHEMATICS AND GEOMETRY CLASSES

Class	Mean pretest scores	SD	Mean posttest scores	SD
CM	41	28.9	55	31.1
G	63	27.1	82	21.5

According to the teacher, the consumer mathematics class was composed of students who possessed a low aptitude and a poor attitude toward the course and its content. The pretest and posttest scores were very low for this group of students. A look at the individual scores and the number of sections of the fractions unit composed by the students would be enlightening. This data can be seen in Table IV-13.

As one might observe from the data in Table IV-13, the students in the consumer mathematics class did not complete the course of study prior to taking the posttest. This factor alone could make a significant difference in the outcome of the posttest.

As was stated in Chapter I, the material was field-tested on a general mathematics class in a private school. The students in that class completed the fractions unit in six days. Hence, the researcher believed that the students

TABLE IV-13

INDIVIDUAL PRETEST SCORES, POSTTEST SCORES, AND SECTIONS COMPLETED

Student number	Pretest score	Posttest score	Number of sections completed
1	20	50	3
2	100	90	9
3	30	20	4
4	20	20	1
5	20	20	2
6	20	30	4
7	20	30	3
8	10	40	4
9	20	60	4
10	30	100	4
11	40	40	3
12	80	80	4
13	40	60	4
14	10	10	4
15	50	50	4
16	40	80	5
17	90	100	7
18	90	100	7
19	20	20	5
20	80	100	7

could finish the material in that length of time. However, that assumption was not valid with the consumer mathematics class.

On the other hand, the geometry class progressed sufficiently, and, for the most part, all students completed the entire unit. The geometry class progressed as well as the PSI taught elementary algebra I-part II class.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

I. SUMMARY OF FINDINGS

The purpose of this study was to compare PSI taught classes with traditionally taught classes of mathematics. Specifically, the experiment was designed to compare these classes as to their mean posttest scores and attitude scores. The two hypotheses tested were:

1. There will be no significant differences in the mean achievement scores of the experimentally taught students and the lecture-recitation taught students.

2. There will be no significant differences in the mean attitude scores of the students who receive traditional type of instruction.

The findings of the study with respect to these two hypotheses were as follows:

1. At the .05 level of significance, hypothesis 1 was not rejected. The difference in the mean scores for the posttest was not sufficiently large to warrant rejecting the null hypothesis.

2. At the .05 level of significance, hypothesis 2 was not rejected. The difference in the mean scores for the attitude instrument was not sufficiently large to warrant rejecting the null hypothesis.

II. COMPARISONS WITH PREVIOUS RESEARCH

Introduction

While many articles have been written comparing PSI to other methods of instruction, no comparative studies concerning high school mathematics classes have been reported. Only a few reports involving a study of a comparison of college mathematics classes have been published. See Table II-1 (page 16) in Chapter II. The results of this study are fairly consistent with findings in other mathematics studies.

On Final Examination Scores

A study which has compared one or more PSI sections in mathematics with one or more lecture-recitation classes in mathematics with significant results was done by Haver (25). The studies showing no significant differences between mean final examination scores were those done by Schoen (57), Ewing (17), Liguori (40), and Herring (26).

On Attitudes

Various authors have reported that students taking PSI taught courses reported favorable attitudes toward the method of instruction. It might be well to note here that the PSI taught courses experience larger drop-out rates than conventionally taught classes. The larger drop-out rate might indicate that students who dislike the method of instruction drop out too early to be

questioned as to their attitude toward the method of instruction used in the course. Herring (26) suggested that students might rate more highly any course in which they excelled.

On Design of Experiment

The researcher was inhibited by a lack of available subjects for the experiment and by a lack of time in which to conduct the experiment. Many studies have been conducted on available classes of students, not necessarily starting with comparable groups of students. The researcher attempted to obtain comparable classes of students, and a t-test of independent samples on the pretest scores did show that the two groups of experimental classes were comparable.

III. IMPLICATIONS FOR TEACHING

According to this study and many like it, PSI is a viable alternative to the lecture-recitation method of instruction. However, the study did not indicate that PSI was an improved method of instruction. Studies in many areas and by many authors have shown significant results favoring PSI. Many of these reports involved areas of study which have as their course content material in which memorization is very important. Other course reports, in areas such as physics and engineering, have high-ability, highly-motivated students who would probably excel regardless of the type of instruction employed. Mathematics

classes involve a certain degree of memory work for students who are not accustomed to logical thought processes. More importantly, the concepts in mathematics, as well as other subjects, are built upon preceding concepts. Studying mathematics might be synonymous with building a house, i.e., the foundation is very important. One would not want a house built on a faulty foundation; therefore, it is very necessary for our school children to master the basic concepts from a very early age. So often teachers have allowed students to be socially promoted from one grade to the next. Suppose a child is socially promoted to the second grade without having mastered the material necessary for a successful completion of the first grade. It is reasonable to assume that this child, who is deficient in the basic first grade skills, would then be unable to perform well or master the materials at the second grade level. If the child was once again allowed to move to the next grade level without regard to her/his ability to perform successfully at the second grade level, the situation, for the child, would probably worsen, i.e., the gap between what the child knew and what she/he should know would become wider by the year. Let us further suppose that this child was repeatedly promoted into a higher grade level. Within several years, she/he could be a candidate for the "resource room." Would it not have been better to start in the beginning and teach by the mastery learning method in all areas? It is evident that many educators are beginning to

awaken to this fact and are trying to incorporate mastery learning into their teaching. As stated in Chapter II, the Washington, D.C. school system reported that they had opted for mastery learning beginning in the primary grades rather than for competency testing prior to graduation from high school.

Mathematics is one of many subjects where mastery learning is necessary, and it would also seem reasonable to assume that it would be of uppermost importance to be proficient in the communication skills. Presently, educators are reporting that college board test scores are falling. Perhaps this trend could be stopped and even reversed if school systems would support the mastery learning criterion in teaching.

IV. RECOMMENDATIONS FOR FURTHER RESEARCH

In view of the findings in this study, several recommendations for further research can be made.

1. Although the evidence from this study was inconclusive in proving that PSI is a better method of instruction, six years of teaching experience using a modified form of PSI has convinced the researcher that at least four of the five features of PSI are worthwhile features for any educator to incorporate into her/his teaching. This study was conducted on five tenth grade mathematics classes for the duration of two school weeks. It would be hard to derive

conclusive evidence in that time period. Research in this area should be carried out for a much longer period of time and on a much larger sample of students.

2. At the college level, PSI seemed to be more effective with the better-prepared, more highly motivated student. The poorer student who did not like to study so much and learn the material may not like the PSI method, but it is possible that the student might actually learn more. Students in the primary grades tend to be very positive about learning, and if we could capitalize on this attribute of the young child and utilize mastery learning with them, then we might not have to contend with the student who wants "to memorize enough to get by with." To treat an illness, a doctor does not treat the symptoms and hope the illness will go away. Rather, she/he looks for the cause of the symptoms. More research should be done to investigate the possibility that PSI could help cure the cause of education's downhill swing as evidenced by a decline in college board test scores. A mastery requirement at an earlier age would allow us to condition our students to learn, not for a grade, but because of a desire to want to learn.

3. More research should be done on the effects of having student-proctors. Some research has indicated that students who have served as proctors learned more, as indicated by final examination scores. Indications are that proctoring not only helps the student-proctor but also the

student receiving the help. Different people benefit from different methods of presenting the same material, and there are as many different teaching methods as there are persons. Therefore, the student who cannot understand the teacher's method of presenting a certain topic might very well understand the explanation given by a peer.

4. There should be research done to investigate whether PSI has more of an effect in the higher or lower level of cognitive learning. Some studies indicated that PSI's initial success might have been due to the nature of the material covered in the psychology courses.

5. Is retention of course material greater when PSI is the method of instruction? More research to indicate whether students do learn just for the tests is warranted.

In conclusion, not every teaching method benefits all students. However, it is the belief of this researcher (based upon a great deal of research into the subject and the use of this method of instruction for the past six years) that PSI is the method that will enable most of the students to be reached in the best way. It is human nature to want to achieve; students will beg for retests, study the material once more to master unlearned topics, and retest in order to improve their grade. The real proof of this belief will come not in two weeks or even two years, but in the future when these students enter

post-secondary schools. If they learned to remember, then PSI was a success; if they memorized to forget, PSI is no better or worse than all the other methods which allow students to memorize to forget.

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APPENDICES

APPENDIX A

COURSE DESCRIPTION AND INSTRUCTIONS

PLEASE READ THESE INSTRUCTIONS CAREFULLY!!!

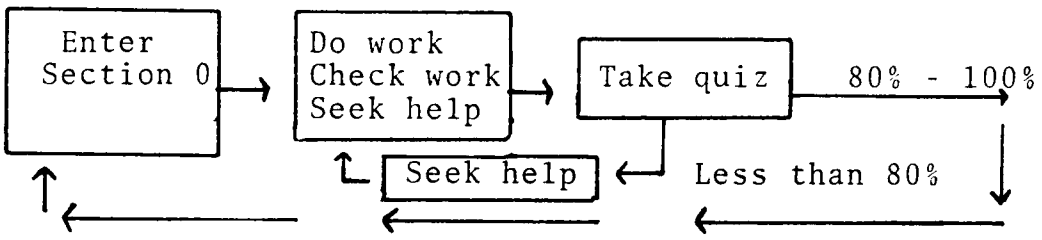
Course Description: FRACTIONS-SELF-PACED COMPETENCY UNIT

The purpose of this unit in mathematics is to develop basic skills in the binary operations (addition, subtraction, multiplication and division) on fractions. These skills are often needed in the normal day to day life situations.

This unit is designed to provide instruction, drill, practice and testing which will insure that each student will develop competency in the binary operations on fractions. The student's success at achieving competency in this unit is dependent upon the student himself.

Format of Instruction:

Small group instruction will be given periodically; however, no class lectures are scheduled unless the entire class experiences difficulty in a particular area. For the most part, the student will read the instructions for each section, study the examples, do the problems (seeking help from the instructor or fellow students when needed), take a quiz or quizzes on each section, and proceed to a new unit when 80% competency has been attained. See the flow chart below.



Tests:

There will be 11 section quizzes and one review--or final--test.

Section Quizzes: You may take a section quiz whenever you feel you have mastered the material in

each section. These tests must be taken in order and are to be taken during class time. There will be no numerical grade or partial credit assigned to the section quizzes. You either pass (80% competency) or fail. If you fail, you must complete additional problems on the section--to be determined by your teacher--and take another quiz on the same material. You may proceed to succeeding section ONLY after a pass on the quiz.

Review Test: There will be one review test. This test will be the final test given on the unit. It is a cumulative test to be given on the completion of section 11. The unit grade will be determined by the review test grade.

Unit Grades:

The unit grade is determined by the review test grade as follows:

A 92 - 100
B 86 - 91
C 75 - 85
D 70 - 74
F All below 70

How To Get Help:

1. A chart with each student's progress will be placed on the bulletin board. If you are having difficulty in a section, consult the chart and seek help from any student who has completed that section.
2. Seek help from the teacher.
3. If you have failed two quizzes on the same section, you must seek help from the teacher.

FRACTIONS

Topics to be Covered

Introduction - Fractional Parts

1. Equivalent fractions
2. Mixed and improper fractions
3. Addition
    a. Similar fractions
    b. Mixed, similar fractions
    c. Unlike mixed fractions
4. Subtraction
    a. Similar fractions
    b. Similar mixed fractions
    c. Unlike fractions
    d. Unlike mixed fractions
    e. Borrowing with similar and unlike fractions
5. Multiplication
    a. Simple fractions
    b. Mixed fractions
6. Division
    a. Simple fractions
    b. Mixed fractions

INSTRUCTIONS

1. Complete the sheets in each section.

2. Check your work with the answer booklet.

3. Seek help in problem areas.

4. Take the section quizzes. When you achieve 80% accuracy, go to the next section. If you do not achieve 80% accuracy, seek help from the teacher or from fellow students who have mastered the section.

APPENDIX B

PRETEST/POSTTEST

Part II--Common Fractions

Directions: Show your answer in "reduced form" or as a mixed number, and transfer this to the answer column to the right.

21) $\frac{2}{5} + \frac{3}{10} =$

22) $\frac{2}{3} + \frac{1}{5} + \frac{4}{15} =$

23) $5\frac{1}{2}$
$+3\frac{2}{3}$

24) $\frac{3}{5} - \frac{1}{5} =$

25) $\frac{5}{8} - \frac{1}{3} =$

26) $5\frac{2}{3}$
$-1\frac{3}{4}$

27) $\frac{4}{5} \times \frac{1}{9} =$

28) $4\frac{3}{7} \times 14 =$

29) $8 \div \frac{1}{5} =$

30) $3\frac{1}{3} \div \frac{5}{6} =$

ANSWERS

21. _____
22. _____
23. _____
24. _____
25. _____
26. _____
27. _____
28. _____
29. _____
30. _____

APPENDIX C

STUDENT CHART

NAME:								PRETEST:				POSTTEST:			
SECTION 1				SECTION 2				SECTION 3				SECTION 4			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
SECTION 5				SECTION 6				SECTION 7				SECTION 8			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
SECTION 9				SECTION 10				SECTION 11				INTRO:			
1	2	3	4	1	2	3	4	1	2	3	4				

APPENDIX D

ATTITUDE INSTRUMENT

Please circle the class you are in: Regular/ Experimental.

Instructions: Draw a circle around the letter(s) that show(s) how you agree or disagree with each statement: SD (Strongly Disagree), D (Disagree), U (Undecided), A (Agree), SA (Strongly Agree).

1. Mathematics makes me feel uneasy and confused.

   SD D U A SA

2. Mathematics is enjoyable and stimulating to me.

   SD D U A SA

3. Mathematics is dull and boring because it leaves no room for personal opinion.

   SD D U A SA

4. The material in this mathematics course seemed worthwhile.

   SD D U A SA

5. This course held my interest.

   SD D U A SA

6. The teaching methods used were not appropriate for this concern.

   SD D U A SA

7. Compared to other mathematics courses I have had, I enjoyed this mathematics course less.

   SD D U A SA

8. Compared to other mathematics courses I have had, I tended to procrastinate more in my work in this course.

   SD D U A SA

9. Compared to other mathematics courses I have had, this course required more work to obtain the grade I desired.

SD D U A SA

10. Compared to other mathematics courses I have had, this course demanded less time to obtain the grade I desired.

SD D U A SA

11. If I were going to take another mathematics course, I would not want to take one taught in this manner.

SD D U A SA

12. I would not recommend to my best friends that they take this course.

SD D U A SA

13. The grading of my work in this course was fair and reasonable.

SD D U A SA

14. The tests administered in this course were fair appraisals of the course content.

SD D U A SA

15. The objectives of this course were not clear.

SD D U A SA

16. Compared to other mathematics courses I have taken, I feel I have learned more.

SD D U A SA

17. The method of instruction used in this course did not encourage me to use good study habits.

SD D U A SA

18. Compared to other mathematics courses I have taken, the pace at which I worked in this course was too fast.

SD D U A SA

19. I could have made a better grade in this course if it had been taught differently.

SD D U A SA

20. The textbook used in this course was helpful.

SD D U A SA

21. The supplementary material and "units" prepared by the teacher were helpful.

SD D U A SA

22. The outside reading assignments were helpful.

SD D U A SA

23. Overall, this course was not a good one.

SD D U A SA

VITA

D. Sharon Husch was born in Fancy Gap (Carroll County), Virginia on November 9, 1947. She attended elementary school in Oak Ridge and Knoxville, Tennessee and high school in Knoxville, Tennessee and Niles, Michigan and was graduated from West High School, Knoxville, Tennessee, in June 1965.

She attended The University of Tennessee, Knoxville for two years and the University of Georgia, Athens for two years before receiving the Bachelor of Science in Education degree with a major in mathematics from the University of Georgia in June 1969. She enrolled in the Graduate School of The University of Tennessee, Knoxville in 1975 to pursue a Master's degree in the College of Education with a major in Curriculum and a minor in mathematics education.

She has taught science and mathematics for three years at the junior high level at Sacred Heart School, Knoxville, Tennessee, English as a Second Language and mathematics in K-2 for one year at the American School of Zagreb (Yugoslavia), and mathematics for three years at Knoxville Catholic High School, Knoxville, Tennessee. She has also served as Chairperson of the mathematics department at Knoxville Catholic High School for the past two years.

She holds membership in the National Council of Mathematics Teachers, Tennessee Mathematics Teachers Association, and Kappa Delta Pi honorary fraternity.

While a student at the University of Georgia, she met and married Dr. Lawrence S. Husch, Jr. They have two daughters, LoriAnne Faye and Donna Michelle.