AN ABSTRACT OF THE THESIS OF

GALE NORMAN NEFF for the DOCTOR OF EDUCATION
(Name) (Degree)

in EDUCATION presented on August 2, 1972
(Major) (Date)

Title: THE DESIGN, DEVELOPMENT AND TESTING OF AN EXPERIMENTAL INDIVIDUALIZED LEARNING SYSTEM

Abstract approved: Redacted for privacy
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This study was an experimental investigation of two methods of teaching students the cognitive knowledge and psychomotor skills pertaining to the automobile brake system. The methods investigated were the experimental individualized learning system and the traditional group-lecture and demonstration.

Experimental Design and Procedure

The experiment, conducted during the spring term of 1972, utilized a simple randomized design. One hundred students enrolled in the Automotive Technology program at Portland Community College, Portland, Oregon, were the subjects. They were randomly assigned to two groups of 50 each; the experimental group using the individualized learning system, and the control group using the traditional group-lecture and demonstration method.

Pretest measures were obtained as control variables for analysis of covariance test of significance of difference between groups. The pretests consisted of a comprehensive cognitive knowledge paper-and-pencil test and a comprehensive psychomotor skills evaluation. The criterion achievement measures, comprehensive cognitive knowledge posttest and a comprehensive psychomotor skills evaluation, were administered upon completion of each instructional treatment.

In order to separate the effects of each variable, a preliminary analysis of variance was performed. A significant F value was not reached and, therefore, random assignment of subjects to groups was considered successful. The pretest measures were used as control variables for the two analyses: (a) cognitive knowledge achievement as measured by a paper-and-pencil test, (b) psychomotor skills performance as measured by a psychomotor performance evaluation. The control and criterion data obtained were used to test the two hypotheses.

Hypotheses Tested and Findings

The statistical analysis of covariance was utilized to test the following null hypothesis: When learning the necessary cognitive knowledge, there will be no significant differences in the mean scores produced by the individualized learning system (experimental group) and the traditional group-lecture and demonstration (control group) method of teaching students the automobile brake system.

Finding: No significant difference.

By capitalizing on a design strategy used by Walbesser and Carter (1968) in which expected learner outcomes are described in terms of observable behavior, the following hypothesis was tested: All 100 subjects participating in the study will be able to master 100 percent of the psychomotor performance tasks satisfactorily.

Finding: The data collected on a satisfactory-unsatisfactory basis supported the hypothesis in that all subjects did master 100 percent of the psychomotor performance tasks satisfactorily. Therefore, no significant differences were found regarding the instructional methods used to teach the psychomotor skills pertaining to the automobile brake system.

Conclusions

1. Methods of instruction studied did not have a significant effect upon cognitive knowledge achievement.
2. Methods of instruction studied did not have a significant effect upon psychomotor skill development.
3. The individualized learning system did promote time as the variable and learning as the constant.
4. The average completion time was 23 hours and 48 minutes for the subjects in the experimental group. The control group utilized

75 hours of instruction to achieve the same performance objectives as the experimental group.

Recommendations

1. The individualized learning system can be used to teach the basic unit involving cognitive knowledge and psychomotor skills pertaining to the automobile brake system.
2. Investigations to determine the efficiency of instructional systems in other vocational education areas are needed.
3. Additional research concerning the effectiveness of instructional systems with students not enrolled in vocational education courses is needed.
4. Systems utilizing other educational technology components and organized to teach for similar objectives should be developed and tested.
5. Additional research should be designed to test the strength and instructional value of various components of the learning system utilized in the present study.
6. Additional research is needed concerning the rate of learning in terms of time.
7. Research dealing with the cost of instructional systems is needed.

The Design, Development and Testing of an Experimental Individualized Learning System

by

Gale Norman Neff

A DISSERTATION

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Education

June 1973

APPROVED:

Redacted for privacy

Assistant Professor of Education
in charge of major

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Date thesis is presented August 2, 1972

Typed by Mary Jo Stratton for Gale Norman Neff

ACKNOWLEDGMENTS

The writer wishes to express his sincere appreciation and gratitude to Dr. Melvin D. Miller, Association Professor, Division of Vocational, Adult and Community College Education; and to Dr. Wayne Courtney, Visiting Professor, whose guidance and counsel have contributed to the successful completion of this study.

Grateful acknowledgment is also made to Dr. Henry TenPas, Director, Division of Vocational, Adult and Community College Education for his eternal counsel and support; to Dr. Pat Atteberry, Coordinator, Department of Industrial Education; Dr. John K. Ellis, Associate Professor, Health Education; Dr. Royce Smith, Assistant Professor, Business Administration, for their assistance in reading the manuscript and providing advice as committee members.

Without the understanding and self-sacrifice of the EPDA awardees at Oregon State University and especially Dr. Amo DeBernardis, President of Portland Community College who dedicated all of his resources to my study, the beginning and finalization of this goal may not have been possible.

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I. INTRODUCTION

Background of the Problem

For many years vocational educators have struggled with methodological problems which are inherent in the teaching of multiple activities involving cognitive knowledge and psychomotor skill development. An example of teaching multiple activities is the typical automotive mechanic program in which front end alignment, brakes, safety, steering, suspension, and wheel balancing are commonly taught in a single course. One important problem with which the vocational educator is concerned is the discovery of a satisfactory method to organize a diversified class so that effective and efficient learning will prevail. The inclusion of so many related areas in one course presents many methodological problems which need investigation (Aquirre, 1966).

Recent developments in instructional systems indicate that this approach might be applicable for vocational education in teaching multiple activities. Hinst (1971) defines instructional systems as, "a systems approach to the teaching/learning process which centers around optimal design, implementation, and evaluation of teaching and learning as such" (p. 39).

The individualized learning system stresses the systematic organization of steps leading toward the acquisition of specifically stated learning objectives and the effective evaluation of that learning. The systems concept emphasizes the individualizing of instruction with an overall purpose of promoting learning as the constant and time as the variable. Research is needed in adaptation of instructional systems as a possible solution to some of the instructional problems facing the vocational educator in teaching skill development combined with the necessary technical knowledge.

Impellitteri and Finch (1971) state:

> The most promising area of individualized instruction research and development in terms of its potential contribution to the improvement of vocational and technical instruction is represented by the instructional systems approach (p. 67).

This study involves the development and utilization of an individualized learning systems model applicable to instructional programs requiring cognitive knowledge combined with psychomotor skill development. The automobile brake system was chosen as the instructional unit to be used for the study. An individualized learning system was designed, developed, field tested, and its effectiveness to teach cognitive knowledge and psychomotor skill development relating to the automobile brake system compared to the traditional (group-lecture and demonstration) method of instruction.

Statement of the Problem

This study was designed to ascertain the effectiveness of an experimental individualized learning system as opposed to the traditional group-lecture and demonstration method of teaching. Students were randomly assigned to two groups (experimental and control). Cognitive knowledge and psychomotor skills pertaining to the automobile brake system were identified and written in the form of performance objectives by the Automotive Technology program advisory committee, the automotive instructors, and the administrators at Portland Community College. These performance objectives serve as the criteria of instructional content to be presented to both groups independently.

Definition of Terms

Vocational Educator is defined as a person who teaches cognitive and psychomotor skills relating to occupations classified as something less than professional and requiring less than a baccalaureate degree.

Teaching of Multiple Activities relates to the teaching of several related areas in one course.

Individualized Learning System is defined as

> . . . an effort to organize and condense those necessary or desired experiences as concisely and systematically as

> possible so as to increase the probability that learning will occur in an efficient manner. A learning systems concept, when applied to educational or training courses, offers an opportunity to develop or rebuild these courses to be significantly more effective and efficient in relation to the learning tasks and goals of the students (Stewart, 1964, p. 7).

The Instruction Book utilizes programmed instruction to reinforce the cognitive knowledge and psychomotor skills shown in the instructional media presentation. The instruction book prepared for this study presents a fact followed by an incomplete sentence relating to the fact. The student is directed to correctly complete each sentence by writing words in the spaces provided. Correct answers are shown on the back of each page for immediate reinforcement. A review test is provided at the end of each programmed instruction unit.

Programmed Learning is defined in the following manner: "Self-instruction by means of a carefully designed series of questions which, through immediate reinforcement, motivates and enhances the learning process"(Morgan, 1961, p. 684).

Instructional Media Presentation refers to a highly organized and sequenced color slide presentation synchronized with a sound tape presentation. The slide presentations show basic cognitive knowledge and psychomotor skills necessary to become an automotive brake mechanic. The comments recorded on the sound tapes explain the facts, principles, and procedures that are illustrated.

Teacher Demonstration is a method of simultaneously showing and explaining the steps in an operation in a vocational education course. The demonstration may be presented to a whole class, a small group, or to an individual.

Group-lecture and Demonstration method is defined as an instructional method which utilizes limited instructional media with correlated lecture followed by teacher demonstrations.

Psychomotor Skill is a learned muscular movement of complexity acquired as a result of responding to sensory stimulus. Psychomotor skills require a constant surveillance and concentration for instantaneous reaction to varying stimulus cues generated by overt responses.

Performance Objectives tell the student what he will have to be able to do when he is evaluated, the important conditions under which he will have to perform, and the lower limit or quality of performance expected of him.

Diversified Learning Activities provide alternative approaches for achieving the performance objectives, and include such activities as large-group and small-group instruction, field trips, model building, drama productions, games, laboratory experiments, role playing, pupil-teacher conferences, reflective thinking, and the like.

Pre-evaluation is designed to assess the extent to which the pupil has already achieved the performance objectives as a result of his earlier learning experiences. Pre-evaluation enables the pupil to invest his time wisely in areas in which he is weak.

Post-evaluation is designed to assess the extent to which the pupil has achieved the performance objectives as a result of his learning experiences.

Student's Performance Evaluation is designed to assist the pupil in determining his own progress toward achieving the performance objectives. This evaluation occurs after the pupil has used the multi-dimensional learning materials and participated in diversified learning activities.

Need for the Study

One important problem facing the teacher of vocational courses is the need for a satisfactory method to organize and teach a diversified class. A satisfactory solution to this problem involves the presentation of related technical information, teacher demonstration, application by the student, and consideration of individual differences. Empirical efforts to arrive at solutions to this problem by various leaders in vocational education have been reported in literature. The one thing common in these reports is the effort to enable the student to function in an intelligent manner rather than in one which is primarily manipulative. Also, with the development of manipulative skills is an understanding of how and why the student is performing certain manipulative acts. Most of the methods and techniques recommended attempt to fulfill the above criteria; however, none of these is completely satisfactory.

In a classical book on methods, Theodore Struck states the following:

> The term 'method' means essentially a way, an orderly procedure, or a regular manner. So methods in teaching should be thought of as ways of getting learners to develop habits and skills, or acquiring knowledge and of developing attitudes and ideals. A given method may be the best one to use in a particular situation, with certain types of pupils or learners, but no single method is adequate for all types of teaching requirements. Good teaching, therefore, under varying conditions will require the use of several methods of instruction (Struck, 1929, p. 36).

In a more recent book, Ericson and Seefeld state:

> It is evident that it would not be necessary or even desirable to confine a teaching situation to the use of any one method. Basic elements of several of these approaches may appropriately be combined for best results depending upon the age of students and type of subject matter being taught. The skillful teacher will use these methods in such rotation and combination as will be indicated by existing needs (Ericson and Seefeld, 1960, p. 45).

Although Ericson, Struck, and others discuss the various teaching methods in great detail and stress the importance of getting students to work in the various general shops or laboratories as soon as possible, there is almost a complete lack of specific information on how to accomplish this task.

The various techniques in common use, such as instructional sheets, demonstrations, required projects, exercises, and mass production, often fail to solve critical instructional problems facing the vocational educator. Investigation of recent and past research revealed that little primary research has been conducted for the specific purpose of findings solutions to the teaching problems associated with the diversified class.

Organization of the Study

One hundred students enrolled in the Automotive Technology program at Portland Community College participated in the study. They were randomly assigned to two groups of 50 each (control and experimental).

Performance objectives were used as the criteria of instruction for both control and experimental groups. The size of each group was limited to not more than 20 students at any given time, the reason for this being the limited facility, equipment, and materials.

Students assigned to the control group were subjected to the traditional group-lecture and demonstration method of teaching. Each student was given a cognitive knowledge pretest pertaining to the automobile brake system. The students were allowed to take a comprehensive psychomotor skill evaluation if they so desired. The pretest and psychomotor skill evaluations were administered prior to any instruction pertaining to the automobile brake system. Instruction began with group-lectures and demonstrations. Several short quizzes were given relating to the materials covered in the lectures and demonstration. Practice sessions were scheduled to enable the student to develop the necessary psychomotor skills.

The control group was scheduled for 75 hours of instruction (three weeks; five hours per day, five days per week). At the end of the 75 hours of instruction, the students will be given a cognitive knowledge posttest and a comprehensive psychomotor skill evaluation.

The experimental group was subjected to the experimental individualized learning system. The same pretest and psychomotor skill evaluation given to the control group was administered to the experimental group prior to any instruction.

The student was scheduled for a five-hour block each day and allowed to progress at his own rate. Traditionally, students have been locked into 75 hours (three weeks) of instruction. It was estimated that it would take considerably less than 75 hours for the student to progress through the instructional unit when utilizing the learning system.

The experimental learning system consists of 24 performance objectives which have been divided into seven modules. Results were evaluated by the use of objective knowledge tests and skill performance tests. These tests were developed by the researcher from the performance criteria used as a base for the construction of the individualized learning system.

When a learner completed the instructional phase of the module, he then proceeded to the performance test. If the student was unsuccessful on the knowledge test, he repeated all or part of the instruction. A checklist was used by the instructor in the evaluation process, which included the operations to be performed and the expected student behavior pertaining to each. Records were kept of the student's performance.

The same posttest and psychomotor skill evaluation given the students in the control group were administered to the experimental group upon completion of the individualized learning system. These evaluation instruments, administered to both control and experimental groups, provided the data necessary for a statistical analysis of the two groups.

The four remaining chapters of this study are organized so that the review of related literature is reported in Chapter II; the procedures, methods, techniques and instruments are described in Chapter III; the empirical data and quantitative analyses are given in Chapter IV, with Chapter V presenting the summary, conclusions, recommendations, and implications.

Assumptions and Limitations

The assumptions and limitations of the research were as follows.

Assumptions

1. The length of training is short enough to eliminate confusion by reason of maturation.

2. Random assignment eliminates the confounding variables of history, testing, statistical regression, and selection.

Limitations

1. The study is limited to selected post-secondary students at Portland Community College, Portland, Oregon.
2. The study is limited to the acquisition of prescribed levels of cognitive and psychomotor skills.
3. The study is limited to students who score less than 80 percent on the pretest.
4. Equipment necessary for skill development was made available to students only during their regularly scheduled class period.

Summary

A satisfactory method to organize and teach a diversified vocational educational class has been identified as a major problem facing vocational educators today. While different methods and techniques to fulfill established creteria have been reported, none have proven completely satisfactory.

The tremendous population growth experienced in America over the past years has resulted in crowded classrooms, high educational costs, and greatly reduced time for teacher-student consultation. As a result, individual instruction (one-to-one relationship) on any significant scale has of necessity fallen into the background.

A systematic approach to instruction is represented by this study. The systems concept emphasizes the individualizing of instruction with an overall purpose of promoting learning as the constant and time as the variable. "It is clearly becoming evident that these systems will have far-reaching implications for those not only in vocational-technical and related fields, but in all fields concerned with instruction" (Impellitteri and Finch, 1971, p. 50).

This study ascertained the effectiveness of an experimental individualized learning system as opposed to the traditional group-lecture and demonstration method of teaching. One hundred students enrolled in the Automotive Technology program at Portland Community College were randomly assigned to two groups of 50 each. Students in each group were given a cognitive knowlege pretest and psychomotor skill evaluation prior to any instruction. The appropriate instructional treatment was applied to each group. At the end of each instructional treatment, a cognitive knowledge posttest and a psychomotor skill evaluation was administered. Data collected by these instruments were utilized to conduct a statistical analysis of the two groups.

II. REVIEW OF LITERATURE

Introduction

Individualized learning systems are relatively new in education. However, there has been considerable research conducted in a wide variety of educational settings pertaining to individualized instruction. Because of the large amount of research in individualizing instruction, this review is limited to selected studies which were of direct interest to the present study.

Individualized Instruction

The teaching of knowledge and skills has confronted man from the beginning of his existence. It began as a tutor-student relationship and has become known as individualized instruction. As the population increased, the direct teacher-student relationships have become more difficult both in terms of money and time. As a result, a number of changes have taken place in individualized instruction.

Della Vos, in 1868, has been recognized as the first to use individualized instruction in industrial education. He developed an instruction method utilizing job planning sheets to guide learners in performing assigned exercises. By utilizing this technique, Della Vos was able to work individually with the students (Bennett, 1937).

A number of others have reported using Della Vos' methods.

However, it was not until 1926 when R. W. Selvidge wrote Individualezed Instructional Sheets pertaining to industrial educational courses that the elements of instructional sheets were actually defined. According to Selvidge, the instructional unit must include the skill to be taught, the information to be imparted, and the attitudes to be developed. Selvidge also identified the following advantages in the use of instructional sheets: (1) if the student fails to understand the instruction the first time, he can re-read the material; (2) it places the responsibility for learning on the student; (3) it develops in the student a feeling of responsibility and self-reliance (Selvidge, 1926).

During the 1960's, educators have become more concerned with the developing of each student to his full potential. Research, as a result, has been conducted in the area of individualized instruction. One of the most prominent researchers in this area is Benjamin S. Bloom.

According to Bloom, the United States and other highly developed nations can no longer operate an educational system in which only a few succeed (Bloom, 1968). The traditional method of grading has forced the placing of students into one of three categories; high ability, medium ability, and low ability. Connected with this approach is the most commonly used method of instruction, the group lecture-demonstration activity. Under this traditional approach, the teacher is forced to organize his instruction to meet the need of the middle ability group. Bloom has labeled this the "shot-gun" pattern effect in that those at the extreme ends of the curve receive little material or attention.

In "Learning for Mastering," Bloom (1968) utilizes what he calls the rifle-type approach. Its goal is to assist each student in developing mastery of the subject to the best of his ability. The most desirable type of instruction would be that of tutor-student. However, this type of relationship in itself is not practical due to its high cost and the number of students who must be educated (Courtney and Sedgwick, 1969). Bloom's strategy is to combine the regular group lecture-demonstration approach with that of classification procedures and alternative instructional methods and materials in order to achieve learning mastery by a large proportion of the students.

In addition to the research conducted by Bloom, Gordon H. Flammer states "the lecture method of teaching, which is the foundation of the conventional approach to education, leaves some very compelling questions unanswered." Some of these questions are: "How can educators truly develop each individual student to his ultimate potential? How can the present teacher-centered system be changed to a learner-centered system? How can the role of the teacher be changed from that of a dispenser of information to that of a diagnostician and prescriber of learning experiences for each individual student? and, "How can modern technology be used to aid the learning process and to conserve the teacher's time for individualized instruction?" (Flammer, 1971, p. 511).

According to Flammer, individualized or self-paced instruction appears to answer most of these questions in ways acceptable to both teachers and students. Individualized instruction offers a method of quality control and this becomes increasingly important as the public begins to cry for "accountability in education."

The theme of Flammer's study was that individualized instruction with learning as the constant and time as the variable "...is not only practical, but is considerably more ethical and humane than the lecture method with its cumulative ignorance and designed failure" (Flammer, 1971, p. 512).

Educational Technology

The concept of a systematic approach to education is not new. However, the expanding field of instructional technology has opened the way for many alternative instructional patterns. One pattern is the systems approach to instruction.

Slaughter suggests that to obtain maximum use of educational technology, systems of instruction might be established. According to Slaughter:

> Educational technology is not just destined to grow in certain directions. One unmistakable direction will be the development of educational technology on a systems basis, with close and direct relevance to the pruposes of education and objectives being made by each component of the technology to the

> end result obtained in the system. Claims for the system will be supported by research and experimental results (Slaughter, 1966, p. 6).

The systems approach requires examination of a process as an entity with recognition of the relationships involved in and among all components. It starts with specification of objectives, proceeds through the necessary operations, evaluates the end product in terms of the objectives, and modifies the system if needed.

Donald K. Stewart defines learning systems as:

> . . . an effort to organize and condense those necessary or desired experiences as concisely and systematically as possible so as to increase the probability that learning will occur in an efficient manner. A learning systems concept, when applied to educational or training courses, offers an opportunity to develop or rebuild these courses to be significantly more effective and efficient in relation to the learning tasks and goals of the students (Stewart, 1964, p. 7).

For a better understanding of systems, it might be helpful to examine what happens when a student learns from instruction developed on a systems basis:

> First the student masters information in small steps. Each step presents a carefully sequenced unit of information such as a rule, definition, example, illustration, or fact which builds tightly on the preceding materials.
>
> He then utilizes this new material in making an active response. The step or part that teaches also asks him to complete a sentence, or some other overt response. Making this response is not difficult in itself, but it guarantees that attention will be paid to significant information.
>
> Finally, the student is presented with immediate confirmation or feedback in the form of the correct answer. With programmed instruction, the student might turn the page to reveal the correct response; or the student might compare his result

> with correct examples or solutions. This technique permits new learning to be reinforced immediately and corrects wrong responses before learning proceeds on false premises (Haizlip, 1966, p. 35).

Good systems of instruction are carefully designed, produced, tested with students, and then revised. When errors accumulate, the system is inadequate and a study of the wrong responses will reveal the trouble. Changes are then made to eliminate the problem. Systems developed in this manner may be mastered with a low error rate for each student (Sergeant, 1968).

Systems of instruction are self-pacing, and each learner advances at his own best rate. In contrast to fixed pace of the traditional classroom, slow learners work at an appropriate pace and rapid learners are not idle waiting for the slower ones. The same assignment which one student might finish in six hours may require ten hours for a slower student. Yet both students can reach similar levels of achievement.

<u>Multi-Media Approach</u>

Several studies reviewed attempted to develop individualized instructional programs which were indicated to be of the multi-media variety. Because of the impending dangers in using such a term as "multi-media" without clearly specifying its overall characteristics, the researcher has selected a definition and brief description of the term to be utilized in this study.

> The term, multi-media, means a combination of various types of media arranged so as to provide appropriate presentational capability to realize the objectives and content of a lesson through eliciting desired pupil responses. The key factor in a properly designed multi-media arrangement is not simply the use of more than one kind of audiovisual device. It is the interrelationship of the media used in order to capitalize on the distinctive characteristics and capabilities of each, making them mutually supportive in the creation of a new learning environment (Haney and Ullmer, 1970, p. 49).

Filmstrips, Slides, and Transparencies

The Air Force has developed a completely automated multi-media self-study program for teaching a portion of electronic solid-state fundamentals (Whitted *et al.*, 1966). Media utilized in the program include tape-slide audiovisual presentations, programmed texts, a sound movie, a cued text, a workbook and an RCA transistor trainer. In a comparison between the self-study program and the conventional classroom presentation, no significant difference was found.

In his 1960 review of audiovisual communication devices, Allen (1960) concluded that the research up to that time found in general that projected still pictures were about as effective as silent or sound films in teaching factual information. This conclusion was based on the results of studies which compared filmstrips and slides with either silent or sound-motion picture instruction. These studies included a wide range of subject matter areas, including spelling, mechanics, social studies, nursing, health education, economics, and safety education. The studies were used with various grade levels from the elementary schools to the four-year university.

Allen (1959) suggests that filmstrips and slides have been found to be at least as effective as films because of special learning conditions (individual pacing and student participation) for which they are especially suited. Wendt and Rust (1962) indicate a number of studies which indicated no significant differences in comparing filmstrips, slides, and transparencies with other media (lecture, still pictures, and motion pictures). However, they cited one study conducted by Chance (1960) which compared these to the use of the chalkboard for teaching engineering drawing. A significant difference was found in favor of transparencies.

Nish (1968) describes the development and testing of a polysensory instructional system for teaching knowledge and skills associated with the use of expandable polystyrene plastics. This instructional system utilized single concept films, programmed instruction books, laboratory experiences and teachers' guides. The effectiveness of this design was measured by the demonstrated skill of the student in constructing a foam ice bucket. Nish indicated that the performance of the students exceeded the predetermined minimal standard, and concluded that self-instructional systems can be effectively used to teach all types of knowledge and skills. Hill (1968) utilized the polysensory approach in the teaching of basic electrical occupational competencies. Media included a series of tape-slide sequences, workbook, and a set of laboratory exercises. A criterion test given at the conclusion of instruction indicated satisfactory performance. In discussing the implication of these polysensory approaches, Bakamis (1969) states that, "It is clearly becoming evident that these systems will have far-reaching implications for those not only in vocational-technical and related fields, but in all fields concerned with instruction" (p. 57).

Programmed Instruction

Many articles relating to programmed instruction have appeared in psychological, educational, and vocational and industrial journals over the past few years. Several programs in various subject areas have been developed, tested, and are now being utilized. A review of some of these studies will contribute to an understanding of programmed instruction as it is used in the individualized learning system proposed by this study. The majority of the reviewed studies compare similarities and differences of programmed instruction and traditional methods of instruction.

Goldstein (1964) identifies two basic styles of programming commonly used as being (1) linear programs, and (2) intrinsic programs. Skinner (1958) developed a linear program in which he used a constructed response type of design. The material is presented in small bits or steps in a logical sequence in which each succeeding frame is in some way related to the preceding frame. Within each frame the learner is required to make a constructed response to the stimulus material. Once the learner's response has been made, the correct answer is revealed to him.

In a program developed by Crowder (1959) utilizing intrinsic programming, the learner is presented with as many as three or four paragraphs of material to read within one frame. Then he is required to make a response by choosing the correct answer from a given multiple choice. If the learner chooses correctly, he is sent on to the next frame. If he selects an incorrect response, he is told that he is wrong and why he is wrong. He is given additional information and is then sent back to the original frame to make another choice. This kind of programming, when used with textbook format, is known as "scrambled text" (Crowder, 1959).

After presenting the two most accepted methods of programming instruction, the question arises as to which method is most effective. According to Trow (1963), a program for any topic or course could contain a combination of the two, using the one that is most satisfactory for any part of the content. He indicates that linear method may be quite satisfactory for teaching facts and concepts, and a combination of the two methods is better for dealing with opinions and implications. Trow concluded that there is no final answer as to the superiority of the two and that experiments designed to determine this will be difficult.

Coleman (1964) conducted an experiment in programming the care and use of aircraft mechanics' hand tools. He concluded that programmed instruction can teach knowledge items more effectively than conventional instruction and also accomplish the instruction in less time. Of particular significance to vocational education, Coleman noticed that programmed instruction can very effectively train students in simple manual skills.

Gropper (1966) found in his study that when a visual (pictorial) presentation of a concept to be learned preceded a verbal (printed) presentation of the same concept, the learning was significantly greater and took significantly less learning time than when the verbal presentation preceded the visual one.

The effectiveness of a programmed textbook on students' learning 16 mm motion picture projection principles and projector operation skills was determined by Gordon (1965). His findings indicated that students who used the programmed textbook with visuals learned the principles in less time than did a lecture group. However, when the students used programmed textbooks with visuals as a step toward learning projector operation, they had difficulty transferring skills information from the book to the machine.

Smith (1962), in an experiment at the United States Air Force Academy, compared the efficiency of learning elementary statistics by "scrambled textbooks" and by standard textbooks. He found no significant difference between the two methods. However, he did note a saving of one-third in the amount of time taken to reach the same level of attainment by using the "scrambled textbook" method.

Out of 36 studies comparing programs involving programmed instruction with conventional instruction, one-half (18) showed no significant difference, 17 indicated a significant difference in performance favoring the programmed instruction. Only one study showed a significant superiority for the conventional instruction (Schramm, 1964).

Sound Tape Recordings

A graduate-level course in educational research was taught by a series of tape-recorded lectures combined with brief instructor-led discussions. When the experimental group was compared with a controlled group taught by the traditional lecture and discussion methods, no significant differences were found (Popham, 1961). In a similar later study, Popham (1962) used student-led discussions and tape-recorded lectures in the experimental group and again failed to show any significant differences between the achievement of the experimental and control groups. The subject matter for this study was a college course in Principles of Secondary Education.

Carroll (1963) notes that a few experimental studies on teaching foreign languages have investigated questions of "how much and in what ways the tape recorder may contribute" and "the degree to which the tape recorder may be expected to take over some of the functions of the instructor." He criticizes these studies on the grounds that uncontrolled factors or other deficiencies because of "valid research methodology" prevent any reliance on their findings.

Sticht (1969) conducted a series of studies which focused on learning by listening in relation to aptitude, reading, and rate-controlled speech. From a total of five studies, it was concluded that certain materials may be presented as effectively through listening as through reading for men of both average and low aptitude. Additionally, moderate degrees of speech compression may improve the listening efficiency of men with high average, average, and low aptitudes. The findings generally indicated that in some instances listening materials may be as useful as reading materials for training men of all aptitudes. Also, the data suggest that the potential motivational value of listening materials in inducing men to study should be investigated.

Instructional Systems

As the demand for qualified individuals to serve in business, industry, government, and academic institutions increases, the need for educating and training these people becomes greater and greater. In recent years, numerous attempts have been made to develop methods and techniques which will meet this need.

Modern developments of vocational-technical curricula require the utilization of educational technology. According to Slaughter, "the potential contribution of technology to education is enormous. . . and will depend up on the research and development effort put behind the planning and production of systems of technology" (Slaughter, 1966, p. 11). The ever increasing technological age is changing our traditional notions of education. The role of the teacher and the nature of the learning process must be reexamined in light of new educational technology (Sergeant, 1968).

Burns (1967) suggests that programs for utilizing the new technology should consider the best uses of devices such as:

1. Centralized tape libraries from which local school systems could select, for example, an entire course of instruction or specialized lectures prepared by the greatest teachers in specific fields;

2. Closed-circuit TV systems for a school district or region and individual video tape players--the hear-and-see devices--to enable each classroom to utilize the course materials that can be made available to every school;

3. Electronic teaching machines that have been particularly successful in language instruction;

4. Programmed learning systems for detailed, repetitive instruction;

5. Scanning devices in each classroom that would be linked to the library and records office to free teachers of a time-consuming chore;

6. Computer centers for grading examinations for a school or an entire school district relieving teachers of a time-consuming chore;

7. Computers for cataloging and retrieving information;

8. A flexible open-circuit educational TV network to bring a variety of current events type instruction to classrooms.

Burns also proposes that to obtain maximum use of these and other devices, systems of instruction might be developed.

The major problem has not been due to the inappropriateness of any particular method or technique, or to the poor quality of any particular materials. Rather "the difficulty has lain with the failure of the existing systems to deal with the differing abilities and requirements of today's students" (Baker and Goldberg, 1970, p. 775).

Individualized Learning Systems

The learner is an individual, and should be taught accordingly. Many innovations, such as audio- and video-tape lectures and demonstrations, small group work, and teaching machines and programmed instruction materials, have all helped, to some degree, to improve education and skill training. However, "what is needed is a system which permits the selection of both the curriculum and the manner in which it will be presented for each individual learner"

(Baker and Goldberg, 1970, p. 775). Individualized learning systems have been developed to accomplish just this.

Before an individualized learning system is described and discussed, it should first be defined. Specialists in the analysis and design of systems vary in their definitions of system or systems design. The following is a definition presented by Donald Stewart (1964):

> A learning systems approach is an effort to organize and condense those necessary or desired experiences as concisely and systematically as possible so as to increase the probability that learning will occur in an efficient manner. A Learning Systems concept, when applied to educational or training courses, offers an opportunity to develop or rebuild these courses to be significantly more effective and efficient in relation to the learning tasks and goals of the students (p. 7).

Canfield (1965) proposes:

> The systems approach to instruction embodies the major characteristics of any system; specifically defined objectives, detailed plans for their achievement in identifying all crucial elements and their inter-reactions, and continued feedback (p. 3).

Corrigan (1964) explains:

> System requirements are postulated to organize and develop the methods and materials of instruction including automatic teaching most consistent with efficient individual learning requirements in both individual and group settings. The underlying philosophy of this system provides the most meaningful rationale to organize, coordinate and direct the efforts of all contributing groups (p. 36).

The definitions by Stewart (1964), Canfield (1965), and Corrigan (1964) were needed in order to present a comprehensive view of the systems design. Stewart (1964) capitalizes on the systematic organization of experiences to bring about more effective and efficient learning in relation to students' goals. Canfield (1965) lists the characteristics of a system and Corrigan (1964) goes one step further by suggesting the systematic organization and development of methods and materials to meet individual requirements.

Design and Development of Instructional Systems

A systematic approach to the management of learning is not entirely new. However, the rapidly advancing field of instructional technology has opened the way for many alternative instructional patterns. In developing a system of instruction, Kaufman (1970) suggests that the following steps be followed:

1. Identify the problem
2. Analyze the problem and set goals
3. Select a solution strategy from alternatives
4. Implement solution strategy
5. Evaluate performance effectiveness

The systematic structuring of curriculum material from the learner's point of view, resulting in a logical, functional, step-by-step path whereby the learner proceeds from his own starting level through accomplishment of previously set performance objectives, is representative of the systems approach to instruction (Lehmann, 1968). Lehmann lists eight steps in the development of an instructional system which are similar to Kaufman's. An important step included in Lehmann's list is modification--the change of the system to account for the deficiencies noted.

Smith (1966) views instructional systems as developmental and changing, and sees the function of evaluation as an aid in the continuous modification of the individualized learning system. He also lists similar steps to those of Kaufman and Lehmann. One significant step listed by Smith is analyzing cost-effectiveness. This certainly need not be viewed as an integral part of the instructional design. However, personnel responsible for operating vocational programs should view it as being an important consideration.

Robert E. Corrigan (1964), one of the most noted leaders of programmed instruction and individualized learning, lists eight design requirements and classifications for systems development. They are:

1. Statement of objectives for instruction and individual learning expressed in performance terms.
2. Determination of the essential (minimal) subject matter to meet the stated objectives.
3. Ordering of subject matter into a program-format designed to expedite the learning objectives.
4. Highly individualized student participation on a continuously

active basis featuring the recurrent requirement for overt, observable responses to strengthen the learning process and to evaluate student achievement.

5. Controlled pacing of instruction consistent with student performance as measured by the pre-established criteria of learning.

6. Highly directed communication by the "instructor" (media) using the "tutorial" or "coach-pupil" two-way communication model to insure continual and purposeful interaction between "instructor and student."

7. Incorporation throughout the system of those fundamental principles essential to efficient learning, such as:

   a. knowledge of results of performance
   b. immediate correction of incorrect response
   c. purposeful repetition and reinforcement scheduling
   d. directing the student in purposeful learning sequences with his prior knowledge of learning objective present and future.

8. Statement of interim and final performance requirements and measures.

Ikenberry (1970) proposes a set of specifications for an instructional system which are very similar to Corrigan's. However, Ikenberry's list centers on interrelationships between ability levels, type and complexity of content, organization and sequencing, material, method and media of instruction, motivation, and management.

Ikenberry (1970) states:

1. The instructional system shall be independent of time restrictions in the sense that individuals shall be able to progress at their own rates, shall be able to begin the learning sequence when it seems educationally desirable and shall be able to continue the instructional process until mastery has been achieved.

2. The objectives of instruction shall be relevant to the immediate and long-term needs of the learner, and the learner shall be cognizant of this relevance.

3. Educational objectives shall be stated in unambiguous terms which make clear the intellectual competencies to be developed by the learner.

4. The instructional system shall maximize student active involvement in the learning process.

5. The instructional system shall provide accurate, timely and formative feedback to the learner regarding his progress toward learning goals.

6. The instructional system shall be designed to maximize the principles of positive reinforcement and eliminate or minimize those aspects known or suspected to be aversive to the learner.

7. The instructional system shall insure appropriate sequencing of learning experiences, shall be capable of diagnosis of learner deficiencies and adjust the instructional sequence appropriately.

8. The instructional system shall solicit reliable and timely information on individual student learning progress and shall make adaptations appropriate to the individual learner.

9. In the development of instructional goals and processes, the instructional system shall take into account the total environment in which the student learns.

10. The instructional system shall have a recognizable "style,*" a cognitive structure sufficiently obvious to provide meaning or relevance to learning, and to

> encourage continuous commitment to learning throughout life (Ikenberry, 1970, p. 12).

Corrigan (1964), Smith (1966), Lehmann (1968), Ikenberry (1970), and Kaufman (1970) each go to great lengths in defining the systematic approach to instruction. The steps listed by these noted authors were considered when designing the instructional system to be utilized by this study.

Types of Instructional Systems

While instructional systems applications are relatively new in education, two general types of instructional systems have been identified as being relevant to vocational and technical education. Personnel from the Air Force Human Resources Laboratory have developed what is being referred to as learner-centered instruction (LCI). Another general type being developed throughout the country has been referred to as computer-managed instruction (CMI).

Bumstead (1969) and Valverde (1969) both define LCI as an instructional system designed by the Air Training Command in which a student is assigned behavioral objectives and proceeds at his own rate, with minimum assistance from the instructor, until he can perform those objectives satisfactorily. The LCI system was first introduced via an electronics course designed for airmen training for specific duties as mechanics or technicians working on a particular weapons system. The course included the use of several instructional media, teaching machines, task simulators, and programmed instruction books. The criteria used to measure the success of the LCI course was a special job performance test. The performance test was based upon tasks derived from the behavioral description of the actual job, and contained three parts: (1) operational checkout, (2) troubleshooting, and (3) auxiliary task performance (Pieper, Folley and Valverde, 1969).

LCI course effectiveness was compared to the conventional Air Force course. This was accomplished by comparing each group with regard to their job performance immediately following course completion and also their job performance five months later. Pieper, Swezey and Valverde (1970) reported that the performance for the LCI group was significantly greater than for the conventional group; and that the cost of the LCI course was substantially lower than that of the conventional course. They also stated that the courses were equally acceptable to the trainees.

The outgrowth of the computer-managed instructional system development was due to the effort of a number of researchers to systematically individualize instruction without involving computer-assisted instruction (CAI) (Baker, 1971). The major functions of the computer-managed instruction (CMI) are those of scoring test papers, recording scores, and keeping track of the instructional materials a particular student has used. CAI differs from CMI in that its focus is on instructional functions and CMI focuses on the management of instruction. In reviewing several computer-managed instructional systems, Baker (1971) indicates four major functions: Test scoring, diagnosing, prescribing, and reporting.

A CMI system developed at the Memphis Naval Air Technical Training Center may have some relevance to vocational and technical education. This system is aimed at reducing training costs (Johnson, 1967). The selection of one of two alternatives in individualizing instruction was the rationale for developing this training system. One may either hold quality constant and let the training time vary, or hold time for training constant and allow quality to vary.

The objective of this CMI system was to reduce training time as much as possible while holding to a constant minimal level of quality. The CMI system as developed resulted in reduced training time by: (1) alternating instructional paths; (2) avoiding repetition of what some students already know by pretesting; (3) eliminating unnecessary instruction; and (4) having the students take greater advantage of self-instructional materials (Impellitteri and Finch, 1971).

Summary

Considerable research has been conducted in a wide variety of educational settings pertaining to individualized instruction. Research findings pertaining to individualized learning systems are limited primarily due to the fact that instructional systems are relatively new in education. This chapter has limited its review to selected studies of direct interest to the present study.

Studies related to educational technology involving filmstrips, slides, and transparencies; programmed instruction; and sound tape recordings were presented. Some significant facts reported by the research are:

1. Projected still pictures were about as effective as silent or sound films in teaching factual information (Allen, 1960).
2. Filmstrips and slides have been found to be at least as effective as films because of special learning conditions (individual pacing and student participation) for which they are especially suited (Allen, 1959).
3. A significant difference was found in favor of transparencies when compared to the chalkboard (Chance, 1960).
4. Self-instructional systems, utilizing single concept films, programmed instruction, laboratory experiences, and teacher's guides can be effectively used to teach all types of knowledge and skills (Nish, 1968).
5. There are two basic styles of programmed instruction; (1) linear programs, and (2) intrinsic programs (Goldstein, 1964).

6. The linear method may be quite satisfactory for teaching facts and concepts; and a combination of the two methods is better for dealing with opinions and implications (Trow, 1963).

7. Programmed instruction can teach knowledge items more effectively than conventional instruction and also accomplish the instruction in less time. Also, programmed instruction can very effectively train students in simple manual skills (Coleman, 1964).

8. Learning was significantly greater and took less time when a visual (pictorial) presentation of a concept to be learned preceded a verbal (printed) presentation of the same concept (Gropper, 1966).

9. Students who used the programmed textbook with visuals learned the 16 mm motion picture projection principles in less time than did a lecture group (Gordon, 1965).

10. Studies conducted by Popham (1962) indicate no significant difference when comparing a series of tape-recorded lectures combined with brief instructor-led discussions with the traditional lecture and discussion methods.

Research indicating the need and importance of vocational-technical curricula utilizing educational technology was reported. The instructional system has been identified as a desirable method of instruction capitalizing on instructional media and emphasizing individualized instruction. Several instructional system designs were presented. Ikenberry's design was chosen as being appropriate for the design of the instructional system to be utilized by this study.

III. THE STUDY

Introduction

The purpose of this study was to develop and test an experimental individualized learning system. The study involves two major dimensions:

1. To design, construct, field test, and evaluate an individualized learning system.
2. To conduct a comparison of two methods of teaching; one utilizing an instructional systems concept and the other utilizing traditional concepts and methods of teaching (group-lecture and demonstration).

Development of the Study

The experimental individualized learning system was designed and developed as follows:

1. A major instructional need was identified in the area of automotive technology. The need was identified by the automotive students and instructors, Automotive Technology program advisory committee, and community college administrators.
2. A target population was selected (students enrolled in Automotive Technology programs).

3. Job tasks were listed and then behavioral objectives formulated.

4. Experimental instructional materials were developed. They consisted of:

   a. a student's guide and answer booklet,
   b. a programmed instruction book,
   c. 35 mm color slides in sequence with a sound tape,
   d. equipment designed for practice sessions.

5. Evaluation instruments and procedures were developed. They consisted of:

   a. a comprehensive cognitive knowledge pretest,
   b. cognitive knowledge check-ups,
   c. psychomotor skill performance checklists,
   d. student psychomotor skill evaluations,
   e. a comprehensive cognitive knowledge posttest,
   f. a comprehensive psychomotor skill evaluation.

6. The individualized learning system was field tested with 21 students.

7. Revisions were made based on the results of the field test.

8. The individualized learning system was compared to the traditional method of teaching.

9. The test results were analyzed and reported.

The individualized learning system used in this study utilized the following media and methods:

1. Four hundred eighty 35 mm color slides sequenced with 24 cassette tapes to provide visual and aural information.

2. Programmed information for reinforcing learning initiated by the slide-tape presentations.
3. Practice sessions to develop psychomotor skills.
4. Psychomotor skill performance checklists to serve as reinforcement of motor skill development and as evaluation criteria.

The system was designed to facilitate instruction by providing the necessary equipment, materials, and procedures for effective and efficient learning experiences for each individual student. The system was developed in the following manner:

1. The performance objectives were established and arranged in a purposeful sequence.
2. Types of learning involved in reaching each objective were identified. In other words, the learning of principles and concepts, identifying components and parts, or learning a specified psychomotor skill.
3. Stimuli which would induce each type of learning were identified. The primary learning stimulus used in this system is sight and sound.
4. The stimuli served as criteria for the selection of media that would be most useful in the individualized learning system.
5. The slide-tape presentation was selected to present the

knowledge and skills to be learned and developed. Media were selected with regard to effectiveness of stimuli.

General Conditions

The experimental nature of the individualized learning system and the need for uniformity in testing the system required that general conditions be established to guide the researcher, students, and instructor. The conditions were as follows:

1. Each student was provided equipment and material necessary to:
   a. Identify and interpret the function of components and parts of the automobile braking system;
   b. Disassemble, service, and reassemble components of the automobile braking system.
2. Each student was responsible for use of the equipment and materials necessary to complete the learning unit.
3. Each student worked individually with the exception of two or three students mutually viewing a slide-tape presentation occasionally.
4. No student was allowed to proceed in an unsafe manner or in ways detrimental to the equipment.
5. Each student was instructed to perform in such a manner as to produce or develop an individual with demonstrated abilities consistent with the specified criteria.

The instructor was available at all times to assist the student. This usually consisted of giving directions, providing special tools, replacing expendable materials, and evaluating student psychomotor skill development. The researcher was also available at all times to assist the instructor when he needed assistance and to observe student performance.

<u>Operational Objective</u>

An operational objective was developed in order to provide an indication of results obtained by the use of the system. The objective served as a basis for determining criteria for evaluating the results of all instruction (control and experimental groups). The following operational objective was selected:

The student, upon completion of this unit, will have demonstrated acceptable levels of performance to include the following:

1. Identify and interpret the function of components and parts of the automobile braking system.
2. Disassemble, service, and reassemble components to include:

   a. brake shoe assembly
   b. master cylinder
   c. wheel cylinder
   d. backing plate
   e. brake shoes
   f. brake drums

The student will be required to demonstrate safe working procedures, proper use of tools and equipment, and proper use of technical manuals. Also, he will be required to follow automotive specifications when needed.

Performance Objectives

A thorough analysis of skills and knowledge necessary for mastery of the automobile brake system provided a basis for establishing criteria for performance objectives. Source materials utilized in developing performance objectives are listed in Appendix A. The evaluation of student performance was based upon criteria from the performance objectives. The performance objectives are listed in Appendix B.

Media Presentation

A combination of instructional media were selected to achieve the performance objectives. The following components were used:

1. 35 mm color slides
2. cassette tapes

Each slide-tape presentation was from four to seven minutes in length. Previously established performance objectives were utilized in establishing criteria for producing the presentations that would teach specific cognitive knowledge and psychomotor skills necessary to master the automobile brake system.

Four viewing stations were set up with one Kodak Carousal projector, one Sony cassette recorder, and two sets of headphones each. It was possible for each student to view the presentation as often as he desired by repositioning the carousal and rewinding the cassette tape.

The identified skills and necessary knowledge presented in the slide-tape presentations were evaluated by the Automotive Technology program advisory committee. Members of this advisory committee are listed in Appendix C.

Narration was recorded on magnetic sound tape. Care was used in developing and sequencing the 35 mm color slides and the magnetic sound tape in a manner consistent with the findings of research.

A jury of educational experts evaluated the slide-tape presentation for consistency with accepted criteria for effective instructional media design. Jury members are listed in Appendix C. Content of the presentations was based upon the 24 performance objectives. A series of slides and one cassette tape were developed for each performance objective. The 24 presentations were divided into six modules as listed below (for detailed descriptions, see Appendix B):

Module 1 - Performances I, II, III

Module 2 - Performances IV, V, VIa, VIb, VII, VIIIa, VIIIb, IX

Module 3 - Performances X, XIa, XIb, XIIa, XIIb, XIIIa, XIIIb

Module 4 - Performance XIV

Module 5 - Performances XV, XIX

Module 6 - Performances XVI, XVII, XVIII

Module 7 - Performance XX (psychomotor skills evaluation)

The seventh module specifies that the student will satisfactorily demonstrate his ability to:

1. Service wheel bearings
2. Remove and replace brake shoe assemblies
3. Service wheel cylinders
4. Service master cylinders
5. Bleed and adjust brakes

These skills were presented and demonstrated by the student in the previous modules. Module 7 provides an opportunity for the student to demonstrate his ability to accomplish all of these skills in one setting. Essentially, Module 7 is a typical brake job on an automobile and will be utilized as the assessment instrument to evaluate psychomotor skill development of all subjects.

Note: Not all of the performance objectives require a psychomotor skill development. Performances requiring a psychomotor skill development are (for detailed descriptions, see Appendix B):

Module 1 -	Performance III	(5 minutes)
Module 2 -	Performance V	(10 minutes)
	Performance VII	(10 minutes)
	Performance IX	(15 minutes)
Module 3 -	Performance X	(5 minutes)

	Performance XIa	(5 minutes)
	Performance XIb	(5 minutes)
	Performance XIIa	(20 minutes)
	Performance XIIb	(20 minutes)
	Performance XIIIa	(5 minutes)
	Performance XIIIb	(5 minutes)
Module 4 -	Performance XIV	(12 minutes)
Module 5 -	Performance XV	(4 minutes)
Module 7 -	Performance XX	(1.5 hours)

The time notation indicated in parentheses was established as a maximum time for the student to satisfactorily complete the performance objective. The time limitations were based on Chilton's Flat Rate and Parts Manual (1963).

Programmed Instruction

An Instruction Book was also prepared to help the student learn the automobile brake system. This book consists of programmed instruction to reinforce the learning of the knowledge and skills shown in the slide-tape presentations.

The programmed instruction was presented in two parts; one for Module 1 and another for Module 2. The programmed instruction includes performances I through IX. This type of instruction was developed in accordance with acceptable principles and procedures.

The jury of educational experts which evaluated the slide-tape presentations also evaluated the content, organization, and format of the programmed instruction.

The programmed instruction was designed in accordance with B. F. Skinner's (1958) linear program. The items were stated in small sequential steps so that each individual student would make responses and proceed a short distance each step. The student was directed to write appropriate words as a response based upon his recall. The instruction was self-pacing and each student advanced at his own rate. Immediate feedback and reinforcement were provided by placing a response in the designated place and checking the back of the page for the correct response. A review test was provided at the end of each programmed instruction unit.

Each frame in the programmed instruction also included pictorial illustrations referring to the major concept or principle introduced in that frame. The pictorial illustration preceded the verbal or printed presentation as suggested by research conducted by Gropper (1966).

Student's Guide and Answer Booklet

A Student's Guide and Answer Booklet was prepared to introduce the students to the system, to briefly outline the purpose of the system, and to provide step-by-step procedures for advancement through the system. A separate booklet was developed for each module. These booklets also contained check-up evaluations for the cognitive knowledge, student's progress guides and student's performance evaluations for the psychomotor skill development.

Practice Sessions

The purpose of practice was to provide the student with opportunity for application of knowledge and development of skills shown in the slide-tape presentations and the programmed Instruction Book. Upon completion of the slide-tape presentation and/or the programmed Instruction Book and the satisfactory completion of a cognitive knowledge check-up (evaluation), the student was directed to practice in a manner similar to those shown in the media presentation.

Safe and proper use of equipment was required at all times. These were illustrated by the slides which the students had viewed. The instructor was responsible for making certain that these procedures were followed. If a student neglected to follow safety practices or began to use equipment in a detrimental fashion, he was stopped immediately by the instructor. The student was informed why he was stopped and directed to review the appropriate materials on safety. After reviewing the materials, the student proceeded with his work.

Evaluation Procedures

A pretest was used to determine the specific cognitive knowledge each student possessed regarding the automobile brake system. Previously established performance objectives served as the criteria for the development of the pretest. Complete instructions accompanied the pretest which was administered to individual students on a group basis.

The pretest was an objective (multiple-choice, completion, and identification) paper-and-pencil test consisting of 88 questions. The test covered cognitive knowledge to be taught in the individualized learning system. The pretest is located in Appendix D.

The students were also given the opportunity to complete a comprehensive psychomotor skill evaluation. The cognitive knowledge pretest and the comprehensive psychomotor skill evaluation were administered prior to any instruction.

The instructor assured the students that all pretest results would not be used to determine student grades for the course in which they were enrolled; and that results would be used only to help each individual student learn what he needed to accomplish next to reach his objective.

The continuous evaluation principle is a basic element and integral part of the individualized learning system. The evaluation was accomplished by the student, the instructor, or by both; but in all cases, results were immediately available to the student. The results of the evaluations determined whether the student proceeded to the next phase of work or repeated previous work to acquire skills and knowledge required to proceed.

Two forms of evaluation were used within the system: (1) cognitive knowledge review tests (check-up evaluation), and (2) skill performance tests (student performance evaluation). The cognitive knowledge review tests were used to evaluate the student's knowledge of information contained in the media presentation and the programmed Instruction Book. They were incorporated into the Student's Guide and Answer Booklet and were used by the students at the end of each presentation and/or programmed Instruction Book.

The performance tests for each instructional unit were used to evaluate the student's ability in performing tasks presented in the slide-tape presentations. They were used to evaluate student's performance during and upon completion of practice sessions.

Performance checklists were used to evaluate student's proficiency in learning skills and utilization of knowledge presented by the instructional media. Satisfactory levels of performance were established for each part of the experiment by the automotive technology program advisory committee. Each individual student had to perform at a specified level of satisfactory performance before he was permitted to progress to the next part of the system.

The program advisory committee indicated the need for the student to perform the individual tasks within certain time limitations. Based upon the technical experience of the individual members of the committee, and the Chilton's Flat Rate and Parts Manual (1963), a maximum time for the completion of each skill performance was established.

Upon completion of the experimental individualized learning system, each student was given a cognitive knowledge posttest administered individually and in a group setting. The posttest was essentially the same as the pretest only it was restructured by rewriting the test. A comprehensive psychomotor skill evaluation was also given upon the completion of the learning system.

Design Procedure of the Traditional Method

Performance objectives were used as the criteria of instruction for both methods of instruction; the experimental individualized learning system and the traditional group-lecture and demonstration method. The control group, utilizing the traditional method of instruction, was designed and developed as follows:

1. A cognitive knowledge pretest and comprehensive psychomotor skill evaluation was administered prior to any instruction.

2. The instructional treatment was administered utilizing group-lectures and demonstrations and practice sessions.
3. At the end of the traditional instructional treatment (three weeks; 75 hours of instruction), a cognitive knowledge posttest and comprehensive psychomotor skill evaluation was administered.

The pretests, posttests, and psychomotor skill evaluations administered to the control and experimental groups provided necessary data to perform a statistical analysis of the two groups.

Hypotheses

H_{01}: When learning the necessary cognitive knowledge, there will be no significant differences in the mean scores produced by the individualized learning system (experimental group) and the traditional group-lecture and demonstration (control group) method of teaching students the Automobile Brake System.

H_{02}: All 100 subjects participating in the study will be able to master 100 percent of the psychomotor performance tasks satisfactorily.

Selection of Subjects

Post-secondary students served as the population for this study. One hundred students enrolled in the Automotive Technology program at Portland Community College, Portland, Oregon, were randomly assigned to two groups; experimental and control.

Based upon the results of a preliminary field test of the experimental instructional system, the teacher variable will be more easily controlled for error if the study is limited to Portland Community College.

Experimental Design for Cognitive Knowledge

Campbell and Stanely (1963) list 12 confounding variables (dependent and independent) which jeopardize the validity of experimental design if they are not controlled. Two methods of minimizing the effects of these variables are the random assignment of subjects to treatment groups, and the limitation of treatment time.

In experimental research designs similar to that which is projected by this study, the researcher used a design in which he randomly assigns students to groups for the experiment. This type of group assignment is both proper and necessary to inferential research; however, Courtney and Sedgwick (1969) suggest the analysis of covariance for studies where there is reason to think that great variation exists among the subjects used in the study. The analysis of covariance is a procedure for testing the significance of differences among means, accounting for the influence of uncontrolled factors in the experiment. This statistical procedure was chosen as being appropriate for this research study.

From a population of 100 students, 50 were randomly assigned to the experimental treatment group and 50 to the control treatment group. This is essentially a fixed model design. The experimental design for this study can be projected as follows:

(R) Experimental group 0_1 X_E 0_2

(R) Control group 0_1 X_C 0_2

where R indicates random assignment,

0_1 is the pretest score,

X_E is the experimental treatment,

X_C is the control treatment,

0_2 is the posttest score.

The most widely used acceptable test is to compute the pretest-posttest gain scores for each group and to compute an $\underline{F}$ between the experimental and control group on the gain scores (Gage, 1967, p. 193). Randomized "leveling" on pretest scores and the analysis of covariance with pretest scores as the covariant was utilized as preferable to simple gain-score comparisons. In order to determine the influence of two methods of instruction, the pretest-posttest gain scores were computed for each group (control and experimental) and then an $\underline{F}$ computed between the two groups utilizing the gain scores.

In testing the null hypothesis it was necessary to set confidence limits for testing the probability that the null hypothesis is or is not tenable. Common practice has been to use the .01 or .05 level. Wert *et al.* (1954) state that:

> The probability required for rejecting the null hypothesis is highly arbitrary but common practice has been to use the 5 percent or the 1 percent level. The former level, usually referred to as a significant difference, implies that the sample mean difference is so great that it would occur in less than 5 percent of the samples from populations in which the mean differences are zero (p. 383).

For the purposes of this study, the .05 level was selected.

The one-way analysis of covariance is appropriate for this study and tests of H_{01} were made according to the following:

Adjusted data (by covariance)

Source	df	ss	MS	*F*
Group	1	A	A/1	MS group/MS error
Error	97	B	B/97	
Total	98	C		

The hypothesis (H_{01}) was tested by entering the *F* table and using 1, 97 degrees of freedom. If the computed *F* is larger than the tabular *F* at the .05 level, the hypothesis is rejected; if smaller, it is retained.

It is first necessary to separate the effect of the variables by a preliminary analysis of variance as stated by Dixon (1957). According to Edwards (1955):

> The rationale of this analysis of variance is that the total sum of squares of a set of measurements composed of several groups can be analyzed by separate parts, from which independent estimates of each population variance are computed (p. 316).

Garrett (1958) suggests that when the F of this preliminary analysis of variance is not significant, it can be assumed that the random assignment of subjects to the groups was successful. Edwards (1955) also makes this assumption of random sampling for the pre-test (x) scores when he states:

> From this computation we may test the null hypothesis that the groups making up the total population are random samples from a common normal population as the two estimates of the population variance may be expected to differ only within the limits of random sampling (Edwards, 1955, p. 316).

Dixon (1957), Garrett (1958), and Walbesser and Carter (1968) all state the importance of the successful random assignment of subjects to groups in experimental studies similar to the present study. Therefore, the preliminary analysis of variance was computed.

Experimental Design for Psychomotor Skills

Walbesser and Carter (1968) discuss several evaluation designs used by experimental curriculum developers. One approach is to allow the developers of the instructional materials to view the units being taught and to evaluate their success or failure on the basis of his observations. This procedure assumes a level of objectivity on behalf of the author which may be difficult to maintain.

Another strategy for the assessment of the effectiveness of a curriculum can be based upon behavioral or performance objectives (Walbesser and Carter, 1968). This strategy requires the curriculum developer to describe expected learner outcomes in terms of observable behavior. The success of this evaluation strategy rests with the intimate involvement of the author of the instructional materials in the construction of both the performance objectives and their assessment.

The description of aims or objectives can be written so as to assist in their evaluation. One way is to construct the instructional objective as descriptions of observable behavior. That is, observe whether the subjects exposed to the instructional treatment are able to exhibit the behaviors described. And, on the basis of these observations, construct a success-or-failure decision.

It is unlikely that an evaluation of behavior could be restricted to paper-and-pencil measures of performance and still directly measure the total array of expected behavioral acquisitions. The expectation is that most of the measures of behavior will require performance tasks for which paper-and-pencil items are unacceptable as adequate measures.

Assessment measures of behavior also raise interesting psychometric questions. For example, the behavior described by an objective is to be acquired by what percentage of subjects. Should it be 50, 75, or 100 percent? According to Walbesser and Carter (1968), individual differences in acquisition contributed to the decision that 100 percent of the subjects acquiring 100 percent of the described behaviors was unrealistic. It was conjectured that the 90/90 level of attainment will provide an acceptable indicator of success.

However, the researcher, instructors, and Automotive Technology program advisory committee strongly recommended that all subjects satisfactorily complete all tasks stated on the psychomotor skills performance evaluation in order to provide an acceptable indicator of success. The rational presented for this decision was that all performance objectives are minimal in terms of cognitive knowledge and psychomotor skills. Anything less would not meet industry standards and would be unsatisfactory.

The data collected to test the hypothesis (H_{02}) were obtained from the assessment administered before the instructional treatment and after the instructional treatment. The assessment measures are the same for all subjects and were recorded on a successful-unsuccessful basis. Assessment tasks were prepared by the researcher, instructional staff, and the Automotive Technology program advisory committee. The assessment tasks are listed in Appendix E.

IV. PRESENTATION OF FINDINGS

The analyses of data collected for this study have been presented in two major sections. The first section deals with the analysis of covariance statistical technique. This technique describes the results of testing for differences among mean scores produced by two methods of instruction; the individualized learning system and the traditional group-lecture and demonstration method.

The second major section deals with the collection and interpretation of data relating to psychomotor skill development. The technique describes the results among the two groups in regard to obtaining pre-established satisfactory levels of achievement.

Analysis of Covariance Technique

The statistical technique used in this study was the analysis of covariance. The null hypothesis was tested to determine if significant differences existed between the mean scores produced by the individualized learning system and the traditional group-lecture and demonstration method of teaching the cognitive knowledge relating to the automobile brake system.

A summary of the experimental design and techniques is presented in Table 1. The control variable used was the cognitive knowledge pretest designated as X. The control variable was

Table 1. Summary of Experimental Design and Procedures.

Groups	Pretest	Treatment	Criterion measure achievement posttest	Analysis
<u>Control</u>				
This group was taught by the group-lecture & demonstration method.	(X) cognitive knowledge objective test.	The treatment effect for both groups was tested by the null hypothesis. The level of significance was set at .05.	(Y) cognitive knowledge objective test.	Analysis of covariance utilizing data from both groups.
<u>Experimental</u>				
This group was taught by the individualized learning systems method.	(X) cognitive knowledge objective test.		(Y) cognitive knowledge objective test.	

administered prior to any instruction pertaining to the automobile brake system. The cognitive knowledge criterion posttest, designated as Y, was administered upon completion of the instructional treatments.

Table 2 presents the data for the control and criterion measures. The pretest and posttest scores, represented by X and Y, are reported as raw scores.

Assessment of Pretest and Posttest Scores

In the analysis made in this study, the pretest (X) scores served as the base reference for achievement gain to enable the application of appropriate statistical techniques. The preliminary analysis of variance yielded an *F* ratio of 0. 3979 for X. From a standard table of *F* values for one and 98 degrees of freedom, these values did not reach significance at the . 05 level and the hypothesis of random samples was accepted for the initial pretest (X) scores.

Computations were made for the purpose of adjusting the posttest (Y) scores for differences in pretest (X) scores. An analysis of covariance was then applied to the data in order to determine a difference in the means of the residuals of the sums of the squares of posttest scores and pretest scores together (SSy, x). By dividing these sums of squares by the appropriate degrees of freedom, a variance of y, x was determined for between group means and within group means.

Table 2. Pretest and Posttest Scores Made by the Group-Lecture and Demonstration Group and the Individualized Learning System Group.

Group-lecture and Demonstration Group						Individualized Learning System Group					
Control						Experimental					
No.	X	Y	No.	X	Y	No.	X	Y	No.	X	Y
1	68	82	26	60	79	1	54	87	26	70	83
2	64	76	27	60	79	2	50	81	27	48	79
3	63	79	28	55	82	3	38	58	28	27	84
4	63	80	29	48	84	4	32	81	29	17	83
5	62	80	30	44	85	5	56	88	30	31	71
6	62	81	31	39	77	6	7	83	31	43	81
7	61	83	32	15	84	7	61	78	32	42	82
8	43	85	33	69	83	8	43	85	33	23	75
9	42	70	34	67	86	9	43	85	34	65	83
10	38	78	35	66	88	10	23	86	35	54	84
11	34	83	36	65	82	11	67	87	36	63	82
12	32	79	37	59	83	12	50	87	37	30	72
13	24	76	38	59	85	13	67	83	38	62	82
14	15	78	39	56	85	14	52	88	39	30	79
15	61	87	40	55	87	15	30	82	40	52	78
16	61	79	41	53	77	16	36	83	41	61	87
17	57	78	42	52	75	17	59	73	42	55	85
18	44	76	43	52	84	18	55	84	43	38	78
19	43	82	44	49	81	19	42	88	44	22	87
20	41	79	45	48	76	20	62	79	45	22	82
21	30	79	46	36	86	21	54	76	21	54	76
22	24	62	47	35	83	22	69	86	47	25	74
23	14	83	48	33	79	23	42	84	48	31	81
24	5	69	49	27	62	24	25	87	49	64	84
25	67	86	50	22	86	25	32	82	50	44	87

Note: X = Cognitive knowledge pretest; Y = Cognitive knowledge posttest. A perfect score is 88.

The quotient of these variances yielded the _F_ statistic by which the null hypothesis was rejected or was not rejected (Garrett, 1958).

The analysis was calculated from raw score data which are reported in Table 2. The following is a description of the analysis and a presentation of the data necessary to its computation. An interpretation of the results of this analysis is made in the following chapter.

Analysis

1. This analysis was made to determine the comparative effect of teaching method on cognitive knowledge as shown by the Automobile Brake System Posttest (Y).

2. The preliminary analysis of variance of X and Y scores taken separately failed to show any significant differences. The _F_ values obtained were as follows:

   (1) X = 0.3979 and (2) Y = 2.06

3. The covariance analysis of the final Y scores which were adjusted for differences in the initial pretest (X) scores also failed to show a significant difference. The _F_ value obtained for the covariance analysis was 2.73. A summary of these data is reported in Table 3.

Based upon data collected and tabulated for the analysis, the null hypothesis (H_{01}) was accepted. Had a significant _F_ value for the

Table 3. Summary of the Statistical Analysis for the Automobile Brake System Pretest and Posttest Scores Made by Two Groups of Students.

Source of variation	df	Sum of squares	Mean squares	Computed *F*	Tabular *F*
Analysis of variance of automobile brake system pretest (X) scores					
Between groups	1	115	115.00	.3979[a]	3.94
Within groups	98	28,309	288.87		
Total	99	28,424			
Analysis of variance of automobile brake system posttest (Y) scores					
Between groups	1	63	63.00	2.06[a]	3.94
Within groups	98	2990	30.51		
Total	99	3053			
Covariance analysis between pretest (X) and posttest (Y) scores					
Groups	1	76.83	76.82	2.73[a]	3.94
Error	97	2727.99	28.12		
Total	98	2804.81			

[a]The *F* values were not significant.

analysis of covariance been obtained, tests of homogeneity of variance and linearity of regression would have been advisable since assumptions underlying the tests of significance demand that regression be linear and that the distributions have the same variance for the test to be valid (Lindquist, 1953). If significant *F* values had been obtained, an adjustment of the criterion means also would have been in order. Wert, *et al*. (1954), however, state that this adjustment process is in order only when the *F* value is found to be significant. "It should be further noted that this adjustment process is only in order when significant *F* values have been found in the analysis of covariance" (Wert, *et al*., 1954, p. 348).

Assessment of Psychomotor Skill Development

The strategy of evaluation for the assessment of the effectiveness of the psychomotor skill development was based upon performance objectives commonly known as criterion assessment. The psychomotor tasks written in terms of learner outcomes in observable behavior were clearly delineated. The researcher and instructor were both closely involved in the construction of the performance objectives and their assessment as stated in the design strategy developed by Walbesser and Carter (1968).

All subjects were given the opportunity to demonstrate their psychomotor skills pertaining to the automobile brake system before the instructional treatments were administered. Only two students in the control group (group-lecture and demonstration method) chose to attempt the psychomotor performance objective. They were both completely unsuccessful. All 100 subjects were rated unsuccessful on the psychomotor skill assessment prior to the administration of the instructional treatments.

Upon completion of the instructional treatments, all subjects demonstrated their psychomotor skills related to the automobile brake system. The psychomotor skills assessment (student performance evaluation) is listed in Appendix E.

All 100 subjects demonstrated satisfactory levels of achievement on 100 percent of the described performance tasks and were rated successful on the psychomotor skills assessment. Therefore, the hypothesis (H_{02}) was accepted and it was determined that the method of instruction did not have a significant effect upon achievement of psychomotor skills.

Individualized Instruction

As stated previously, the individualized learning systems concept emphasizes the individualizing of instruction with an overall purpose of promoting learning as the constant and time as the variable. A study of the data listed in Table 4 will clearly show time as the variable; and, by previously establishing the necessary cognitive

Table 4. Presentation of the Number of Times the Subjects in the Experimental Group used the Media and the Learning Time Needed to Complete Each Module.[a]

	Pretest	Posttest	Net Gain Score	Module 1		Module 2		Module 3		Module 4		Module 5		Module 6		Module 7	Total	
				No. times use media	Learning time to complete	No. times use media	Learning time to complete	No. times use media	Learning time to complete	No. times use media	Learning time to complete	No. times use media	Learning time to complete	No. times use media	Learning time to complete	Learning time to complete	No. times viewing	Time to complete
1	54	87	33	6	2:30	14	4:30	15	6:30	3	1:30	4	1:30	7	1:30	1:55	49	21:55
2	50	81	31	4	1:30	8	4:30	8	4:30	1	0:25	2	0:30	4	0:45	3:00	27	17:10
3	38	58	20	7	2:50	18	4:30	17	7:30	2	2:20	5	2:30	7	1:00	3:15	56	25:55
4	32	81	49	6	5:45	16	7:30	16	7:30	2	5:45	4	2:00	7	2:00	4:40	51	37:10
5	56	88	32	4	2:00	14	4:30	16	3:45	2	3:30	5	3:00	7	1:00	2:50	48	22:35
6	7	83	76	4	2:00	8	4:35	7	4:00	2	1:15	2	2:05	3	0:30	3:10	26	19:35
7	61	78	17	3	2:15	12	9:00	8	9:30	1	2:30	2	3:20	3	1:00	4:10	29	33:45
8	0	82	82	5	2:15	14	6:00	14	4:30	6	1:50	3	1:00	4	0:25	5:00	46	23:00
9	43	85	42	3	1:40	8	3:10	8	4:30	1	1:00	2	0:40	3	0:30	2:45	25	16:15
10	23	86	63	5	2:30	10	7:30	11	8:00	2	1:45	3	2:00	6	2:30	5:30	37	31:45
11	67	87	20	3	1:55	9	5:40	9	4:00	1	1:50	2	0:30	7	1:30	1:30	31	18:55
12	50	87	38	6	1:30	14	4:30	14	4:30	2	1:15	4	1:30	7	1:30	1:25	47	18:10
13	67	83	16	6	2:30	16	5:00	15	7:00	1	2:00	4	1:00	4	0:30	3:00	46	23:00
14	52	88	36	4	3:15	11	6:00	8	5:00	1	0:20	2	0:25	4	0:30	2:00	30	17:30
15	30	82	52	6	2:55	18	9:30	17	7:00	2	2:30	4	3:30	6	2:30	5:30	53	36:25
16	36	83	47	6	1:50	8	6:15	14	4:30	2	1:45	3	1:40	5	1:45	5:00	38	24:45
17	59	73	14	3	2:30	8	6:20	7	2:30	1	0:40	3	1:00	3	0:30	3:50	25	19:00
18	55	84	29	4	2:30	10	8:00	11	6:20	1	1:00	2	1:00	4	1:00	3:10	32	25:00
19	42	88	46	4	2:45	11	6:00	9	6:00	2	1:30	2	0:30	5	1:30	2:30	31	22:45
20	62	79	17	4	1:45	16	5:00	12	6:30	1	1:40	4	2:00	6	0:55	3:50	43	23:40

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Table 4. (Continued)

	Pretest	Posttest	Net Gain Score	Module 1		Module 2		Module 3		Module 4		Module 5		Module 6		Module 7	Total	
				No. times use media	Learning time to complete	No. times use media	Learning time to complete	No. times use media	Learning time to complete	No. times use media	Learning time to complete	No. times use media	Learning time to complete	No. times use media	Learning time to complete	Learning time to complete	No. times viewing	Time to complete
21	54	76	22	6	4:40	17	11:20	14	7:15	2	5:30	4	2:40	7	2:20	3:05	50	38:50
22	69	86	17	4	1:30	8	3:00	8	4:40	1	0:30	3	0:45	4	0:45	3:20	28	16:30
23	42	84	42	3	2:30	10	7:00	7	2:30	1	0:45	3	1:00	3	0:35	3:50	27	20:10
24	25	87	62	5	2:40	8	4:30	10	6:00	2	1:30	2	2:10	3	0:30	3:20	30	20:10
25	32	82	50	4	2:00	12	9:00	17	7:20	2	2:30	5	2:30	7	2:00	4:30	47	31:50
26	70	83	13	6	2:40	16	7:00	15	7:00	1	2:00	4	1:00	4	0:45	3:00	46	24:25
27	48	79	31	4	2:30	9	5:10	8	4:10	1	1:50	2	0:30	7	1:30	2:50	31	19:30
28	27	84	57	3	2:15	12	8:00	14	8:00	1	2:20	2	3:00	3	1:00	4:10	35	29:45
29	17	83	66	4	2:00	8	4:35	7	3:50	2	1:20	2	2:20	3	0:30	3:20	24	19:55
30	31	71	40	6	2:50	11	6:00	15	7:00	1	2:00	4	1:00	4	0:30	3:00	41	24:20
31	43	81	38	3	1:45	9	5:30	9	4:10	1	2:00	2	0:30	7	1:20	3:00	30	20:15
32	42	82	40	5	2:30	8	3:15	16	3:45	2	3:30	5	3:00	7	1:00	3:10	43	22:10
33	23	75	52	4	1:30	10	6:40	8	3:45	1	0:30	2	1:00	4	0:30	2:30	19	18:25
34	65	83	18	6	2:00	14	5:00	14	4:30	6	1:45	3	1:10	4	0:30	5:00	47	21:55
35	54	84	30	5	2:15	10	7:30	11	8:00	2	1:45	3	2:00	6	2:30	5:30	37	31:30
36	63	82	1	6	2:30	9	5:15	14	4:50	2	1:40	3	1:30	5	1:45	5:00	39	24:30
37	30	72	42	3	1:55	8	5:50	8	3:50	1	0:50	2	0:40	3	0:30	2:45	25	18:20
38	62	82	20	4	3:15	11	6:00	9	5:50	2	1:40	2	0:30	6	1:40	3:00	34	23:55
39	30	79	49	4	2:30	10	8:00	16	4:00	2	3:10	5	3:00	7	1:00	3:10	44	25:50
40	52	78	26	6	3:00	8	6:15	7	2:30	1	0:40	3	1:00	3	0:30	3:50	28	19:45

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Table 4. (Continued)

	Pretest	Posttest	Net Gain Score	Module 1		Module 2		Module 3		Module 4		Module 5		Module 6		Module 7	Total	
				No. times use media	Learning time to complete	No. times use media	Learning time to complete	No. times use media	Learning time to complete	No. times use media	Learning time to complete	No. times use media	Learning time to complete	No. times use media	Learning time to complete	Learning time to complete	No. times viewing	Time to complete
41	51	87	26	6	5:30	10	7:50	14	7:15	2	5:00	4	2:10	7	2:10	3:05	43	35:00
42	55	85	30	4	2:45	14	4:30	12	6:30	1	1:40	4	2:00	6	0:50	3:40	41	23:55
43	38	78	40	3	1:50	9	5:30	8	5:00	1	1:50	2	0:30	7	1:30	2:50	30	21:00
44	69	88	19	6	4:00	8	4:20	16	4:30	2	1:45	3	1:40	5	1:45	5:00	40	25:00
45	22	82	60	4	2:30	10	7:10	11	6:30	1	1:00	2	1:00	4	1:00	3:20	32	23:30
46	63	83	30	6	2:30	14	4:30	14	4:30	2	1:10	4	1:30	7	1:30	2:45	47	20:25
47	25	74	49	4	2:00	8	6:30	9	4:00	1	0:45	3	1:00	3	0:30	3:30	28	20:15
48	31	81	50	6	5:20	11	6:00	14	4:30	2	1:45	3	1:40	5	1:45	5:00	41	28:00
49	64	84	20	5	1:30	9	5:20	9	4:10	1	0:40	2	0:40	7	1:10	2:30	33	18:00
50	44	87	43	3	2:30	8	6:20	8	4:00	1	1:15	2	1:00	6	2:35	5:30	28	25:10

[a]Time tabulated in hours; minutes to the nearest five minutes.

knowledge and psychomotor skills in terms of performance objectives, the learning was constant for all participants in the study.

In the experimental group, utilizing the individualized learning system, each student advanced at his own rate. One student completed the traditional three-week unit in 16 hours and 15 minutes. The longest time required to complete the unit was 38 hours. The average time for all 50 students in the experimental group to complete all performance objectives was 23 hours and 48 minutes. The control group was locked into 75 hours of instruction to satisfactorily complete the same performance objectives.

In this study, the subjects assigned to the experimental group and utilizing the individualized learning system completed the total instructional unit on an average of one-third the time of those assigned to the control group. Instructor time normally used for lectures and demonstration was utilized in assisting individual students and documenting each student's achievement in terms of both cognitive knowledge and psychomotor skill development.

The individualized learning system was developed with the intent of providing maximum flexibility to facilitate learning. There are a total of 24 slide-tape presentations. The total number of times each student viewed these presentations varied from one viewing of each presentation to an average viewing of 2-1/2 times. One student viewed one presentation six times.

The minimum total viewings was 25 and the maximum number of viewings was 56. The varied time factor and number of times each presentation was viewed clearly indicates the flexibility of the individualized learning system.

Assessment of Total Time

A comparison of the total time needed by the subjects of each group was not within the scope of the present study. However, the researcher conducted a statistical comparison to determine if significant differences existed between the mean time produced by the individualized learning system and the traditional group-lecture and demonstration method.

The statistical technique used was the analysis of variance. This analysis yielded an F ratio of 4150. From a standard table of F values for one and 98 degrees of freedom, these values reached significance at the .01 level. It was conjectured that there was a significant difference in the total time used by the subjects in each group. A summary of these data are reported in Table 5.

Table 5. Summary of the statistical analysis for the total time used by each group of students.

Source of variation	df	Sum of squares	Mean square	Computed F	Tabular F
Between groups	1	65,485	65,485	4150	3.94
Within groups	98	1,546	15.78		
Total	99	67,031			

Summary

A statistical comparison was made to determine if significant differences existed between the mean scores produced by the individualized learning system and the traditional group-lecture and demonstration method of teaching the cognitive knowledge relating to the automobile brake system. The statistical comparison utilized a one-way classification analysis of covariance.

In order to separate the effect of the variables (pretest and posttest scores taken separately), a preliminary analysis of variance was computed. The preliminary analysis of variance was also used to determine the success of the random assignment of subjects to the experimental and control groups.

Data pertaining to the successful or unsuccessful psychomotor skill development were tabulated according to the strategy utilized by Walbesser and Carter (1968). Subjects were evaluated before and after the appropriate instructional treatment.

The following represents a summary of the analysis generated by this study.

1. The preliminary analysis of variance of the pretest (X) and posttest (Y) scores taken separately failed to show any significant differences. Therefore, as stated by Garrett (1958), it can be assumed that the random assignment of subjects to the groups was successful.

2. The covariance analysis of the final posttest (Y) scores, which were adjusted for difference in the initial pretest (X) scores, also failed to show a significant difference. The null hypothesis (H_{01}) was accepted.
3. All 100 subjects were rated unsuccessful before and successful after both instructional treatments were administered regarding psychomotor skill development. The hypothesis (H_{02}) was accepted.
4. The experimental individualized learning system promoted the concept of time being the variable and learning being the constant. The time needed for completion of the instructional unit ranged from 16 hours and 15 minutes to 38 hours with an average time of 23 hours and 48 minutes for the subjects. This represents a saving of approximately two-thirds when compared to the control group which was locked into 75 hours to learn the identical performance objectives.
5. Flexibility to facilitate learning was an integral part of the experimental individualized learning system. Of the 24 slide-tape presentations, each student in the experimental group viewed each presentation an average of 2-1/2 times. The most any single presentation was viewed was six times and the least was one time.

6. Instructor time, normally devoted to lectures and demonstrations, was utilized to assist individual students and document student achievement.

V. SUMMARY, CONCLUSIONS, RECOMMENDATIONS, AND IMPLICATIONS

Summary

This study was an experimental investigation of two methods of teaching students the automotive brake system. The two methods were the experimental individualized learning system and traditional group-lecture and demonstration.

An intensive review of the literature failed to reveal research in vocational and technical education that corresponded directly with the present study. There were, however, a limited number of studies involving individualized instruction concerning various uses of programmed instruction. These studies support findings in other educational areas that programmed instruction is as effective as other well-prepared instructional methods.

Also, research was reported indicating the need and importance of vocational-technical curricula utilizing educational technology. The instructional system was identified as a desirable method of instruction capitalizing on instructional media and emphasizing individualized instruction. Several studies indicated various methods of designing and developing individualized learning systems.

The performance objectives were identified and written out to provide the instructional criteria for both experimental and control groups. The slide-tape presentations, programmed instruction book, and student's guide and answer booklets were prepared for presentation to the experimental group. Group-lectures and demonstrations were prepared for the control group.

During the winter term of 1972, a field test of the experimental individualized learning system was administered at Portland Community College, Portland, Oregon. The field test was for purposes of perfecting the methods, materials, procedures, and instruments. Appropriate revisions were made after the trial run.

The experiment conducted during the spring term of 1972 utilized a simple randomized design in which 100 students enrolled in the Automotive Technology program at Portland Community College were the subjects.

Pretest measures were obtained as control variables for tests of significant differences utilizing the analysis of covariance techniques. The criterion achievement measures (posttest) were administered upon completion of the instructional treatments.

In order to separate the effect of each variable, a preliminary analysis of variance was performed. A significant $\underline{F}$ value was not reached; therefore, random assignment of subjects to groups, which is critical for this type of research design, was considered successful. The control (pretest) and criterion (posttest) data obtained were used to test hypothesis (H_{01}).

Each of the 100 subjects were allowed to demonstrate their psychomotor skills pertaining to the automobile brake system prior to either instructional treatments. Upon completion of the instructional unit, each student demonstrated his psychomotor skill development. Data were collected on a successful-unsuccessful basis as suggested by Walbesser and Carter (1968). These data were used to test hypothesis (H_{02}).

The assessment measures consisted of a paper-and-pencil pretest and posttest, and a manipulative psychomotor performance skill test. The content validity of these tests was established by investigation of textbooks, research in the field, and review by a panel of specialists (Appendix C).

Conclusions

The problem of this study was to test two hypotheses concerning two methods of teaching the automobile brake system. It must be pointed out that generalizations from experiments of this nature which utilize sample populations should be made with extreme caution. However, keeping these limitations in mind, the findings of this study appear to warrant certain conclusions listed below:

1. The experimental individualized learning system was as effective as the traditional group-lecture and demonstration

method in teaching cognitive knowledge pertaining to the automobile brake system.

2. The experimental individualized learning system was as effective as the traditional group-lecture and demonstration method in teaching psychomotor skill development pertaining to the automobile brake system.

3. The average instructional time needed for completion was 23 hours and 48 minutes for the subjects in the experimental group. When one compares this to the 75 hours the subjects in the control group used to learn the same performance objectives, the potential for all education becomes very obvious.

Recommendations

Because of the apparent success, based upon the findings and conclusions of the individualized learning system utilized in this study, some recommendations were made regarding educational systems:

1. The individualized learning system should be used to teach the basic unit regarding the automobile brake system. Utilization of this method of instruction can enable the vocational educator to use the time thus gained for individual assistance and evaluation of growth, attitudes, and related areas.

2. Investigations to determine the efficiency of instructional systems in other vocational education areas are needed. Because of the many activities taught in a typical vocational education laboratory, it is difficult to present necessary information at the most opportune time. Individualized learning systems needed for teaching cognitive knowledge and psychomotor skill development used in vocational education laboratories may provide a means of presenting instruction when the learners are ready to learn. Similar research studies in the various areas of vocational education may also provide methods of presenting cognitive knowledge and psychomotor skills more effectively.

3. Additional research concerning the effectiveness of instructional systems with students not enrolled in vocational education courses is needed. Vocational teachers in the public schools are often asked to help students enrolled in science and mathematics, as well as other courses, with their class projects. It becomes necessary for the vocational education teacher to either, (a) spend considerable time instructing these students from other subject matter areas on the proper use of tools and equipment, (b) let these students operate as best they can with a minimum of instruction, or (c) refuse to help. None of these alternatives seems very satisfactory.

4. Systems utilizing other educational technology components and organized to teach for similar objectives should be developed and tested.
5. Additional research should be designed to test the strength and instructional value of various components of the learning system utilized in the present study.
6. The subjects in the experimental group completed the instructional unit on an average of approximately one-third the time as those in the control group. This alone suggests that additional research is needed concerning the rate at which students learn.
7. Research dealing with the cost of instructional systems is needed.

Implications

Individualized learning systems should be used as an essential part of a broader educational plan. The present study has demonstrated that cognitive knowledge and psychomotor skills pertaining to the automobile brake system taught by an individualized learning system was at least as good as one of the traditional methods employed in most vocational laboratories. The next logical step would seem to be the utilization of instructional systems as an integral part of a complete vocational program.

Some of the problems which could be solved by the implementation of an individualized learning system are:

1. Since all areas would be taught simultaneously through self-instructional devices, diverse psychomotor skills could be started within a short period of time and in a safe and knowledgeable manner.
2. It is imperative that related and technical information on a particular machine be presented when the learner needs it. Because of the many areas taught in a typical vocational laboratory, it has been difficult to present necessary information at the most appropriate time. Instructional systems for each area may provide means for presenting the instruction when it is most needed.
3. If a student is to benefit from a demonstration, he should come to it with some basic understanding as to what he is to see and what will be expected of him after the demonstration. Because the many machine operations and processes that traditionally must be demonstrated are not necessarily in any order, it has been very difficult to provide the

student with the necessary background of information prior to seeing the demonstration. Individualized learning systems in each operation would provide a means of individualizing instruction prior to any demonstration or actual hands-on experiences.

4. Implementation of systems of instruction could modify the role of the instructor. He may become a leader, diagnostician, counselor, and manager of instruction. Considerably less time would be spent in preparation of instructional materials because the system would transmit the materials and procedures necessary for learning to the learners.

Adaptation and utilization of the systems concept also has implications for planning vocational education facilities. Individual and small group instructional areas would need to be located so as to provide easy student access to equipment and materials of an instructional resource center. Design of facilities should encourage flexibility and change for adaptation to the newly evolving educational technology.

Development and utilization of instructional systems such as the one tested in this study have implications for:

1. Grading and Classifications: Grading as it is commonly

known can be eliminated because the student's performance will be evaluated upon reaching established criterion levels of achievement. Students can advance at their own pace.

2. Curriculum Development: Educational programs would be prepared by instructional system experts and used only after lengthy field tests and revision.

3. Teacher-training: Teacher-training institutions and others in education should adjust to the fact that "instructional staff" includes both ends of the mediation process. There will be a reshuffling and reassignment of personnel; technology will force the transfer of classroom teachers from one side of mediation to the other. A large portion of the teaching profession may become engaged in preparing instructional materials with little or no direct face-to-face contact with students.

4. Development of More Flexibility: Instruction can better be adapted to the abilities and needs of the learner by utilizing instructional systems. Traditional lockstep classes can be eliminated and more instruction can be available where and when it is needed to meet the student's interests.

Instructional systems research and development efforts are needed to improve the current status of individualized instruction in vocational and technical education. The present study has noted some significant findings; however, the true significance of these findings can be realized only if additional research is conducted. Taylor and Christensen (1967) should be supported in their call for profession-wide research and development program to assess the optimal application of media to vocational and technical education. Attempts such as these are essential in moving toward realization of the potential individualizing instruction has in all areas of education.

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APPENDICES

APPENDICES

APPENDIX A

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APPENDIX B

Performance Objectives

NOTE: Work performed in this unit will be on school controlled equipment. All operations will follow safety standards, technical specifications, and require use of approved tools.

PERFORMANCE I

The student will identify the major components of the automotive brake system and know the purpose of each. The major components for this performance are:

1. Master cylinder and linkage
2. Hydraulic brake lines
3. Wheel cylinder
4. Backing plate
5. Brake shoes
6. Brake drums
7. Brake fluid

Satisfactory level of student achievement will be determined by objective evaluation. A score of 100% correct will be required.

PERFORMANCE II

The student will identify the major parts of the brake shoe assembly and know the purpose of each part. The major parts for this performance are:

1. Wheel cylinder assembly
2. Backing plate
3. Primary brake shoe
4. Secondary brake shoe
5. Adjusting screw

Satisfactory level of student achievement will be determined by objective evaluation. A score of 100% correct will be required.

PERFORMANCE III

The student will disassemble and reassemble brake shoe assemblies. The student will complete a performance evaluation certificate to verify satisfactory achievement.

PERFORMANCE IV (Wheel Cylinders)

The student will identify parts of the wheel cylinder and know the purpose of each part. The parts for this performance are:

1. Cylinder housing
2. Bleeder screw
3. Cups
4. Pistons
5. Dust Boots
6. Spring

Satisfactory level of student achievement will be determined by objective evaluation. A score of 100% correct will be required.

PERFORMANCE V (Wheel Cylinders)

On laboratory controlled equipment, each student will remove and replace various types of wheel cylinders, disassemble and reassemble wheel cylinder and identify the size of the wheel cylinder. He will complete a performance evaluation certificate to verify satisfactory achievement.

PERFORMANCE VIa (Single Piston Type Master Cylinders)

The student will identify parts of the single piston master cylinder and know the purpose of each part.

The parts are:

1. Master cylinder casting which includes reservoir, cylinder barrel, and ports
2. Filler cap
3. Residual check valve
4. Piston Return spring
5. Primary cup

6. Piston
7. Secondary cup
8. Piston stop
9. Push rod
10. Snap ring
11. Dust boot

The student will complete an objective evaluation to assure satisfactory achievement. A score of 100% correct will be required.

PERFORMANCE VIb (Single Piston Type Master Cylinders)

The student will complete an objective evaluation to demonstrate his knowledge of the following functions of the single piston master cylinder. A score of 100% correct will be required.

The master cylinder:

1. Provides reservoir for brake fluid.
2. Changes mechanical force to a hydraulic force
3. Brake pedal linkage increases force
4. Provides a method for increasing volume of fluid in the actuating portion of the system
5. Provides for contraction and expansion of brake fluid
6. Maintains residual pressure

PERFORMANCE VII (Single Piston Type Master Cylinders)

On laboratory controlled equipment, the student will disassemble and reassemble the master cylinder. The student will complete a performance evaluation certificate to verify satisfactory achievement.

PERFORMANCE VIIIa (Double Piston Type Master Cylinders)

The student will identify parts of the double piston master cylinder and know the purpose of each part.

The parts are:

1. Master cylinder casting which includes reservoirs, cylinder barrel, and ports

2. Filler caps
3. Residual check valves
4. Primary piston
5. Secondary piston
6. Primary piston return spring
7. Secondary piston return spring
8. Primary cups
9. Secondary cups
10. Piston stop
11. Push rod
12. Snap ring
13. Dust boot

The student will complete an objective evaluation to assure satisfactory achievement. A score of 100% correct will be required.

<u>PERFORMANCE VIIIb</u> (Double Piston Type Master Cylinders)

The student will complete an objective evaluation to demonstrate his knowledge of the following functions of the double piston type master cylinder. A score of 100% correct will be required.

The master cylinder:

1. Provides reservoir for brake fluid
2. Changes mechanical force to a hydraulic force
3. Brake pedal linkage increases force
4. Provides a method for increasing volume of fluid in the actuating portion of the system
5. Provides for contraction and expansion of brake fluid
6. Maintains residual pressure
7. Provides safety factor by utilizing separate hydraulic systems

<u>PERFORMANCE IX</u> (Double Piston Type Master Cylinders)

On laboratory controlled equipment, using technical manual specifications, the student will disassemble and reassemble the master cylinder. The student will complete a performance evaluation certificate to verify satisfactory achievement.

PERFORMANCE X (Measuring Brake Drums)

The student will measure brake drums with drum micrometers and properly check and evaluate the condition of each drum. The student will complete a performance evaluation certificate to verify satisfactory achievement.

PERFORMANCE XIa (Mounting the Brake Drum on the Barrett Brake Drum Lathe)

The student will mount several different types of brake drums on the lathe and prepare the lathe for cutting. The student will complete a performance evaluation certificate to verify satisfactory achievement.

PERFORMANCE XIb (Mounting the Brake Drum on the AMMCO Brake Drum Lathe)

The student will mount several different types of brake drums on the lathe and prepare the lathe for cutting. The student will complete a performance evaluation certificate to verify satisfactory achievement.

PERFORMANCE XIIa (Machining the Brake Drum on the AMMCO Brake Drum Lathe)

The student will mount and turn a brake drum to size indicated by the instructor. The student will complete a performance evaluation certificate to verify satisfactory achievement.

PERFORMANCE XIIb (Machining the Brake Drum on the Barrett Brake Drum Lathe)

The student will mount and turn a brake drum to size indicated by instructor. The student will complete a performance evaluation certificate to verify satisfactory achievement.

PERFORMANCE XIIIa (Brake Shoe Arcing on the Barrett Brake Shoe Arcer)

The student will set up the arcing machine and correctly arc brake shoes. The student will complete a performance evaluation certificate to verify satisfactory achievement.

PERFORMANCE XIIIb (Brake Shoe Arcing on the AMMCO Brake Shoe Arcer)

The student will set up the arcing machine and correctly arc brake shoes. The student will complete a performance evaluation certificate to verify satisfactory achievement.

PERFORMANCE XIV (Wheel Bearing Service)

The student will service front wheel bearings. The following steps are included in this procedure:

1. Remove wheel bearings, seals, and inner bearing assembly
2. Clean and dry bearings
3. Inspect bearings
4. Pack bearings and reinstall inner bearing assembly and seal
5. Install front hub assembly on the axle
6. Adjust the wheel bearing

The student will complete a performance evaluation certificate to verify satisfactory achievement.

PERFORMANCE XV (Adjust and "Bleed" Brakes)

The student will adjust brakes and "bleed" a brake system using laboratory controlled equipment. The student will complete a performance evaluation certificate to demonstrate satisfactory achievement.

PERFORMANCE XVI (Disc Brakes)

The student will identify and know the purpose of each component of the disc brake system listed.

The components are:

1. Disc rotor
2. Caliper assembly
3. Master cylinder
4. Pressure differential switch

5. Proportioning valve
6. Metering valve
7. Hydraulic brake lines

Satisfactory student achievement will be determined by the successful completion of an objective type evaluation instrument. A score of 100% correct will be required.

PERFORMANCE XVII (Disc Brakes)

The student will identify parts of the caliper assembly and know the purpose of each part.

The parts are:

1. Caliper housing
2. Brake shoe pads
3. Piston
4. Piston seal
5. Anchor plate
6. Dust boot

An objective type evaluation instrument will be utilized to determine satisfactory student achievement. A score of 100% correct will be required.

PERFORMANCE XVIII (Disc Brakes)

The student will know service procedures unique to disc brakes as listed.

1. Pad replacement and inspection
2. Check rotor runout
3. Check rotor thickness
4. Check rotor parallelism

The student will complete an objective evaluation instrument to verify satisfactory achievement. A score of 100% correct will be required.

PERFORMANCE XIX (Brake Malfunctions)

The student will diagnose brake system malfunctions and select best repair procedure. Common malfunctions to include:

1. Low brake pedal
2. Locked or dragging brakes
3. Pulsating brake pedal
4. Fading brake pedal
5. Spongy brake pedal
6. Brakes pull car to one side.

Satisfactory achievement will be determined by objective evaluation. A score of 100% correct will be required.

PERFORMANCE XX (Brake System Overhaul)

The student will overhaul a brake system using laboratory controlled equipment. Acceptable achievement will be based upon the brake system being restored to specified operating conditions. The overhaul sequence must be completed within a specified time.

Satisfactory level of achievement will be verified by the student completing a performance evaluation certificate.

APPENDIX C

Jury for Evaluating Instructional Procedure

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APPENDIX D

Automobile Brake System

Pretest

Name: ________________________________ Soc. Sec. ____________
(Last) (First) (M. I.)

Mailing Address: ____
(Street No.) (City) (State)

Date of Birth: ________________________ Sex: M_____ F ______
(Mo.) (Day) (Year)

Previous Education: (Circle highest year completed in each)

Elementary: 1 2 3 4 5 6 7 8

High School: 9 10 11 12

College: 1 2 3 4

Other (Military School, etc.): 1 2 3 4

Do you have automotive mechanic work experience? _____yes ____no

Have you attended a course or program in automotive mechanics? _____ yes _____ no

Why did you enroll in this class?

_____ Career Technology (2 yrs.)

_____ Special Certificate

_____ Upgrade Job

_____ Personal Enrichment

How is your training being financed?

_____ Self

_____ Parents

_____ MDTA

_____ Voc. Rehab.

_____ Tuition Waiver

_____ Welfare

____
(Other)

Automotive Unit 5 - Brakes

Pretest

Underline the correct answer to complete the statement:

1. The unit in which hydraulic pressure is developed is the ________.

   a. hydraulic brake lines   c. master cylinder
   b. wheel cylinder   d. brake drum

2. The hydraulic brake lines connect the master cylinder with the wheel cylinders and are filled with ________.

   a. alcohol   c. water
   b. hydraulic brake fluid   d. oil

3. The ________ receives pressure from the master cylinder and in turn forces the brake shoe to the brake drums.

   a. master cylinder   c. backing plate
   b. brake drum   d. wheel cylinder

4. The ________ provides a rigid surface to attach the brake shoe assembly.

   a. backing plate   c. brake drum
   b. wheel cylinders   d. axle spindle

5. The ________ provide a braking effect for the automobile when forced against the brake drum.

   a. wheel cylinders   c. hydraulic brake fluid
   b. backing plates   d. brake shoes

6. The ________ completely surrounds the brake shoe assembly and rotates around the brake shoes.

   a. brake drum   c. backing plate
   b. hydraulic brake lines   d. wheel cylinders

7. In most cases the ________ brake shoe faces the front of the automobile.

   a. primary   b. secondary

8. The ________ is used to adjust the clearance between the brake shoes and the brake drum.

   a. backing plate
   b. wheel cylinder
   c. master cylinder
   d. star adjusting screw

9. In order to prevent damage, it is generally good practice to cover the threads on the ________ spindle.

   a. star adjusting screw
   b. axle
   c. brake drum
   d. wheel cylinder

10. Following a logical sequence in disassembling and reassembling the brake shoe assembly is a ________ practice.

   a. good
   b. bad

11. The brake spring remover tool fits over the end of the ________ pin to lift the retracting spring off its position.

   a. wheel cylinder
   b. hold-down
   c. anchor
   d. parking brake lever

12. A special tool is used to remove the hold-down spring unit which serves to hold the ________ in place.

   a. brake drum
   b. wheel cylinder
   c. brake shoe
   d. backing plate

13. The hand brake strut, its spring, and the parking brake lever are all located on the ________ brake assembly.

   a. rear
   b. front

14. The primary and secondary brake shoes, along with the star adjusting screw and adjuster spring are all attached to the ________.

   a. brake drum
   b. backing plate
   c. master cylinder
   d. axle spindle

15. The backing plate must be replaced if the ________ are deeply grooved.

   a. brake drums
   b. support pads
   c. brake shoes
   d. wheel cylinder pins

16. A slight amount of ________ should be applied to all backing plate support pads and areas where there is metal-to-metal contact.

    a. oil
    b. brake fluid
    c. high temperature grease
    d. rubber lubricant

17. The brake shoe assembly springs are particularly important and should be checked to make sure that they are not ________.

    a. bent
    b. stretched
    c. overheated
    d. all of these

18. When installing the star adjusting screw, the ________ spring holds the primary and secondary brake shoes together.

    a. hold-down
    b. adjuster
    c. retracting
    d. hand brake

19. The star wheel of the adjusting screw must be aligned with the hole in the ________.

    a. backing plate
    b. primary brake shoe
    c. anchor pins
    d. wheel cylinder

20. The brake shoes, star adjusting screw and adjuster spring are positioned as an assembly on the backing plate so that the ________ holds them in place when released.

    a. wheel cylinder
    b. brake drum
    c. anchor pin
    d. support pads

21. The ________ which holds the brake shoes in place are installed through the holes in the back plate.

    a. wheel cylinder pins
    b. hold-down pins
    c. star adjusting screw
    d. retracting springs

22. The parking brake lever is normally attached to the ________ on rear brake assemblies.

    a. primary brake shoe
    b. wheel cylinder
    c. secondary brake shoe
    d. star adjusting screw

23. The rear brake ________ connects the parking brake lever to the primary brake shoe.

    a. strut
    b. cable
    c. anti-rattle spring
    d. retracting spring

24. Normally, passenger cars equipped with drum brakes use larger diameter wheel cylinder on the ________.

 a. front b. rear

25. The brake shoe assembly should be ________ before replacing the wheel cylinder.

 a. covered c. removed
 b. cleaned

26. On the ________ brake assembly, you must remove the lock clip which holds the brake hose to the chassis bracket.

 a. front b. rear

27. The wheel cylinder is secured to the ________.

 a. axle spindle c. brake shoes
 b. backing plate d. master cylinder

28. Clean the entire wheel cylinder with ________.

 a. diesel fuel c. kerosene
 b. denatured alcohol d. gasoline

29. The pistons, cups, and cylinder wall should be liberally coated with ________.

 a. motor oil c. brake fluid
 b. alcohol d. mineral oil

30. The solid side of the wheel cylinder cup is positioned against the ________.

 a. boot c. piston
 b. spring d. pins

31. The ________ is normally made of heavy cast iron and has a machined inner surface that makes contact with the brake lining.

 a. backing plate c. brake shoe
 b. brake drum d. wheel cylinder

32. The brake drum should be visually inspected and measured with an accurate drum ________.

 a. caliper c. micrometer
 b. ruler d. gauge

33. If the brake drum is not scored too deeply, the drum can be machined on the ________.

    a. brake drum polisher
    b. brake drum mill
    c. brake drum lathe
    d. brake drum sander

34. The brake shoe ________ is used to allow the lining to fit against the drum with a slight clearance at each end.

    a. lathe
    b. arcer
    c. mill
    d. polisher

35. Bleeding the brakes means removing ________ from the brake system.

    a. water
    b. grease
    c. air
    d. dirt & grit

WHEEL CYLINDERS

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 36 through 41.

________a. wheel cylinder housing

________b. bleeder screw

________c. cups

________d. pistons

________e. boots

________f. spring

36. Seals the cylinder wall from contamination.

37. Provides a cylinder for the pistons and boots.

38. Provides a seal to keep the hydraulic brake fluid inside the cylinder.

39. Allows trapped air to escape from the hydraulic brake system.

40. Provides a rigid backing for the cups and a means of transferring the pressure in the wheel cylinder to the brake shoes.

41. Keeps the cups in contact with the pistons.

MASTER CYLINDER

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 42 through 48.

________a. mechanical	________d. reservoir
________b. residual	________e. brake fluid
________c. force	________f. volume
	________g. safety

The master cylinder:

42. Provides a ________ for brake fluid.

43. Changes ________ force to a hydraulic force.

44. Brake pedal linkage increases ________.

45. Provides a method of increasing the ________ of fluid in the actuating portion of the system.

46. Provides for contraction and expansion of ________.

47. Maintains ________ pressure.

48. With double pistons, provides a ________ factor by utilizing separate hydraulic systems.

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 49 through 54.

________a. piston	________d. check valve
________b. primary cup	________e. secondary cup
________c. return spring	________f. boot

49. Prevents leakage of brake fluid past the piston.

50. Presses against the rubber primary cup.

51. Prevents the entry of dust, water, etc., into the cylinder.

52. Holds the check valve against a rubber seat and maintains a residual pressure in the brake lines.

53. Allows brake fluid to return to the master cylinder after the brakes have been applied and released.

54. Prevents leakage of brake fluid from the master cylinder.

DISC BRAKES

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 55 through 60.

________ a. caliper housing

________ b. shoes and lining pads

________ c. piston

________ d. piston seal

________ e. anchor plate

________ f. dust boot

55. Hollowed for heat insulation and has a groove around the outside for the dust boot.

56. A one-piece construction providing the cylinder bore.

57. Bolted to the spindle and allow for a more rigid caliper assembly.

58. Prevents brake fluid leakage between the cylinder bore wall and the piston and also acts as a retracting mechanism for the piston.

59. Presses on each side of the disc with equal pressure.

60. Prevents moisture and road contamination from entering the cylinder bore.

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 61 through 67.

________ a. pressure differential switch

________ b. disc rotor

________ c. hydraulic brake lines

________ d. caliper assembly

________ e. master cylinder

________ f. metering valve

________ g. proportioning valve

61. Made of cast iron and has machined braking surfaces on each side.

62. Provides a means of applying the brake shoes to the rotor.

63. The unit in which hydraulic pressure is developed.

64. Provides a telltale light to notify the driver that a failure has occurred in some part of the hydraulic system.

65. Restricts hydraulic pressure to the front caliper cylinders at low pressures from the master cylinder.

66. Properly balances the output of the rear brakes with the front brakes when high pressure from the master cylinder is used.

67. Steel tubing connecting the master cylinder with each wheel cylinder and allows a pressure transfer.

BRAKE MALFUNCTIONS

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 68 through 73.

________ a. spongy brake pedal

________ b. low brake pedal

________ c. pulsating brake pedal

________ d. fading brakes due to heat

________ e. grab or pull to one side

________ f. locked or dragging brakes

68. Grease or brake fluid on brake lining.

69. Brake shoes need adjusting.

70. Thin brake drum and/or poor lining to drum contact.

71. Air in the hydraulic system.

72. Brake drum out-of-round.

73. Frozen or sluggish wheel cylinder pistons due to contamination.

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 74 through 77.

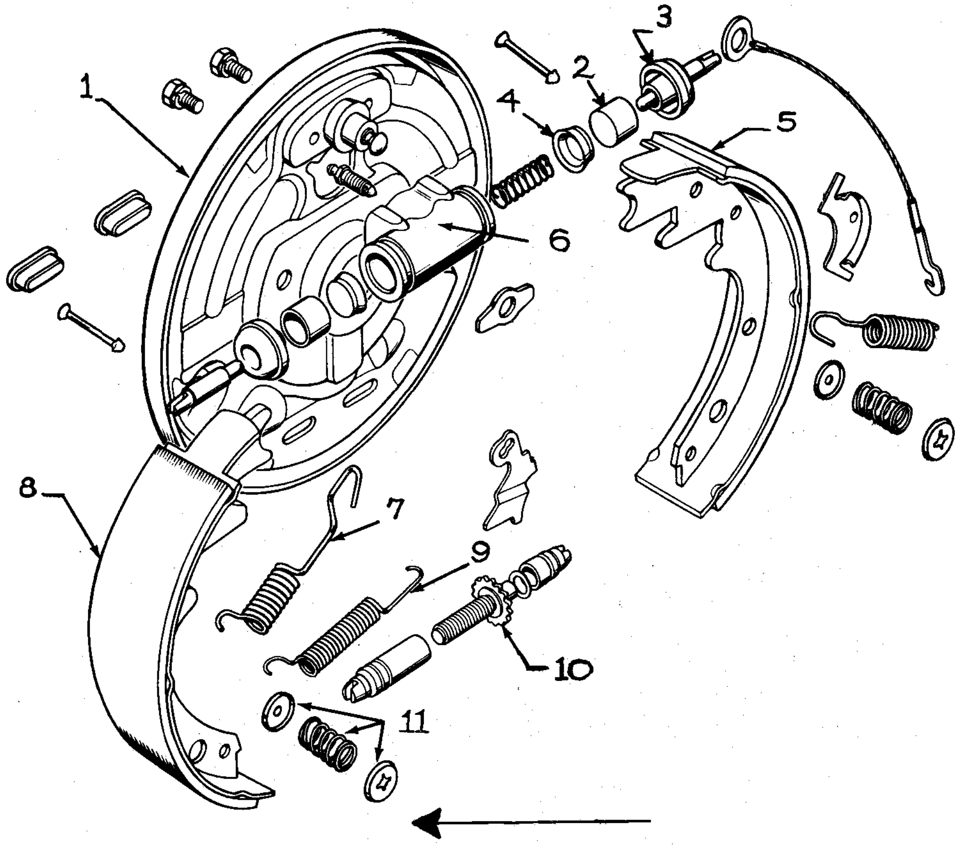
________ a. scored drum surface	________ c. bell mouthed
________ b. out-of-round	________ d. hard spots

74. Occurs mostly on wide drums and is caused by poor outside support of the drum.

75. Caused by sand or grit in the brake shoe assembly.

76. Results from a change in metallurgy caused by braking heat.

77. Egg-shaped condition caused by heating and cooling during braking.



CAR MOVING FORWARD

Match the name of the parts with the number of the parts in the above picture by placing the number beside the correct name.

78. ________ backing plate

79. ________ primary brake shoe

80. ________ secondary brake shoe

81. ________ retracting brake spring

82. ________ wheel cylinder housing

83. ________ brake shoe adjuster spring

84. ________ wheel cylinder piston

85. ________ star adjusting screw

86. ________ hold-down spring assembly

87. ________ wheel cylinder boot

88. ________ wheel cylinder cup

Automobile Brake System

Posttest

Underline the correct answer to complete the statement:

1. The ________ provides a rigid surface to attach the brake shoe assembly.

   a. backing plate
   b. axle spindle
   c. wheel cylinders
   d. brake drum

2. In most cases the _____ brake shoe faces the front of the automobile.

   a. secondary
   b. primary

3. The hydraulic brake lines connect the master cylinder with the wheel cylinders and are filled with ________.

   a. oil
   b. water
   c. hydraulic brake fluid
   d. alcohol

4. The ________ completely surrounds the brake shoe assembly and rotates around the brake shoes.

   a. hydraulic brake lines
   b. backing plate
   c. wheel cylinders
   d. brake drum

5. The unit in which hydraulic pressure is developed is the _______.

   a. hydraulic brake lines
   b. master cylinder
   c. wheel cylinder
   d. brake drum

6. The ________ provide a braking effect for the automobile when forced against the brake drum.

   a. wheel cylinders
   b. hydraulic brake fluid
   c. brake shoes
   d. backing plates

7. The ________ receives pressure from the master cylinder and in turn forces the brake shoe to the brake drums.

   a. backing plate
   b. brake drum
   c. wheel cylinder
   d. master cylinder

8. A slight amount of ________ should be applied to all backing plate support pads and areas where there is metal-to-metal contact.

   a. oil
   b. high temperature grease
   c. rubber lubricant
   d. brake fluid

9. A special tool is used to remove the hold-down spring unit which serves to hold the ________ in place.

   a. backing plate
   b. brake shoe
   c. brake drum
   d. wheel cylinder

10. The ________ is used to adjust the clearance between the brake shoes and the brake drum.

    a. star adjusting screw
    b. backing plate
    c. wheel cylinder
    d. master cylinder

11. The backing plate must be replaced if the ________ are deeply grooved.

    a. support pads
    b. wheel cylinder pins
    c. brake shoes
    d. anchor pins

12. The brake spring remover tool fits over the end of the ________ pin to lift the retracting spring off its position.

    a. hold-down
    b. anchor
    c. parking brake lever
    d. wheel cylinder

13. In order to prevent damage, it is generally good practice to cover the threads on the ________ spindle.

    a.. brake drum
    b. star adjusting screw
    c. wheel cylinder
    d. axle

14. Following a logical sequence in disassembling and reassembling the brake shoe assembly is a ________ practice.

    a. bad
    b. good

15. The hand brake strut, its spring, and the parking brake lever are all located on the ________ brake assembly.

    a. front
    b. rear

16. The primary and secondary brake shoes, along with the star adjusting screw and adjuster spring are all attached to the ________.

    a. master cylinder
    b. axle spindle
    c. brake drum
    d. backing plate

17. The ________ which hold the brake shoes in place are installed through the holes in the back plate.

    a. star adjusting screw
    b. retracting springs
    c. hold-down pins
    d. wheel cylinder pins

18. Normally, passenger cars equipped with drum brakes use larger diameter wheel cylinder on the ________.

    a. rear
    b. front

19. The brake shoe assembly springs are particularly important and should be checked to make sure that they are not ________.

    a. overheated
    b. bent
    c. stretched
    d. all of these

20. The rear brake ________ connects the parking brake lever to the primary brake shoe.

    a. cable
    b. anti-rattle spring
    c. retracting spring
    d. strut

21. When installing the star adjusting screw, , the ________ spring holds the primary and secondary brake shoes together.

    a. hand brake
    b. retracting
    c. adjuster
    d. hold-down

22. The parking brake lever is normally attached to the ________ on rear brake assemblies.

    a. star adjusting screw
    b. primary brake shoe
    c. wheel cylinder
    d. secondary brake shoe

23. The brake shoes, star adjusting screw and adjuster spring are positioned as an assembly on the backing plate so that the ________ holds them in place when released.

    a. wheel cylinder
    b. anchor pin
    c. brake drum
    d. backing plate bosses

24. The star wheel of the adjusting screw must be aligned with the hole in the ________.

    a. primary brake shoe
    b. backing plate
    c. wheel cylinder
    d. anchor pins

25. The brake shoe assembly should be ________ before replacing the wheel cylinder.

    a. removed
    b. covered
    c. cleaned

26. If the brake drum is not scored too deeply, the drum can be machined on the ________.

    a. brake drum mill
    b. brake drum sander
    c. brake drum polisher
    d. brake drum lathe

27. On the ________ brake assembly, you must remove the lock clip which holds the brake hose to the chassis bracket.

    a. rear
    b. front

28. The brake drum should be visually inspected and measured with an accurate drum ________.

    a. micrometer
    b. caliper
    c. gauge
    d. ruler

29. The pistons, cups, and cylinder wall should be liberally coated with ________.

    a. mineral oil
    b. brake fluid
    c. alcohol
    d. motor oil

30. The wheel cylinder is secured to the ________.

    a. axle spindle
    b. master cylinder
    c. backing plate
    d. brake shoes

31. The ________ is normally made of heavy cast iron and has a machined inner surface that makes contact with the brake lining.

    a. backing plate
    b. wheel cylinder
    c. brake drum
    d. brake shoe

32. Clean the entire wheel cylinder with ________.

    a. denatured alcohol
    b. solvent
    c. gasoline
    d. brake fluid

33. The solid side of the wheel cylinder cup is positioned against the ________.

a. piston
b. boot
c. pins
d. spring

34. Bleeding the brakes means removing ________ from the brake system.

a. grease
b. water
c. dirt & grit
d. air

35. The brake shoe ________ is used to allow the lining to fit against the drum with a slight clearance at each end.

a. polisher
b. lathe
c. mill
d. grinder

WHEEL CYLINDERS

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 36 through 41.

______a. spring
______b. boots
______c. pistons
______d. cups
______e. bleeder screw
______f. wheel cylinder housing

36. Provides a rigid backing for the cups and a means of transferring the pressure in the wheel cylinder to the brake shoes.

37. Provides a seal to keep the hydraulic brake fluid inside the cylinder.

38. Keeps the cups in contact with the pistons.

39. Seals the cylinder wall from contamination.

40. Allows trapped air to escape from the hydraulic brake system.

41. Provides a cylinder for the pistons and cups.

MASTER CYLINDER

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 42 through 48.

______a.	reservoir	______d.	safety
______b.	brake fluid	______e.	force
______c.	volume	______f.	residual
		______g.	mechanical

The master cylinder:

42. Provides a method of increasing the ________ of fluid in the actuating portion of the system.

43. With double pistons, provides a ________ factor by utilizing separate hydraulic systems.

44. Provides a ________ for brake fluid.

45. Maintains ________ pressure.

46. Changes ________ force to a hydraulic force.

47. Provides for contraction and expansion of ________.

48. Brake pedal linkage increases ________.

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 49 through 54.

______a.	return spring	______d.	boot
______b.	check valve	______e.	primary cup
______c.	piston	______f.	secondary cup

49. Holds the check valve against a rubber seat and maintains a residual pressure in the brake lines.

50. Prevents leakage of brake fluid from the master cylinder.

51. Presses against the rubber primary cup.

52. Allows brake fluid to return to the master cylinder after the brakes have been applied and released.

53. Prevents leakage of brake fluid past the piston.

54. Prevents the entry of dust, water, etc., into the cylinder.

DISC BRAKES

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 55 through 60.

_______a. anchor plate

_______b. piston

_______c. dust boot

_______d. caliper housing

_______e. piston seal

_______f. shoes and lining pads

55. Presses on each side of the disc with equal pressure.

56. A one piece construction providing the cylinder bore.

57. Prevents moisture and road contamination from entering the cylinder bore.

58. Bolted to the spindle and allow for a more rigid caliper assembly.

59. Hollowed for heat insulation and has a groove around the outside for the dust boot.

60. Prevents brake fluid leakage between the cylinder bore wall and the piston and also acts as a retracting mechanism for the piston.

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 61 through 67.

_______a. hydraulic brake lines

_______b. metering valve

_______c. pressure differential switch

_______d. proportioning valve

_______e. disc rotor

_______f. master cylinder

_______g. caliper assembly

61. Restricts hydraulic pressure to the front caliper cylinders at low pressures from the master cylinder.

62. Made of cast iron and has machined braking surfaces on each side.

63. Steel tubing connecting the master cylinder with each wheel cylinder and allows a pressure transfer.

64. Provides a means of applying the brake shoes to the rotor.

65. Provides a telltale light to notify the driver that a failure has occurred in some part of the hydraulic system.

66. Properly balances the output of the rear brakes with the front brakes when high pressure from the master cylinder is used.

67. The unit in which hydraulic pressure is developed.

BRAKE MALFUNCTIONS

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 68 through 73.

_______a. locked or dragging brakes

_______b. fading brakes due to heat

_______c. spongy brake pedal

_______d. pulsating brake pedal

_______e. low brake pedal

_______f. grab or pull to one side

68. Brake drum out-of-round.

69. Grease or brake fluid on brake lining.

70. Thin brake drum and/or poor lining to drum contact.

71. Frozen or sluggish wheel cylinder pistons due to contamination.

72. Brake shoes need adjusting.

73. Air in the hydraulic system.

Match the name of parts with the statements by placing the number of the statement beside the correct part. Select only 74 through 77.

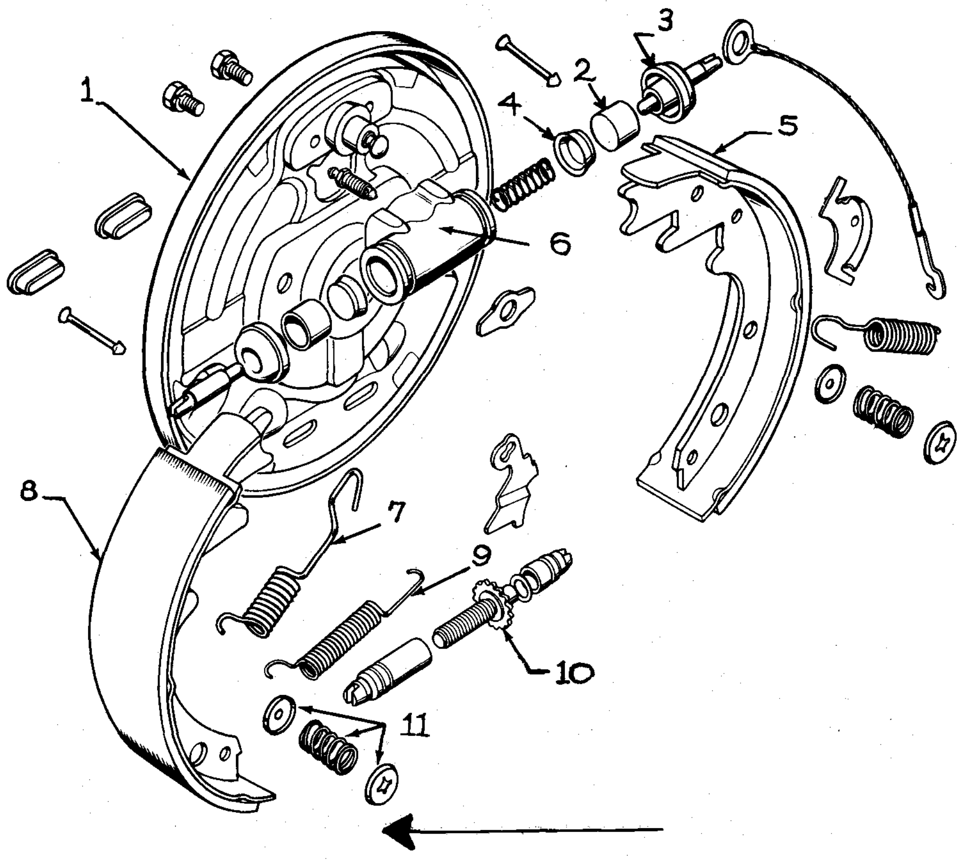
______ a. hard spots	______ c. scored drum surface
______ b. bell mouthed	______ d. out-of-round

74. Results from a change in metallurgy caused by braking heat.

75. Occurs mostly on wide drums and is caused by poor outside support of the drum.

76. Egg shaped condition caused by heating and cooling during braking.

77. Caused by sand or grit in the brake shoe assembly.



CAR MOVING FORWARD

Match the name of the parts with the number of the part in the above picture by placing the number beside the correct name.

78. ________ brake shoe adjuster spring

79. ________ backing plate

80. ________ wheel cylinder cup

81. ________ retracting brake spring

82. ________ hold-down spring assembly

83. ________ primary brake shoe

84. ________ wheel cylinder housing

85. ________ star adjusting screw

86. ________ secondary brake shoe

87. ________ wheel cylinder boot

88. ________ wheel cylinder piston

APPENDIX E

STUDENT PERFORMANCE EVALUATION

I hereby certify that on this date ________________ ______ ______
Month Day Year

the following operations were completed by me: ____________________
Student's name (Print)

Note to Student:

Complete the evaluation below. Fill in the blank space or circle choice where appropriate.

____
Signed by Student

____
Signed by Instructor

This performance evaluation must be completed within 1. 5 hours.

Brake System Repair

		Front Wheel		Rear Wheel	
1.	Service wheel bearings	Satis.	Unsatis.	---	---
2.	Remove and completely disassemble brake shoe assembly	Satis.	Unsatis.	Satis.	Unsatis.
3.	Reassemble brake shoe assembly	Satis.	Unsatis.	Satis.	Unsatis.
4.	Remove, disassemble, reassemble and replace wheel cylinders	Satis.	Unsatis.	Satis.	Unsatis.

5. Remove, disassemble, reassemble and replace master cylinder -- Satis. Unsatis.

6. Bleed brake system---------- Satis. Unsatis.

7.	Adjust brakes	Satis.	Unsatis	Satis	Unsatis.

8. Time for completion ____________

After your instructor has signed this evaluation, you have completed the brake unit.