74-5413

CRAIN, William James, 1937-
THE DEVELOPMENT AND FIELD TESTING OF A WRITTEN OCCUPATIONAL COMPETENCY EXAMINATION FOR AUTO MECHANIC TEACHERS.

Colorado State University, Ph.D., 1973
Education, vocational

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THESIS

THE DEVELOPMENT AND FIELD TESTING OF A WRITTEN OCCUPATIONAL COMPETENCY EXAMINATION FOR AUTO MECHANIC TEACHERS

Submitted by

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In partial fulfillment of the requirements

for the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

August, 1973

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COLORADO STATE UNIVERSITY

July, 1973

WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY WILLIAM JAMES CRAIN ENTITLED THE DEVELOPMENT AND FIELD TESTING OF A WRITTEN OCCUPATIONAL COMPETENCY EXAMINATION FOR AUTO MECHANIC TEACHERS BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

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ABSTRACT OF THESIS

THE DEVELOPMENT AND FIELD TESTING OF A WRITTEN OCCUPATIONAL COMPETENCY EXAMINATION FOR AUTO MECHANIC TEACHERS

The purpose of this study was to develop and refine an instrument that could be used to supplement existing methods of screening future auto mechanic teacher applicants.

A questionnaire, composed of 115 items covering seven categories of automobile repair, was designed and sent to a random sample of auto technicians, service managers and auto mechanic teachers. The direction gained from this questionnaire was used to develop 116 questions covering information in the areas of repair which was considered most important to future auto mechanic teachers. This "trial examination" was mailed to a random sample of service managers, auto technicians, vocational and industrial arts auto mechanic teachers, and sophomore, post-secondary vocational auto mechanic students. These participants were asked to answer and critique each of the 116 questions. An item analysis was made on each of the questions. This analysis, combined with the critiques, provided the basis for eliminating and/or rewording many of the questions before the final form of the examination was developed.

The 88 question final form of the examination was sent to a random sample of individuals from the same groups involved in the trial examination with the exception of service managers. For correlation purposes, a personal data sheet from each participant and a rating form from his immediate supervisor were obtained.

Correlations between the total and sub-test scores and ratings were computed for all participants combined. These correlations indicated that the total examination was a better predictor of a person's performance than any of the sub-tests.

Analysis of variance (AOV) was made between all four groups of participants combined, industrial arts and vocational teachers, and technicians and vocational teachers on total examination scores. In addition, an AOV between technicians and between technicians and vocational teachers on length of time at their jobs was computed. In all cases, a significant difference was found to exist between groups on total examination scores. However the data revealed no significant difference due to the length of service and no significant interactions.

Measures of central tendency were computed for each group of participants individually and collectively. An expectancy table was constructed as a guide to be used when evaluating an individual's trade competency and/or experience.

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August, 1973

ACKNOWLEDGEMENTS

The writer is greatly indebted to all who have contributed to this study. Sincere appreciation is extended to the writer's advisor, Dr. Milton E. Larson, Professor of Vocational Education, Colorado State University, for his wise counseling in making possible the completion of the work for the doctorate, as well as for the encouragement and assistance he has given the writer during the development and completion of this study.

The assistance of Dr. C. Dean Miller, Associate Professor of Psychology, Colorado State University, has been of tremendous benefit to the writer. His help and suggestions in the gathering, treating and reporting of the statistical data was most generous, as was that of the other members of the graduate committee: Dr. Harry Gibson, Dr. Albert C. Masterson and Dr. Ivan Valentine.

The writer acknowledges the support he received from service managers, auto technicians and teachers as well as all the supervisors who so willingly gave of their time to provide data for this project.

The writer would like also to extend special thanks to his family for their encouragement and understanding throughout the study.

Finally, he wishes to express his gratitude to his father who taught him much of what he knows about automotive mechanics, and who passed away while this study was in progress.

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CHAPTER I

THE PROBLEM

"A nation which lets incapables teach it while capable men and women only feed and clothe it, or amuse it, is committing intellectual suicide."

--Thorndike

Introduction

The auto mechanic occupation, like many others in our society, is becoming highly specialized. This high degree of specialization has led to a shortage of qualified technicians. This shortage of personnel and the growth of our American economy have led to a common policy of unit replacement at many service establishments. This, of course, limits the breadth of repair experience and technical understanding that the auto mechanics (hereafter referred to as auto technicians) in the trade have when they enter the teaching field. However, pre-service or the skill and related knowledge training offered by most vocational-technical schools is designed to provide the student with training on the total automobile.

A problem arises when the administrators for auto mechanic training programs recruit teachers from the ranks of experienced tradesmen whose most recent repair experiences have been highly specialized.

Need for the Study

A major problem confronting vocational-technical administrators when hiring staff members to teach auto mechanics is determining how well they know the trade.

At present, a person applying for a Trade and Industrial (T & I) vocational teaching position in Colorado, for example, is required to have completed the Colorado State Board for Community Colleges and Occupational Education's Credential Application Form (VE-104). This form requests: 1) some personal information, 2) a list of previous occupational and teaching experiences which are applicable to the position for which the person is applying, 3) a list of schools attended and the major course of study and degree(s) earned, 4) a list of three character references, and 5) a list of the activities that have been completed to meet the requirements for credential renewal if the present Colorado Vocational Credential is about to expire. When initially applying for a Colorado Vocational Credential, the applicant must meet the following experience and educational minimums as spelled out in the Colorado State Plan for Vocational Education (28:29) under Section 1.33-7:

> Experience
>
> Shall have completed as a full-time wage-earner a minimum of five years (10,000 hours) work experience in the occupation, or the applicant shall provide evidence of having completed three or more years in an occupation as a full-time wage-earner within the occupation identified on the Credential Application, plus a

> minimum of two years of specialized training in vocational subjects which must be related to the area identified on the Credential Application.
>
> In addition, the applicant must meet licensing standards when required in that occupation.
>
> Education
>
> Shall have completed not less than a twelfth grade education or its equivalent, as required to carry out the objectives of Trade and Industrial Education, as determined by the State Board.

Other states use a similar procedure, with slight modifications, to evaluate their vocational teacher applicants.

This information, along with what is gained through interviews, gives the administrator some idea of the applicant's background. But, does it tell how much the applicant knows about the subject? Has this person actually had five well-rounded years of experience, or has he had one year of experience repeated five times? In addition, working in the field may provide performance skills, but does it provide technical knowledge? Today, when the automotive industry is in the age of specialization and unit exchange practices, a person can easily show five years of trade experience and still possess very little technical knowledge of the total trade. A knowledge of the total automobile is necessary for a teacher to be able to answer those "why" or "how come" questions which are so prevalent in the classroom or laboratory. Practically all large garages and dealerships have adopted the practice of specialization and unit replacement. Therefore, most technicians concentrate on only one or two areas of service.

Initial investigation of numerous references revealed that there was only one occupational competency examination for auto mechanics which was available to those who had not developed their own test. This test was listed by Buros (4:1367) and showed that no degree of reliability or validity had been established. Also, it had apparently not been updated since initial publication in 1962.

This apparent lack of valid, reliable research in the area of auto mechanic occupational competency examinations and/or the lack of examinations available to others than those who had developed their own, pointed to a need for further research in this area.

The Problem

The problem for this study consisted of developing and field testing a written occupational competency examination that can be used as an additional screening device for future auto mechanic teachers. The examination was designed to determine the extent of a person's technical knowledge of the auto mechanic trade. Questionnaire responses of auto technicians, service managers, and vocational auto mechanic teachers were secured and analyzed. The results of these responses were used as a basis for the development of the examination questions.

The problem further involved administering a trial examination to a randomly selected group of auto technicians, service managers,

vocational and industrial arts auto mechanic teachers, and sophomore, post-secondary vocational auto mechanic students. These individuals were also asked to critique each question as well as the examination in total. From the analysis of their responses and critiques, a revised examination was then administered to a group of auto technicians, vocational and industrial arts auto mechanic teachers, and sophomore, post-secondary vocational auto mechanic students. From the scores achieved by each of these groups, measures of central tendency were calculated which could be used as a basis for evaluating a future auto mechanic teacher's technical knowledge of the automobile.

Purpose of the Study

The primary objective of this study was to develop and refine a written auto mechanic trade competency examination. This examination was field tested on five different groups of individuals involved in separate phases of automobile service and repair. Validation of each test item as well as the examination as a whole was accomplished by statistically treating the raw scores and supervisor ratings received for participants from each of the five groups.

The product of this study will provide employers, and others, with an effective tool designed to determine the extent of a person's technical knowledge in the field of automotive diagnose repair and service.

Delimitations

This research was limited to developing a written occupational competency examination comprised of seven sub-tests covering the following broad areas: 1) engine repair and rebuild, 2) fuel system, 3) electrical system, 4) power trains, 5) automatic transmissions, 6) brakes, steering and suspension, and 7) a miscellaneous group including convenience and safety items.

The examination was comprised of four response, multiple choice questions covering standard production components found on 1967 and later model American and foreign passenger cars.

The study population consisted of randomly selected vocational auto mechanic teachers at the secondary and post-secondary levels as well as industrial arts auto mechanic teachers from Colorado and its bordering states. Technicians and service managers from Pueblo, Colorado Springs, and Canon City, Colorado as well as sophomore, post-secondary vocational auto mechanic students from several randomly selected post-secondary schools in Colorado and its bordering states were involved in numerous ways during the course of this study.

Definition of Terms

The following is a list of terms used in this study.

Auto Mechanics - A broad term describing the automotive repair and service occupation or the training programs leading up to such an occupation.

Committee - The investigator's graduate committee.

Examination - The Auto Mechanic Teacher Occupational Competency Examination upon which this study is based.

Final Form - The last, or final edition of the Auto Mechanic Teacher Occupational Competency Examination.

Industrial Arts Teacher - A shop teacher who teaches in a non-reimbursed exploratory program.

Occupational Competency Examination - A combination of written tests designed to determine a minimal level of technical knowledge for a teacher candidate in a particular occupation (auto mechanics).

Participant - An individual, chosen at random, to complete and/or critique the questionnaire or a form of the examination.

Questionnaire - The survey questionnaire which was used in the initial stages of this study.

Trial Examination - The first, or trial edition, of the Auto Mechanic Teacher Occupational Competency Examination.

Sub-Test - A test over the technical knowledge of a particular phase of automotive repair. Seven of these specialized tests are combined to form the examination.

Service Manager - The supervisor or person responsible for all service work performed in a large garage or dealership. The service manager aids and assists the technicians in the shop with diagnosis as well as being responsible for the quality and quantity of repairs performed in that shop.

Supervisor - The person to whom each participant who was asked to complete a copy of the final form of the examination is directly responsible.

Technician - A person skilled in the diagnosis and repair of passenger cars.

Vocational Teacher - A shop teacher who has met the minimum requirements or qualifications set forth in the State Plan to teach in a reimbursed program.

Work Experience - Formal full-time and/or part-time employment undertaken by a teacher candidate, for a specified length of time, in a specific occupation considered by the State Board for Vocational Education as being necessary in obtaining technical trade knowledge and skills.

CHAPTER II

REVIEW OF PERTINENT LITERATURE

Introduction

An extensive effort was made to determine what research has been completed pertaining to occupational competency examinations for trade and industrial teachers, particularly auto mechanics; what has been proposed by others and what tests, if any, were available to determine the extent of a person's knowledge of the auto mechanic trade. Much researching was done in the libraries at Colorado State University, Fort Collins, and Southern Colorado State College in Pueblo. An additional attempt was made to locate pertinent information concerning the topic of this dissertation by securing an "automated search" of Abstracts in Research Materials (ARM), Abstracts of Instructional Materials (AIM), and Research in Education (RIE) through the Northern Colorado Educational Board of Cooperative Services (BOCS) in Boulder, Colorado on August 29, 1972.

A number of periodicals concerning vocational education, such as the American Vocational Association Journal, Industrial Arts and Vocational Education (presently named Industrial Education), and School Shop, were used.

The review of pertinent literature was limited to the last 10 years because any developments prior to approximately 1958, and which showed no indications of having been updated, were considered to be of little significance.

The related literature referenced in the remainder of this chapter will be reported in three categories. Automotive trade examinations presently available, or under development, are considered first. Research related to trade competency examinations in general follows with the viewpoint of others who suggest the use of trade competency examinations next. As an outgrowth of this literature, the hypotheses which conclude this chapter establish the extent and direction of research around which this study was conducted.

Examinations Presently Available

Larson and Crain (14:10) conducted a survey of State Directors for all the states and territories in 1968. This survey revealed that 16 states used some form of occupational competency examination. Of these 16 states, seven used only written competency examinations; six used performance examinations; one used an oral examination; and eight indicated that they used a combination of the three types of examinations. Likewise, of the 16 states using some form of occupational competency examination, only eight used it for

credentialing, and 12 used the examinations for a basis of awarding college credit for work experience gained by the applicant. Although the survey questionnaire did not ask if the trade competency examinations each state had developed were available for other individuals or groups to use, the writer had reason to believe that these tests were held under close cover for security reasons and could not be used by anyone else. This investigator tried to obtain a copy of the auto mechanic occupational competency examination from Colorado State University and from the New York State Education Department, but was refused by both.

Several written occupational competency or achievement tests for the auto mechanic trade were found to have been developed by various groups which will make them available to qualified persons or business representatives for a fee. Buros (4:1367) lists an examination which is available from McCann Associates. The brief description indicated that the examination was developed in 1962 and that no data on reliability and validity was available.

The second of these examinations was published in Fleet Owner. It is a complete revision and expanded version of a similar examination published by Fleet Owner almost 10 years earlier. The purpose of this test is to provide fleet owners and managers with an instrument that they can use to test prospective mechanic employees. No mention is made of any attempt to establish a degree of reliability

or validity except for the statement that since then (ten years ago) ". . .month after month to the present. . .fleets have been ordering them and using them to test prospective mechanic employees" (22:61). This in itself would attest to a certain degree of reliability and validity by the mere fact that fleets have been using the examination for screening purposes. Although many of the questions on this test are applicable to passenger cars and light trucks, the terminology used and the areas covered by the different "parts" of the test (diesel engines, air brakes, etc.) are aimed directly at the heavy truck technician rather than the passenger car technician.

The following seven achievement and competency tests are listed by Boyd and Shimberg (2:1-8). Only four of the tests are reported with standardization data.

Dr. Thomas S. Baldwin of the University of North Carolina developed a multiple choice automotive mechanic test in 1968, under a USOE grant. This test produced a reliability coefficient of .97 (KR 14) and was aimed at the junior college or technical institute level. As of April, 1971, no arrangements for the publication and distribution had been completed.

The Department of Industrial Education at Eastern Michigan University developed a similar auto mechanic competency examination in 1969. The percentile norms and the item analysis, both by administration and cumulative, are available. Copies of this examination are presently available for purchase from the University.

The Industrial Materials Laboratory for Trade and Industrial Education at The Ohio State University has a 1961 test which is available only to school administrators. This automotive mechanics test has a reliability coefficient of .95, as determined through the split-half method, as well as the percentile norms for the total and each part score.

Bruce A. Campbell and Suellen O. Johnson developed a short knowledge test for auto mechanics. This test is available from Science Research Associates. This test was copyrighted in 1969 and comes with a reliability coefficient of .88 (KR 20).

Other auto mechanic tests and their dates of publication which are available for general use, but for which no standardization data is listed, include one from each of the following sources: The Instructional Objectives Exchange, 1970; The University of the State of New York, 1969; and Van Valkenburgh, Nooger, and Nevelle, Inc., 1960.

Chrysler Corporation uses a combination written and performance examination in their annual Plymouth Troubleshooting Contest. The degree to which these examinations have been validated is unknown.

It is evidenced by the publication and/or the copyright dates that others across the country were also concerned about the lack of reliable instruments to measure an individual's achievement or

competency as an auto technician. Many of the instruments listed above were published since 1968, the year research commenced on this study.

Related Research

There has been talk about improving the certification standards of vocational education teachers, but little has been done. A study conducted at Eastern Michigan University entitled, An Experimental Project To Determine More Effective Vocational Teacher Certification Procedures in Michigan by Competency Examinations, investigated this very problem. In Phase I of this project, Kazanas and Kieft (10:7) stated one of the objectives was to "determine, develop, and refine the necessary testing trade and industry instruments and testing procedures to be used for teacher certification." Each of the several trades, including auto mechanics, were analyzed.

Phase II of the project apparently has not been completed. Dr. Griess at Eastern Michigan University stated that they were in the process of field testing the examinations and establishing norms as well as reliability.

Two conferences were held at Rutgers, The State University, in 1966 for the purpose of determining the feasibility of establishing a national trade competency examination program. The conferences included representatives from the states which were using competency

examinations at that time. Problems in the development, administration and updating of such a testing program were discussed. It was the general feeling of the participants, according to Griess (8:2), that if such a program were available, their states would use the tests rather than develop their own. Further research on this topic was temporarily curtailed due to a lack of funds.

A paper presented at the second Rutgers conference described the limited field test of the automotive competency examination developed at Eastern Michigan University under the direction of Kazanas and Kieft. In this paper, LaBounty (13:16) stated that, "The real value to the test administration is in the eagerness by which it was received, both by directors and volunteers" (teachers). "The comments made on the score sheets were positive in tone and reflect a feeling of need for some measuring device by which we can begin to evaluate teacher candidates." The extent of the "limited field test" involved the administering of the test to fifteen individuals, mostly teachers, in each of three states.

In 1969, as more funds became available, the project which was initiated at Rutgers was expanded and became known as the National Occupational Competency Testing Project. At the American Vocational Association (AVA) Convention in New Orleans, December 5-10, 1970, Panitz (18:3) reported to the Trade and Industrial Research Committee that two comprehensive occupational competency

examinations in the areas of machine trades and electronic occupations-communications had been developed and field tested. He further stated that the results of the field tests supported the feasibility of developing occupational competency tests in a single center which could be effectively administered and used by the different states in a manner which will meet their needs.

This project has since grown to the point that some 24 competency examinations have been developed in as many different fields, including auto mechanics. Eleven of these examinations were field tested at several locations during the first part of 1972.

Panitz (19:1-2) reports that steps to establish a National Occupational Competency Testing Institute for Vocational and Industrial Technical Education were discussed during the 1972 AVA Convention. At that time the group was accepting proposals from institutions across the country in an effort to select a permanent location for the Institute. Six proposals had been received and were under consideration. Also, 26 states had made statements relating to the use and financial support of a national center.

A cooperative effort between the Automobile Manufacturers Association and the National Automobile Dealers Association led to the development of a written certification examination, General Auto Mechanics (GAM) test, by the Educational Testing Service. Pellaton (20:1) stated that the GAM test would be ready for

administration during the fall of 1972. Diederich (6:2) reported that the validation of the eight part GAM test, which very nearly corresponds to the seven part examination around which this study is based, would be done in part through the use of an evaluation form and by pretesting.

In a related article, Porter (21:10B) stated that the GAM test under development by the Educational Testing Service was a "sample of baby steps we are finally taking toward finding solutions to our ever-widening 'auto mechanics gap'".

United Press International (29:12A) reported the following information about the GAM test after thousands had been administered and scored. A total of 7,899 technicians volunteered to take the four part GAM test during the fall of 1972. Each was told he would be certified a general automobile mechanic if he passed all four tests. An overwhelming majority failed to show enough skill to qualify as all-around experts at their jobs. Only 1,369, or 17 percent, got high enough scores to qualify themselves for the general certification. Although the GAM test is not intended to be used for the certification of teachers, it has a very similar purpose.

Schultz (25:74) reports that another national testing program for the certification of auto mechanics was sponsored by the Independent Garage Owners of America, The National Congress of Petroleum Retailers, and The Automotive Technicians Certification Board. A

technician can elect to take one or more of the 15 written specialty tests, and if passed, he will be certified by the National Automotive Technicians Certification Board (NATCB). This certification program has been operational on a voluntary basis since the early months of 1971.

New York State recently completed a study which investigated the reliability and validity of selected occupational competency examinations and their use in evaluating prospective trade and industrial teachers. One of the three examinations investigated was on auto mechanics. Koenigsberg and Reilly (11:32) reported that "this study has demonstrated the feasibility of using statistical item analysis and cross validation procedures to assess and improve the effectiveness of occupational competency testing programs, and it has also highlighted the need for further research in a number of areas."

Supporting Views

Interest and concern in the area of occupational competency examinations are evidenced, not only by the research that has and is being carried out on this subject, but also by the encouragement of many others to pursue additional research on this topic.

Feirer (7:19) suggested that "realistic performance and related trade tests need to be developed and national norms set up." He also

stated that some competency tests are quite often so "simple or general that anyone who has been around the trade could pass them." This author stated that "trade experience has always been a 'sacred cow,' but that it is time to kill the 'sacred cow' and be realistic about choosing and certifying trade teachers."

Stockwell (27:68) reports that an uneasy climate which exists between industrial arts and vocational teachers is partially the result of the unequal process by which T & I credentials are obtained in the various states. He stated that "many T & I credential applicants object to and are shocked by the obsolete technical information" of which the occupational competency examinations are comprised. This author indicated that the main criticism of occupational competency examinations, from those individuals requested to take them, was not the requirement of taking the examination, but rather the fact that out-of-date forms of the examinations were being used.

Kynard (12:21) suggested a checklist for evaluating the work experience of new T & I teachers. Although he did not specifically recommend the use of occupational competency examinations, he did list "broad occupational experience" number two on his list of 18 important items.

Schaefer (24:3) sent a 26 item "opinionnaire" to a group of vocational-technical teachers and local directors to ascertain a group opinion of the ranking of several characteristics believed to be assets

for vocational teachers. He reported that "experience in the skills of the specialized area being taught" and "knowledge and understanding of related technical theory in specialized areas" were among the seven items rated as "most important" by this group. Both of these items, although not suggested by Schaefer's report, could be evaluated with the use of occupational competency examinations in the trades if valid, and reliable examinations were available.

In an article concerning the recruiting and training of trade teachers, Stern (26:45) recommended that tradesmen with the required trade experience, who have passed a "screening competency test and personal interview," be taken into a two-year teacher training program for which they would be provided scholarships and other financial aid. This author recommended a means by which those individuals who can successfully demonstrate their ability and knowledge in a trade, through the completion of an occupational competency examination, could be enticed to enter a teaching preparation program.

Impellittari (9:8) conducted a study which analyzed individual scores on trade competency examinations. He reported that the number of years of industrial experience the individual had was not predictive of his performance on the test. This statement supported the investigator's belief that there should be additional devices used to screen teacher applicants.

Van Trump (30:22) proposed a systematic program of teacher evaluation to replace the "haphazard teacher requirements" that presently exist. He proposed that the "use of competency testing should be the basis of identifying and assessing proficiency."

Vezzani (31:49) pointed out two important facts about the recruitment of vocational teachers. He stated that vocational educators were torn between trade experience and college degrees, and that academic requirements were consistently weighed high. He said that "it is becoming more important to know what rather than how to teach." Among the remedies proposed to eliminate these problems was the use of occupational competency examinations to id ntify the extent of an individual's knowledge of the area he or she proposed to teach.

Corman (5:105) reports the Trade and Industrial Division of AVA, through the National Occupational Competency Testing Project, is moving toward a recommendation that competency testing be an accepted part of the teacher selection process. Examination scores can be used along with other criteria for one or more of the following purposes: 1) to establish evidence of occupational competency, 2) for admission to trade and industrial technical teacher education programs, 3) to meet state requirements for certification, 4) for advanced standing in the undergraduate or graduate programs of study, and 5) for diagnostic and guidance purposes to determine weak or deficient areas which the candidate needs to correct.

Other uses for trade competency examinations have been investigated by Lauda and McFadden. Lauda (15:33) investigated the extent and process involved in allowing college credit for T & I work experience. The amount of credit allowed was, in the majority of cases, influenced to some degree by the individual's score on a trade competency examination. The purpose of a pilot project reported by McFadden (16:1) was the development and validation of tests to assess student achievement in 12th grade vocational printing programs. Achievement tests in trades, other than printing, were being planned if the results of this pilot project proved encouraging.

At least two manuals have been developed to aid individuals interested in developing occupational competency examinations. The Ohio State Department of Education (17:1) stated that the general purpose of occupational competency examinations was "to appraise, as accurately and fairly as possible, the skill and technology required of those who propose to teach the intricacies and practices to others." Such tests were designed to serve at least two purposes: 1) to screen qualified applicants for better than average ability in order to establish their eligibility and range of occupational experience required for temporary teacher certification as outlined in the Ohio Plan of T & I education, and 2) to establish sufficient and professionally acceptable evidence for the issuance of undergraduate credit toward a degree in a cooperative teacher-training institution or for advanced certification.

The Handbook of Performance Testing, by Boyd and Shimberg (3:1-178) gave some whys and hows of performance testing, and then showed several examples of tests which have been developed in many trades.

The review of the literature revealed that few automotive competency examinations existed. Many of the existing examinations were developed by state departments of vocational education and/or teacher training institutions. Those examinations were used primarily for the awarding of college credit for work experience, although some were used for the direct certification of teachers. Independent testing organizations and automotive related corporations and associations have recently been engaged in developing automotive examinations for their own use.

Hypotheses Tested

After reviewing the previously mentioned literature, the following hypotheses were postulated. These five hypotheses express the purpose for this research project.

1. That a refined, written occupation competency examination for auto mechanic teachers can be developed that will differentiate between present auto mechanic teachers and auto technicians in a manner similar to the differentiation indicated by the rating forms completed by each person's supervisor.

2. That there is no difference between the total examination scores earned by groups of individuals categorized as to their occupations such as vocational auto mechanic teacher, industrial arts auto mechanic teacher, auto technician and post-secondary, vocational auto mechanic students.

3. That there is no difference between the total examination scores earned by teachers teaching in: (1) industrial arts programs, (2) vocational auto mechanics at the secondary level or (3) vocational auto mechanics at the post-secondary level.

4. That there is no difference in the level of technical knowledge between groups of auto technicians classified as to their length of trade experience as auto technicians.

5. That there is no difference in the level of technical knowledge between vocational auto mechanic teachers and auto technicians grouped according to the length of time the teachers have been teaching vocational auto mechanics and the length of time spent in automotive service employment by the auto technicians.

CHAPTER III

METHODS OF RESEARCH

"One can no more teach what he does not know than to return from a place he has never been."

--Ben Franklin

Introduction

The primary objective of this research was to develop and refine, through field testing, a written auto mechanic occupational competency examination.

The purpose of this chapter is to describe the procedures used in selecting and developing this research project. A discussion of the topic, the methods of investigating the topic, and the methods of handling the data are presented.

Selection of the Problem

This investigator has long been concerned with the diverse requirements for the certification of vocational educators, particularly in the trade and industrial section. While on a leave of absence from Southern Colorado State College in Pueblo, Colorado during the 1968-69 school year, the investigator was awarded a research assistantship at Colorado State University in the Department of

Vocational Education, under the direction of Dr. Milton E. Larson. A survey which was undertaken as part of this assistantship involved the utilization of competency examinations in vocational and technical education in all the states and territories of the United States. The findings of this survey reinforced the findings of other similar surveys taken earlier, and did much to entice the writer to choose this problem for his doctoral research.

The fact that there appeared to be an increase in the use of occupational competency examinations by states, as a means of evaluating a person's trade experience and/or competency, is shown among the findings of surveys taken by: 1) Schaefer (23:6) in 1959, 2) Kazanas and Kieft (10:17) in 1966, and 3) Larson and Crain (14:10) late in 1968. The last of the surveys mentioned above indicated a substantial duplication of effort with the developing of a different test in each of the 16 states.

Selection of Participants

Five different groups of subjects were chosen to participate in this study. A cross section of the trade involved the following groups: service managers, auto technicians, industrial arts auto mechanic teachers, vocational auto mechanic teachers, and sophomore, post-secondary vocational auto mechanic students. The geographical area chosen from which participants were randomly selected varied according to the groups involved in the different phases of the study.

The service managers and the auto technicians involved with the survey questionnaire and the trial and final administration of the examination were randomly chosen from a list of 515 names. This list was compiled by contacting all the garages listed in the classified section of the 1969 Mountain Bell telephone directory for Pueblo, Colorado Springs, and Canon City, Colorado.

The industrial arts teacher group was involved with only the trial and final administration of the examination. The industrial arts teachers who participated in the final administration of the examination were randomly chosen from a list of those individuals designated as auto mechanic teachers by the Industrial Arts Supervisors or Consultants from Colorado and the bordering states of Wyoming, Utah, Arizona, New Mexico, Oklahoma, Kansas, and Nebraska. There were approximately 400 teachers involved to some degree with teaching industrial arts auto mechanics in the junior and senior high schools throughout these states. Industrial arts teachers, which were included in the data gathering for the trial examination, were chosen at random from a group of approximately 130 Colorado teachers.

Vocational auto mechanic teachers were involved with the program questionnaire, the trial, and the final examination phases of this research. Only teachers in Colorado at the secondary and post-secondary levels were asked to complete the program questionnaire phase. The vocational auto mechanic teachers involved in the

trial and final administration of the examination were randomly chosen from a list of approximately 500. This list was compiled by selecting only those individuals identified as teaching auto mechanics at the secondary and post-secondary level from the lists of vocational teachers provided by the state supervisors of T & I in Colorado and the above mentioned bordering states.

Sophomore, post-secondary vocational auto mechanic students were involved in two phases of this study, the trial examination, and the final form. The trial examination was given to students attending Trinidad State Junior College, the North Campus of Denver Community College, and Southern Colorado State College.

The final form of the examination was sent to post-secondary schools, randomly selected from Colorado and bordering states, where the auto mechanic department head indicated a willingness to administer the examination to sophomore students. Bulk mailings made to each department head included all the materials for collecting the necessary data on each participant.

Development of Data Gathering Instruments

Instruments which were used during the three data gathering phases of this study were developed after it had been determined what type and kind of information was to be retrieved. In addition, the design of the instruments used in the trial and final form of the

examination were contingent upon data collected during previous phases of the study.

The Questionnaire

In order to develop a meaningful auto mechanic occupational competency examination, it was decided that a survey type of questionnaire should be developed and sent to different groups who were actively involved in different phases of the trade. The writer visited with individuals working in the trade, to provide him with insight into the current trends and problems of the industry. In addition, several different auto mechanic text books and course outlines were used to develop the questionnaire which is found in Appendix A.

The survey questionnaire was divided into four parts. Part I requested background information about the participant and his school or business. Part II, which will be explained in detail later, asked the participants to rate each of the 115 listed operations or principles as to how important they felt it was for an auto mechanic teacher to be knowledgeable in that area. Space was also provided for write-in operations or principles that a participant might want to add. These 115 items were separated into seven broad areas of repair. Part III asked, depending upon groups, what percentage of the total training course, or garage volume, was devoted to, or attributable to, each

of the seven areas of repair listed under Part II. Part IV asked each participant to list anticipated additional areas of training, or service to be added within the next five years to their curriculum or garage.

The seven units in Part II of the questionnaire were selected because of their apparent similarity to the way in which many of the texts and courses were divided. The number of statements contained in each of the seven units varied with what the graduate committee and other interested persons associated with the automotive repair field believed adequately covered the topic.

An extensive follow-up program was used in an effort to increase the number of returns. Three of the follow-up attempts involved mailing another copy of the questionnaire to individuals who had not responded and included a follow-up letter as found in Appendix A. The final attempt to gain returns was a phone call to individuals who had not responded.

A total of 50 survey questionnaires were returned from a random sample of service managers and auto technicians in the Pueblo area and vocational auto mechanic teachers in Colorado.

The Job Analysis

Of the 115 items included on the survey questionnaire, 83 items were rated "essential" by the majority of at least two of the three groups. A job analysis was completed on each of these 83 items.

This procedure was deemed necessary to insure that the questions contained on the trial and final forms of the examination would be the most encompassing and thorough possible.

The analysis was made with the aid of auto mechanic text books and manufacturers' service manuals for 1967 and later model American and foreign passenger cars.

The Trial Examination

Once there had been a specific time limit and number of questions assigned to the final form of the examination, like parameters could be assigned to the trial form of the examination. It was necessary to consider that some of the questions contained on the trial examination would be eliminated from the final form as a result of the item analysis, point biserial correlation test of item effectiveness or validity. Approximately 25 to 30 percent more questions would be necessary on the trial form than would ultimately be needed for the final form.

The question of what proportion of the total examination would be devoted to each sub-test or area of repair was answered by Parts III and IV of the questionnaire. Table 1 summarizes the responses to Part III of the questionnaire. The mean percentages do not add up to an even 100% due to rounding of the numbers to the nearest tenth.

All three groups seemed to agree quite uniformly with respect to the percentages of work performed in industry or subject matter being taught in schools which was attributable to each of the seven areas of repair listed in Table 1. The teachers' percent of fuel system work and the service managers' percent of the miscellaneous work indicated the greatest variance.

TABLE 1. PERCENTAGES OF TYPES OF REPAIR WORK INDICATED BY THE QUESTIONNAIRE.

Repair	Serv. Mgrs. (N=7)		Teachers (N=21)		Technicians (N=11)		Comb. (N=39)
	Mean %	Range	Mean %	Range	Mean %	Range	Mean %
Engine	19.3	10-30	23.1	5-30	21.7	5-50	21.3
Fuel System	9	3-20	15.8	5-20	11.9	4-30	12.2
Electrical Systems	15.7	5-25	20.7	5-50	20.1	8-30	18.8
Power Trains	9.6	5-15	11.4	3-25	9.2	5-15	10
Automatic Trans.	9.8	1-20	8.1	2-15	9.7	5-20	9.2
Brake, Strg. & Supsn.	18.6	10-25	22.7	10-25	22	6-50	21.1
Misc. Repairs	18.8	5-57	16.8	5-32	12.6	5-40	15.9

Those areas of anticipated expansion, which were written in under Part IV, are listed in Table 2 along with the combined frequency with which each was mentioned by the service managers and teachers. The technicians did not respond to this particular section of the questionnaire because it was felt that they had no real in-put in what changes would be implemented in the type of repair work to be performed in the shops where they were employed.

TABLE 2. ANTICIPATED EXPANSION IN TRAINING PROGRAMS AND/OR REPAIR SHOPS

Anticipated Areas	Frequencies		
	Service Managers	Teachers	Combined
Air Conditioning	2	7	9
Alignment		8	8
Brake Service Center		7	7
Lubrication		2	2
Automatic Transmission		2	2
Diagnostic Lane		2	2
Wheel Balancing		2	2
Foreign Car Repair	1		1
Test & Repair Vacuum Systems	1		1
Electronic Controls	1		1
High Performance Center	1		1
Alternator Service		1	1
Radiator Repair		1	1
Boring & Honing		1	1
Lathe Work		1	1
Auto Body		1	1

The responses to Parts III and IV on the questionnaire, which are shown in Tables 1 and 2, show that certain types of repair are emphasized more than others. The weight or length of each sub-test in relation to the total examination was developed in approximately the same proportion that repairs are performed in industry and/or training is offered in auto mechanic training programs. Table 3 shows a comparison of the percentages as indicated by the questionnaire around which the trial examination was constructed.

The proportion of questions included in the fuel system sub-test was substantially higher than the average reported from the

questionnaire. This was done for two reasons: first, the teacher group on the questionnaire indicated nearly twice as high a proportion of time devoted to this area as did the service managers and technicians. Secondly, due to the variety of components and, hence, the need for more questions to cover the subject adequately, a higher proportion was assigned to this sub-test.

TABLE 3. A COMPARISON BETWEEN THE APPROXIMATE PERCENTAGES RELATED TO EACH AREA OF REPAIR

Areas of Repair	Approx. Percentages Dictated by the Questionnaire	Approx. Percentages Used on the Trial Examination
Engines	21.3	21.5
Fuel System	12.2	17.2
Electrical	18.8	18.9
Power Trains	10	8.6
Automatic Trans.	9.2	9.4
Brakes, Strg. & Supsn.	21.1	18.1
Miscellaneous	15.9	6.0

The miscellaneous group of questions contained on the trial examination was reduced percentage-wise from the percentage reported on the questionnaire. This, too, came about as the result of two factors. First, the total of approximate percentages for the seven areas of repair as reported in the questionnaire added to 108% which meant that some areas must be reduced on the trial examination. The other six areas of repair represent the backbone of the trade and were, therefore, given the advantage by not eliminating more

questions from those areas. Secondly, the majority of items to be considered to be miscellaneous on the questionnaire are actually quite difficult to teach, or learn, other than by way of practical experience gained through working in the trade.

The selection of the most appropriate questions from each group was facilitated through the use of the job analysis. A major objective in the choice of the questions for the trial examination was to choose only those questions which could be answered by persons having a good working knowledge of the subject.

The writer consulted the chairman of his graduate committee, Dr. Milton E. Larson and Dr. C. Dean Miller, research consultant on the committee, about the format of the trial examination. It was the opinion of both of these men that the questions should be scrambled rather than separated into seven sections corresponding to the seven units on the survey questionnaire. By scrambling the questions, the validity and reliability of each section of the examination was strengthened.

A list of the question numbers pertaining to each of the seven sections was identified so that sub-scores could be obtained for each person taking the examination.

When all the questions to be used on the trial examination appeared to be clear and to the point, an additional trial examination was reproduced and administered to a volunteer group of eight post

secondary auto mechanics students and two instructors at Southern Colorado State College. Each was asked to take the examination and to comment on anything which did not seem clear or correct. From this, further refinement was possible.

As a method of improving the content validity of the competency examination, each question on the trial examination had a quick check critique area. A three-column critique along the left margin of the page was provided for convenience in marking. A check mark in the appropriate column indicated that person did not think the question was clearly stated, he did not think that the answer was clearly stated, or the question should be omitted. In addition to the three critique columns provided, the directions on the examination invited the individual to make other appropriate comments, either across the critique columns or between the questions.

The trial examination and letters of transmittal, as shown in Appendix B, were printed and mailed along with a franked envelope to individuals selected at random with the aid of the "Table of Random Numbers" as listed by Wert, Neidt, and Ahmann (32:416-417).

Table 4 shows the number of individuals who were chosen at random to receive copies of the trial examination as well as the number and percentage of returns received from each of the groups. A total of 102 usable returns were received.

TABLE 4. BREAKDOWN OF TRIAL EXAMINATIONS MAILED AND RETURNED

Group	Number of Exams Sent	Number of Exams Called For in Proposal	Number of Exams Received	Approx. % of Those Needed
I.A. Auto Teacher	15	10	5	50
Voc. Auto Teacher	45	30	23	77
Service Managers	15	10	8	80
Technicians	23	15	8	53
Students, SCSC	38	38	38	100
Students, DCC	11	11	11	100
Students, TJC	10	10	10	100
Totals	157	124	103	

Double post cards, as shown in Appendix B, were used as a method of follow-up. Three groups of cards were sent out to those individuals who had received a copy of the trial examination, but from whom a returned copy had not been received as of the date the cards were mailed. In addition to the post cards, a fourth follow-up was made by telephoning some 14 persons and asking them to please complete and return the trial examination which had been sent.

The Final Form

The final form of the auto mechanics occupational competency examination was developed with the information collected by the administration of the trial form. Also, the second or final form,

as found in Appendix C, differed considerably from the trial examination. As was previously mentioned, each question on the trial examination was critiqued by all who reviewed the examination. The critiques for each of the groups and for the total of all groups were tabulated as a means of locating misleading or poorly worded questions. A second method, that of item analysis through the application of a point biserial correlation, was employed to help identify the questions that would be used on the final form of the examination.

Several things were considered during the time the questions for the final form were being chosen. First, it was predicted that all the questions to be used on the final form would have a point biserial correlation of .30 or above. This prediction turned out to be negative in order to meet the other objectives which were also considered important. Secondly, members of the committee decided that it was desirable to have 85 to 90 questions in order to adequately cover the seven categories included. Thirdly, the committee members felt it was necessary to maintain a proportion of the number of questions in each of the seven categories as was originally determined through the program questionnaire and maintained with the trial examination. To meet this criteria, a compromise was necessary. The number of questions to be included on the final examination was reduced from the 116 used on the trial examination to 88, or a 24.14 percent reduction.

Table 5 lists the number and percent of questions used on the final form of the examination from each of the correlation categories. As shown, some 76 percent of the questions used on the final form of the examination did have a correlation of .30 or above. It was necessary to include some 24 percent of the questions which did not correlate as highly as the .30 level. About 3.4 percent of the questions were below the .20 correlation level. This was necessary to maintain an approximate balance, or similar proportion, for each of the sub-tests to the total examination as was identified by the responses of individuals on the survey questionnaire.

TABLE 5. ITEM ANALYSIS, POINT BISERIAL CORRELATION LEVELS FOR THE QUESTIONS USED ON THE FINAL FORM

Correlation Level	Number of Questions Used	Approximate Percent of Total
.30 and above	67	76.1
.25 to .30	9	10.2
.20 to .25	9	10.2
.15 to .20	3	3.4

Table 6 shows a complete breakdown of the approximate percentages of total questions that are contained in each of the seven sub-tests. Also shown is the relationship to the percentages contained on the trial and final examination and the number of questions appearing on each of the sub-tests from each correlation level.

TABLE 6. THE APPROXIMATE PERCENTAGES AND THE POINT BISERIAL CORRELATION LEVELS OF QUESTIONS CONTAINED ON EACH OF THE SUB-TESTS ON THE TRIAL AND FINAL FORMS

Sub-Tests	Number of Questions On Final	Number Of Questions Used On Trial	Comprising Approx. % Of Final	Corres. % Of Trial	Number of Questions Used at Various Correlation Levels			
					Above .30	.25 to .30	.20 to .25	.15 to .20
1. Engines	20	80	23	22	14	5	1	
2. Fuel	15	75	17	17	12	1	2	
3. Electrical	16	73	18	19	11	1	2	2
4. Power Trains	7	70	8	9	5	1		1
5. Automatic Trans	8	73	9	9	5		3	
6. Brakes, Strg. & Supsn.	17	81	19	18	16		1	
7. Miscellaneous	5	71	6	6	4	1		
Totals	88		100	100	67	9	9	3

It can be observed that each of the sub-tests was reduced to between 71 and 81 percent of their length on the trial examination. Also, the approximate percentage that each of the sub-tests contributed to the total examination was maintained. The sub-tests three and four, electrical and power trains respectively, contained the questions producing a correlation of less than .20 which were used in an effort to maintain the relative balance.

After the best questions had been selected and those needing revision were rewritten and strengthened, other forms necessary for the collection of additional data to test the hypothesis were finalized. Statements designed to gather the necessary data were arranged and correlated between like forms which had somewhat different formats due to the groups for which they were being developed. The blank spaces were numbered in a manner so that the key punch operator could easily locate the equivalent answer or response on the different formats. The cover letter, as found in Appendix C, explained the role of each group of individuals in the total study. All examinations were prepared on the same format and contained the same information.

A roster was obtained from each of the vocational education and industrial arts supervisors from Colorado and all the bordering states. These listed the automotive teachers at the secondary and post-secondary level in each state for the 1971-72 school year. Ten

percent more examinations and rating forms were mailed out than was needed to meet the minimum as specified in the proposal. As each examination was scored, the raw score was sent to the person completing the examination if requested. Approximately 90 percent of those participants returning a completed examination requested their scores.

The majority of those individuals reporting indicated that they considered themselves "general" technicians, although there were several who indicated one of the other specialty areas or categories. In a few cases, the participants listed two or more specialty areas. When this occurred, he was assigned the area which was listed first and seemed to be his preference.

For any of the information received from any individual to be of value, it had to be matched with other data received from another person, i.e., an examination and data sheet from the participant had to be matched with a rating form from the participants' supervisor. It was for this reason that all three categories (exams, ratings, and matched pairs), were listed under "No. of Returns Received" in Table 7. Table 7 provides an overall view of the numbers of final examinations mailed out and returned by the various groups.

Three follow-up post cards were sent to participants and supervisors from whom a completed return or no previous reply had been received.

TABLE 7. FINAL FORM EXAMINATIONS MAILED AND RETURNED

Groups	Number Needed For Proposal	No. Sent Out	No. of Returns Received			No. of Follow-ups	
			Exams	Rating	Matched Sets	Post Cards	Phone Calls
Voc. Teachers	100	110	80	111	79	3	1
I.A. Teachers	30	33	22	22	22	3	
Technicians	30	33	22	22	22	3	1
Post Sec. Stud.	100	108	84	84	84	3	2
Totals	260	284	208	239	207	3	2

To complete the sets of data, follow-up phone calls were placed to participants and supervisors in the industrial arts and technician groups and to teachers of post-secondary, vocational auto mechanic program. When data was received from those to whom phone calls were placed, it completed the information and made matched sets. It was for this reason that the number of examinations, rating forms and matched sets were so nearly equal in these three groups.

Analysis of the Data

Four different types of statistical analysis were made on the data collected during the various stages of this research. A Pearson Product correlation was used to correlate a person's rating with his total score. A point biserial correlation was used for the item

analysis to identify items which distinguished among participants making high and low total scores. The Guttman formula was used to find the correlation between the scores obtained on the two halves of each sub-test and the total examination as determined on the final form. One- and two-way analysis of variance with the "F" test of significance were employed to determine the significance of the scores obtained by the different groups tested.

The items selected to be included on the trial examinations were determined by merely taking the highest rated items as established through a tabulation of returned program questionnaires. Only those items rated "essential" by the majority of at least two of the three groups asked to respond on this occupational competency examination were included.

The trial examination included a three-column check-mark type critique to be completed if the participant felt that: 1) the question was not clear, 2) the response was not clear, and/or 3) the question was not necessary. A tabulation of the critique marks for each question from each of the groups taking the examination, as well as a grand total of all critiques, was made and used to help select and/or correct the questions to be used on the final form. In addition, the item analysis correlation for each question on the trial examination helped serve as a basis for selecting and/or correcting the questions to be used for the final form. Anastasi (1:152) states:

> Both the reliability and the validity of a test depend ultimately upon the characteristics of the items which make up the test. It follows that any test can be improved through the selection, substitution, or revision of items .... Through item analysis, it is possible to shorten a test, while at the same time increasing its validity and reliability.

Electronic data processing equipment was used to compute the item analysis point biserial correlation, the one- and two-way analysis of variance and other correlations between the groups for this research study. All data for the above operations was punched into cards. The split-half computations were manually performed because the proper computer program to perform this operation was not available. The item analysis data was fed into the International Business Machines 360 computer at Southern Colorado State College. All other data was processed by the Controlled Data Corporation 6400 computer at Colorado State University. Standard Statistical formulas were used for all computations and can be found in Appendix E.

The first hypothesis stated in Chapter II was tested through the use of the Pearson Product correlation. Since the hypothesis sets out to test the value of one instrument to predict the outcome on another, the Pearson Product moment coefficient of correlation appeared to be the most logical. Wert, Neidt, and Ahmann (32:76) state, "One of the most important uses for a coefficient of correlation is that of indicating the extent to which values of one variable may be predicted from known values of another variable."

The four null hypotheses were tested through the use of one- and two-way analysis of variance and the "F" test of significance. The analysis of variance technique and the "F" test of significance seemed the most appropriate tools for statistical analysis.

Wert, Neidt, and Ahmann (32:128) report: "The probability required for rejecting the null hypothesis is highly arbitrary, but common practice has been to use the 5 percent and the 1 percent level." Throughout this study, when the "F" test of significance is applied to a statistical computation, the one and five percent levels are used as the basis for rejecting the null hypothesis.

The data collected through the administration of the final form of the examination will be presented in Chapter IV. In the analysis of the data, an attempt will be made to make the data meaningful and comprehensive so that maximum use can be made of the findings. Tables designed to summarize the findings are presented. These tables are explained in the accompanying exposition.

CHAPTER IV

FINDINGS

Introduction

Discussion and statistical analysis of the data collected using the final form of the Written Occupational Competency Examination For Auto Mechanic Teachers is presented in this chapter.

The findings of this study are based on the data collected using 1) the scores obtained by each participant on the Written Occupational Competency Examination, 2) the rating obtained from each participant's supervisor and 3) the information furnished by each participant on the personal data sheet. Reporting of the data is in the same order as the presentation of hypotheses. The total examination is comprised of seven sub-tests which, in some cases, are reported separately.

A total of 207 returns were received. All were usable for most of the analysis. These returns came from a study population consisting of auto technicians, industrial arts automotive teachers, vocational auto mechanic teachers and post-secondary, sophomore auto mechanic students.

The data reported in decimal form throughout this chapter has been rounded to the nearest hundredth.

Analysis of the Data

The Pearson Product Correlation, was employed to test the first hypothesis which proposes that a written examination can be developed which will correlate significantly between the total scores earned on the examination and the overall ratings received from each participant's supervisor.

Table 8 shows the correlation coefficient between the sub-test scores and the ratings for all groups of participants. This measure of status validity was computed for each group separately as well as for all groups combined. Twenty one of the 40 correlation values listed in Table 8 are significant at the .05 level or above. The correlation values as indicated by the combined group of 207 participants are all significant at the .01 level, however, for each group individually this is not true.

The group of industrial arts teachers includes a wide spread of correlation levels. The sub-tests of Power Trains, Transmissions, and Miscellaneous for this group are all below the minimal .05 level. However, the sub-tests of Engines and Alignment are significant at the .05 level and the remaining sub-tests of Fuel Systems and Electrical are significant at the .01 level.

The vocational teacher and the auto technician groups correlated similarly on the examination. The correlation on only one sub-test taken by the two groups showed an acceptable level of

TABLE 8. CORRELATIONS BETWEEN TOTAL EXAMINATION SCORES AND OVERALL RATINGS WITH THE LEVELS OF SIGNIFICANCE AND INDICATING THE DEGREE OF STATUS VALIDITY

Sub-Score and Rating Area	Groups of Participants				
	Combined (N-207)	Industrial Arts Teach. (N-22)	Vocational Teachers (N-79)	Auto Techs. (N-22)	Students (N-84)
Engines	.31	.52	.20	.04	.09
Fuel Systems	.47	.57	.07	.14	.53
Electrical	.45	.69	.18	.31	.46
Power Trains	.25	.28	.04	.24	.30
Transmissions	.35	.39	.18	.61	.25
Alignment	.36	.47	.06	.18	.56
Miscellaneous	.25	.29	.05	.03	.28
Total or Overall	.56	.59	.15	-.05	.57
.05 Level of Sig.	.14	.42	.22	.42	.21
.01 Level of Sig.	.18	.54	.29	.54	.28

significance. The correlation on the Transmissions sub-test for the auto technician group was significant at the .01 level.

The student group finished with six of the eight scores and ratings correlating at a value which is significant at the .01 level. The other two scores and ratings did not, however, correlate with a value sufficient to meet the .05 level.

The outcome was a reversal of what was expected. It was anticipated that the vocational teacher and the auto technician groups would have achieved higher correlations between their sub-test scores and the ratings that they received from their supervisors. An outcome of this nature is dependent upon a number of variables, among them being the evaluators' interpretation of the evaluation or rating form and the rating form itself. Table 9, although concerned only with the intercorrelation between the total examination score and the overall rating, gives the reader some insight into the reason why the auto technician and vocational auto teacher groups did not produce a significant correlation level between sub-test scores and ratings. These two groups each have several participants who achieved a total score in the 40 to 60 range, yet these same individuals received a rating of three or higher on a zero to five rating scale. Upon close examination of the returns from each of the four groups it can be seen that, overall, participants in the vocational teacher and the auto technician groups received higher ratings throughout than did participants in the industrial arts and student groups.

TABLE 9. INTERCORRELATION DISTRIBUTION BETWEEN TOTAL EXAMINATION SCORES AND OVERALL RATINGS

Total Scores	Industrial Arts Teachers (N-21)				Vocational Teachers (N-77)				Auto Technicians (N-22)				Auto Students (N-84)				Row Totals
80 - 84				3			5	6							1		15
75 - 79		1	1	1			15	3	1	2				1	2		27
70 - 74		3	2	3		1	6	12	2	3	1			2	5	2	42
65 - 69		1	1			2	5	5	2	3	1			6	4		30
60 - 64						2	6	2	1		1		1	13	3	1	30
55 - 59							1	2	1				2	16	2		24
50 - 54			2			1	1			1			1	8	2		16
45 - 49	1							1		1	1			3	1		8
40 - 44			1						1				1	1			4
35 - 39													3	1			4
30 - 34	1													1			2
25 - 29													1				1
20 - 24							1										1
Ratings	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	
Column Totals	2	5	7	7		6	40	31		8	10	4	9	52	20	3	204

Due to the absence of ratings at the 0 and 1 levels, these columns have been omitted from the table.

Table 9 shows the distribution of total examination scores and overall ratings on all participants in each of the four groups for which data was available. As can be seen, the grand total of 204 participants is less than the total number of participants reported earlier due to the fact that three rating forms did not include an overall rating for those participants. The groups of industrial arts teachers and of students clearly show a positive distribution. The relationship between the total examination score and overall rating, cluster in a pattern running from the lower left to the upper right sections of the charts.

The vocational teacher and auto technician groups indicate a pattern running vertically on the chart with a heavy clustering in the upper right hand section. A grouping of tally marks in this type of pattern still indicates an overall positive correlation between the total examination scores and the overall ratings but of a much lower magnitude.

The Pearson Product Correlations, as shown in Table 8, are highly significant at the .01 level for all groups combined. This data supports the first hypothesis which, therefore, must be accepted.

The reliability for the total examination was obtained by the split-half method. Here the total examination was divided into two halves by dividing it on odd and even numbered items. The Guttman formula, as shown in Appendix E, was used for the statistical

calculations because it avoids the assumption that the variabilities of the two half-scores are equal. All the split-half calculations were manually performed due to the lack of the appropriate computer program for the job. The Guttman reliability coefficient came out to be .88. This value is considered satisfactory by Anastasi who states that reliability coefficients usually fall in the .80's or .90's (1:105).

The correlation levels between each of the seven sub-test scores and the total examination scores for each of the four groups and all groups combined is shown in Table 10. These correlations were made to determine if certain sub-tests correlated higher than others with the entire examination. The highest correlation was attained by the industrial arts teacher group on the Brakes and Steering sub-test. The lowest, which was also the only negative correlation, was with the auto technician group on the test covering Miscellaneous items.

Only three of the 35 correlation values in Table 10 failed to be significant at the .01 level. The Miscellaneous sub-test for vocational teachers and the Miscellaneous and Power Trains sub-test for auto technicians failed to be significant at either the .01 or .05 level.

Overall, for all four groups individually, the sub-test on Brakes and Steering had the highest correlation followed by Fuel, Engines, Electricity, Automatic Transmissions, Power Trains and Miscellaneous in that descending order. When all groups were combined the order changes somewhat. The sub-test that had the highest

TABLE 10. CORRELATION LEVELS BETWEEN EACH SUB-TEST AND TOTAL SCORE BY GROUPS

Groups of Participants	Sub-Tests							Levels of Sig.	
	Engines	Fuel	Electri-city	Power Trains	Trans-missions	Brakes & Steering	Misc.	.05	.01
Industrial Arts Teacher (N-22)	.83	.84	.75	.66	.74	.89	.88	.22	.29
Vocational Teacher (N-79)	.72	.76	.74	.58	.59	.69	.22	.42	.54
Auto Technician (N-22)	.81	.81	.74	.38	.62	.79	-.00	.42	.54
Post-Secondary Students (N-84)	.75	.77	.76	.51	.47	.83	.41	.21	.28
Combined (N-207)	.82	.81	.78	.63	.57	.85	.45	.14	.18

correlation was once again Brakes and Steering followed by Engines, Fuel, Electricity, Power Trains, Automatic Transmissions and Miscellaneous in that descending order.

The 95% confidence intervals, as shown in Tables 11 and 12 are plotted for each of the four groups on the total examination score and on the overall rating. It can be clearly seen that the industrial arts and vocational teacher groups earned higher scores and received higher overall ratings than did the technician and student groups which followed in that order. The difference in the range of the confidence intervals is a result of using groups of different sizes and variability within the groups. In addition to the confidence intervals, the group means are plotted for comparison purposes.

By combining the intercorrelation distribution for all four groups onto one chart and converting each cell frequency into a percentage of the corresponding row total an expectancy table was developed which could also be used for prediction purposes. Table 13 contains the data included in Table 9 but converted into an expectancy table based on the returns from 204 participants. The relationship of the total examination scores to the overall ratings as shown in Table 12 are significant beyond the .01 level as indicated in Table 8. In Table 8 a correlation level of .56 is given for an overall correlation between the total examination score and the overall rating for all 207 participants. Similarly, the .01 level of significance for a correlation

TABLE 11. GROUP MEANS AND THE NINETY FIVE PER-CENT CONFIDENCE INTERVALS ON THE TOTAL EXAMINATION SCORES

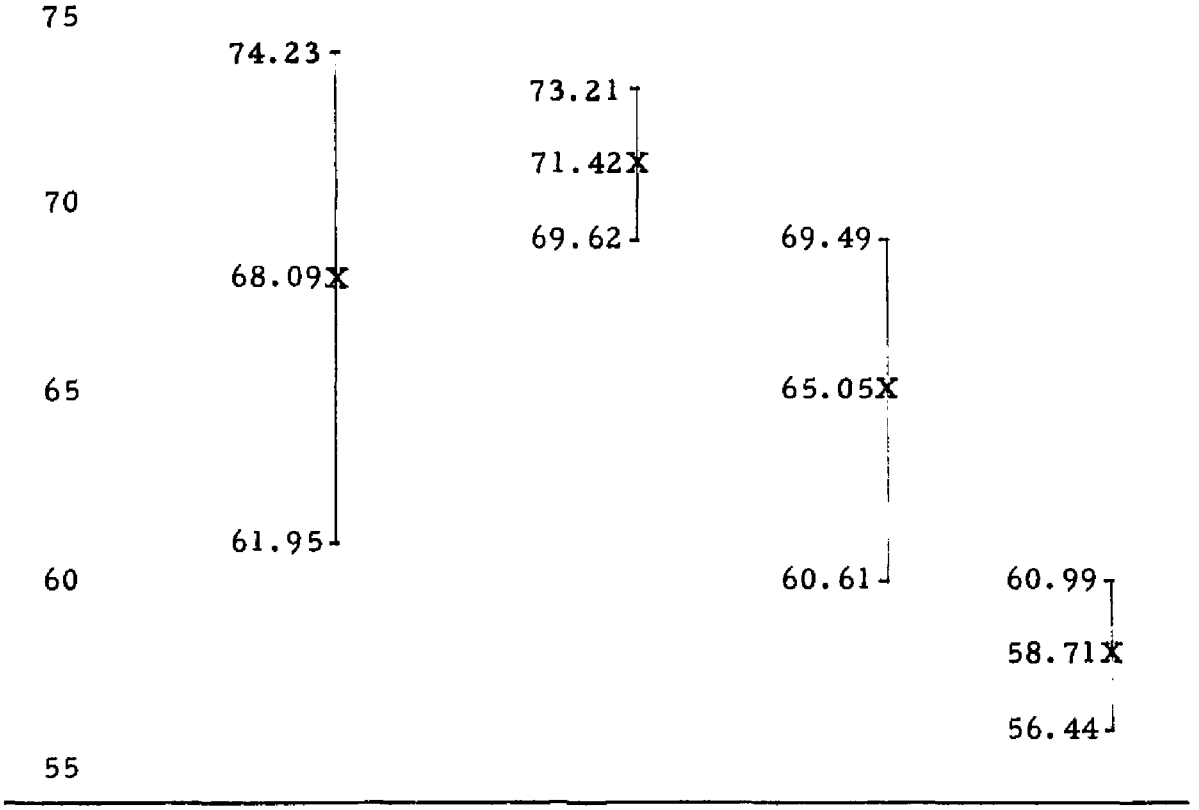
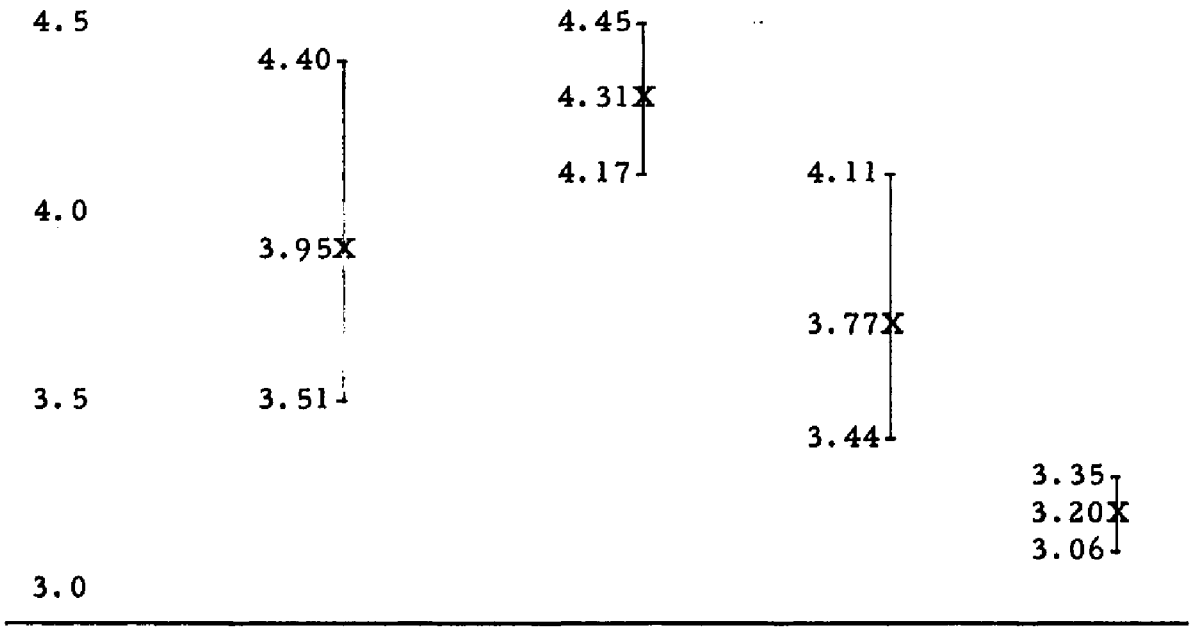


TABLE 12. GROUP MEANS AND THE NINETY FIVE PER-CENT CONFIDENCE INTERVALS ON OVERALL RATINGS



involving 207 individuals is .18, indicating that a significant degree of confidence can be expected from predictions based upon these returns. However, those percentages shown for total examination

TABLE 13. EXPECTANCY TABLE BASED ON TOTAL EXAMINATION SCORES AND OVERALL RATINGS

Total Exam Score	Overall Ratings					
	0	1	2	3	4	5
80 - 84					40	60
75 - 79				11	74	15
70 - 74				19	38	43
65 - 69				37	43	20
60 - 64			3	53	30	14
55 - 59			8	71	13	8
50 - 54			6	56	38	
45 - 49			13	37	25	25
40 - 44			25	50	25	
35 - 39			75	25		
30 - 34			50	50		
25 - 29			100			
20 - 24					100	

scores lower than 45 may be questionable due to the relatively small number of individuals involved in each of the row totals.

The mean score and standard deviation for each of the sub-tests and the total examination are shown in Table 14. The highest mean scores for all sub-tests were obtained by the vocational teacher group.

TABLE 14. MEAN AND STANDARD DEVIATION FOR ALL SUB-TEST AND TOTAL EXAMINATION SCORES

Tests	No. Ques.	Groups of Participants									
		Combined		I.A. Teachers		Voc. Teachers		Technicians		Students	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Engines	20	14.72	2.98	15.32	3.64	16.13	2.23	15.05	2.70	13.15	2.77
Fuel System	15	10.82	2.84	11.73	2.83	11.92	2.03	11.05	2.68	9.49	3.02
Electrical	16	12.42	2.40	12.95	2.48	13.35	2.08	11.86	2.03	11.54	2.42
Power Train	7	5.06	1.38	5.23	1.51	5.65	1.17	5.18	1.22	4.43	1.32
Auto. Trans.	8	5.10	1.89	5.05	2.48	5.58	1.67	4.55	2.34	4.80	1.70
Brakes & Stg.	17	12.64	2.94	13.18	3.58	14.03	2.15	12.95	2.77	11.12	2.77
Miscellaneous	5	4.52	.75	4.64	.66	4.76	.46	4.36	.79	4.31	.90
Exam Total	88	65.23	11.41	68.09	13.85	71.42	7.96	65.05	10.01	58.71	10.41

The industrial arts teachers, auto technician and student groups followed in that descending order.

The mean and standard deviation for each of the four sample population groups, or for all groups combined, may be helpful when evaluating an individual for employment or other purposes. If this examination is administered to an individual from one of the four sample population groups, their score can be compared to these measures of central tendency as an indication of their automotive trade competency and/or experience.

An analysis of variance (AOV) was made on the total examination score for each of the four groups. The AOV on total examination scores, as shown in Table 15, produced an "F" value of 22.83 which is significant beyond the .01 level. Using the "F" test of significance and the .01 level of confidence, the second hypothesis which states there is no difference between the total examination scores obtained by individuals categorized as to their field of employment must be rejected.

The result of the "F" test of significance indicates that there is less than a one percent chance that the differences in the group means, as shown in Table 14, are due to sampling errors and are, in fact, due to the difference in the groups.

TABLE 15. ANALYSIS OF VARIANCE TEST OF SIGNIFICANCE OF TOTAL EXAMINATION SCORES BASED ON A COMPARISON BETWEEN ALL FOUR GROUPS OF PARTICIPANTS

Source	DF	SS	MS	F	P
Total	206	26842.87			
Treatment	3	6771.74	2257.25	22.83	.01
Residual	203	20071.13	98.87		

A one-way AOV was employed to test the difference in total examination scores earned by auto mechanic teachers categorized as industrial arts or vocational education and employed at the secondary or the post-secondary level. Three groups developed as a result of this categorizing since no industrial arts teachers at the post-secondary level were involved in this study.

Although all participants in these three groups were classified as auto mechanic teachers they taught in programs having three separate objectives. Credentialing requirements for these teachers fall into two areas; that of industrial arts and of vocational T & I.

The third hypothesis assumed no difference between these three groups on total examination scores. Table 16 shows the "F" value for the AOV to be 3.33 which is significant at the .05 level. Consequently, the null hypothesis was rejected indicating that group differences do exist, as shown by the examination.

TABLE 16. ANALYSIS OF VARIANCE TEST OF SIGNIFICANCE OF AUTO MECHANIC TEACHERS BASED ON THE TYPE OF PROGRAM TAUGHT AND THE TOTAL EXAMINATION SCORE EARNED

Source	DF	SS	MS	F	P
Total	100	9157.49			
Treatment	2	583.04	291.52	3.33	.05
Residual	98	8574.45	87.49		

The significant difference shown in Table 16 was found between groups of teachers at the secondary and post-secondary level. Table 17 shows very little difference in the means for the groups of industrial arts and vocational teachers at the secondary level while the mean for the post-secondary group is significantly higher.

TABLE 17. GROUP DIFFERENCES BETWEEN TEACHERS CATEGORIZED AS TO THE TYPE AND LEVEL OF PROGRAM TAUGHT

Measures	Groups		
	Secondary		Post-Sec.
	Ind. Arts	Vocational	Vocational
Mean	68.09	69.72	74.34
Variance	191.90	74.74	31.52
Sample Size	22	50	29

To test the fourth hypothesis, a one-way AOV was used involving the total examination score and the length of time that members of the auto technician group had been working in the auto mechanic trade. This hypothesis proposes no difference in total examination scores earned by auto technicians with varying lengths of trade experience. Three levels of trade experience were used although there were no participants in the lowest level which included those with less than three years of experience. As a result, only the two categories of three to five years and more than five years could actually be considered. Table 18 shows the AOV with an "F" value of .44 which was not significant. This test indicated that there was no difference of total examination scores between the two levels of trade experience.

TABLE 18. ANALYSIS OF VARIANCE TEST OF SIGNIFICANCE OF AUTO TECHNICIANS BASED ON THE LENGTH OF TRADE EXPERIENCE IN YEARS AND TOTAL EXAMINATION SCORE EARNED

Source	DF	SS	MS	F	P
Total	21	2104.95			
Treatment	1	45.34	45.34	.44	--
Residual	20	2059.61	102.98		

As a result of the outcome indicating that there was no difference between the levels of trade experience, the null hypothesis of no difference is tenable and cannot be rejected. An outcome of this nature would indicate that an auto technician does not significantly

improve his technical knowledge of the automobile by remaining in the trade for more than five years.

A two-way AOV with an "F" test of significance was used to test the difference in total examination scores earned by participants in the vocational auto mechanic teacher and the auto technician groups. The fifth hypothesis postulated that there was no difference in total examination scores earned by participants in these two groups and categorized as to their length of service at their jobs. Participants were categorized into four levels of experience involving only the teaching experience for the teachers and trade experience for the technicians. Table 19 shows a significant difference at the .05 level was found to exist between the two groups on total scores although no significant difference was found to exist between the two groups as to years of experience. Hence, the null hypothesis must be rejected.

TABLE 19. ANALYSIS OF VARIANCE BETWEEN AUTO TECHNICIANS (BASED ON LENGTH OF TIME WORKING IN THE TRADE) AND VOCATIONAL AUTO MECHANIC TEACHERS (BASED ON YEARS OF TEACHING)

Source	DF	SS	MS	F	P
Groups (A)	1	682.62	682.62	9.69	.05
Experience (B)	3	336.98	112.33	1.59	--
A X B	3	152.64	50.88	.72	--
Within	93	6552.56	70.46		
Total	101	503061.00			

These results support previously mentioned findings of this study which indicate significant differences between groups based on total examination scores. Likewise, the overall scores earned by individuals show a significant degree of correlation with the overall ratings received from supervisors. However, an individual's score does not significantly differ in relation to the length of time spent on the job. A further discussion of these findings along with subsequent conclusions and recommendations will be presented in the following chapter.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to develop and field test a written occupational competency examination for future auto mechanic teachers. To accomplish this purpose, it was necessary to determine what auto technicians, service managers and auto mechanic instructors believed incoming auto mechanic teachers should know to successfully train students to enter the trade. A questionnaire was developed to ascertain the most important areas of auto mechanics so that the examination could be developed around these areas.

The State Directors of T & I and Industrial Arts in Colorado, Wyoming, Utah, Arizona, New Mexico, Oklahoma, Kansas and Nebraska cooperated with the investigator by providing him with the names and addresses of auto mechanic teachers in their respective states. The investigator personally visited all the garages in Pueblo, Colorado Springs, and Canon City, Colorado to secure the names and addresses of auto technicians and service managers willing to participate in this study. Mailing lists were compiled through the use of random samples of individuals from each group of participants for each of the three phases of this study.

Data derived from the 115 item program questionnaire provided the basis for the development of the 116 question trial examination. A job analysis was constructed for each area of repair that was ranked "essential" by the majority of individuals returning completed questionnaires prior to the development of the questions for the trial examination. After the trial examinations were collected and scored an item analysis was computed for each of the 116 questions. In addition, participants who were asked to take the trial examination were also asked to critique each of the questions as to clarity and value. The 88 questions selected to make up the final form of the examination were chosen on the basis of the item analysis and the critique. It was necessary to reword a few of the questions to clarify and make them more meaningful.

Most of the data obtained from the trial and final forms of the examination was punched into cards for computer processing. The investigator was not able to locate a split-half reliability program at either the Southern Colorado State College or the Colorado State University Computer Centers which made it necessary to manually compute this calculation. From the punched card input, analysis of variance, Pearson correlations, and item analysis were made between and within the groups to derive the statistical analysis of the data used in the study.

Conclusions

All conclusions made by the investigator are based on the findings from data used in this study. In analyzing the data it appears that the objectives of this study have been met. First it appears that the examination is actually testing a person's level of competency as indicated by the correlations computed between the total examination score and the individual's overall rating. A significant degree of correlation was found to exist between these two measures of competency. In addition, an AOV computed between industrial arts teachers and vocational teachers showed a significant difference between the two groups on total examination scores. Similarly, certification requirements to teach in an industrial arts of vocational program differ with respect to the degree of trade experience required for employment. The fact that a significant correlation existed between the total examination score and the overall rating makes the examination more useful and effective as an additional screening device for future auto mechanic teachers.

This examination was able to distinguish between groups on total examination scores. An AOV computed between all four groups showed that a significant difference existed between the groups. Also, separate AOV's computed between industrial arts and vocational auto mechanic teachers and vocational teachers and technicians both revealed that significant differences existed between the groups.

As a means of making a cross-check of the correlations computed between total examination scores and overall ratings, an AOV was computed to determine if there was a significant difference between the overall ratings. A significant difference was found to exist between groups on overall ratings, a difference which corresponded favorably to the difference found between groups on the total examination score.

The problem of this research project was to develop and field test a written occupational competency examination. Through the above listed statistical treatment and tests of significance, an expectancy table was developed to aid in the interpretation of examination scores. Measures of central tendency for each group of participants individually and collectively were compiled for prediction purposes. As this examination is administered to additional individuals, the validity of the expectancy tables will increase and become more useful.

Recommendations

The findings of this study indicate that an apparent valid, reliable auto mechanic trade competency examination has been developed and field tested. With accountability acts forcing schools to offer and maintain quality programs, the need for competent trade teachers cannot be overemphasized. The following recommendations are presented as an outgrowth of this investigation.

1. School districts, colleges or State Departments of Vocational Education could administer this examination to

individuals or groups as an aid to present teacher selection or certification practices and/or a means of further refining the instrument.

2. Each sub-test could be developed into separate tests for a more valid examination of individuals in certain specialty areas.
3. Since this examination was developed, much emission control equipment has been added to vehicles. Testing information in this highly important area could be included in the present sub-tests of Fuel Systems or Electrical or a separate sub-test may need to be developed.
4. This examination may be used as a pre- and post-test for auto mechanic training programs, particularly at the post-secondary level.
5. Numerous studies could be undertaken by correlating this examination with other auto mechanic competency examinations available or by administering this examination to other population groups and making correlation studies between them.

Certainly a number of other interesting and informative studies could be designed around this trade competency examination for reasons other than those which have been mentioned. As a means of

achieving a more objective technique for vocational teacher certification, the use of occupational competency examinations should be further explored.

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APPENDICES

APPENDIX A

AUTO MECHANICS QUESTIONNAIRE AND RELATED MATERIALS

The sample documents contained herein are as follows:

Exhibit	Explanation	Page
A-1	Program questionnaire. The Auto Mechanics Program Questionnaire that was sent to auto mechanic teachers	78
A-2	Special questionnaire pages. Those pages from the Auto Mechanics Questionnaire that were sent to participants who were employed in the trade and which differed from pages found on the questionnaire sent to the teachers	92
A-3	Letter of transmittal. The letter accompanying the questionnaire to teachers	94
A-4	Letter of transmittal. The letter accompanying the questionnaire to participants in the trade	95
A-5	Follow-up letter. A copy of the letter sent to all participants who had not responded by the mailing date(s)	96

A-1 Program Questionnaire

AUTO MECHANICS
PROGRAM QUESTIONNAIRE

PART I

Please complete the general information about your school by filling in the blanks with the appropriate information.

Name of school: _____ Town: _____

Number of auto mechanic teachers in your school: full time_____, part time_____.

Total length of your auto mechanics program in hours: 2000, 1080, 540, or 360 (please circle the appropriate one(s).

Average number of students enrolled, per year, in your auto mechanics program over the past 3 years, _____.

PART II

Please respond to this questionnaire with regard to the way your auto shop is presently equipped and your auto mechanics curriculum presently set up. Please respond to each of the operations below by circling the number 4, 3, 2 or 1 which best describes, in your estimation, the extent to which a future teacher in your auto mechanics program would need to be knowledgeable about that particular operation or principle. At the end of each section there are spaces provided for operations which you may feel should be included. Also, please give your estimation of the importance that each item you add would be to a new teacher at your school. Thank you.

Unit I. Engine repair and rebuild.

Sub-heading	Operation or principle	Importance of technical knowledge			
		Essential	Highly desirable	Desirable	Relatively nonessential
A. Head(s)	1. replace head gasket	4	3	2	1
	2. grind valves and seats	4	3	2	1
	3. test for leaks	4	3	2	1
	4. adjust valves	4	3	2	1
	5. replace valve seats and guides				
B. Block	1. valve train	4	3	2	1
	2. rings	4	3	2	1
	3. pistons	4	3	2	1
	4. rods	4	3	2	1
	5. bearings	4	3	2	1
	6. crankshaft	4	3	2	1
	7. oil pump	4	3	2	1
	8. detecting and patching cracks	4	3	2	1
	9. cylinder reboring or sleeving	4	3	2	1
C. Accessories	1. repair radiator	4	3	2	1
	2. cooling system	4	3	2	1
	3. exhaust system	4	3	2	1
	4. lubricating system	4	3	2	1

Unit 1 (Continued)

Sub-heading	Operation or principle	Importance of technical knowledge			
		Essential	Highly desirable	Desirable	Relatively nonessential
D. Diagnosis	of malfunctions of the above listed parts or systems	4	3	2	1
E. Other	1. _____				
	_____	4	3	2	1
	2. _____				
	_____	4	3	2	1
	3. _____				
	_____	4	3	2	1
	4. _____				
	_____	4	3	2	1

Unit 2. Fuel systems.

A. Carburetor	1. rebuild (1, 2, and 4 barrel)	4	3	2	1
	2. adjustment (external)	4	3	2	1
	3. automatic choke	4	3	2	1
	4. circuits	4	3	2	1
	5. multiple carburetion	4	3	2	1
B. Air cleaners	1. dry type	4	3	2	1
	2. oil bath	4	3	2	1

Unit 2. Fuel systems (continued)

Sub-heading	Operation or principle	Importance of technical knowledge			
		Essential	Highly desirable	Desirable	Relatively nonessential
C. Fuel pump	1. vacuum	4	3	2	1
	2. electric	4	3	2	1
D. Fuel supply	1. tank	4	3	2	1
	2. lines	4	3	2	1
E. Emission control	1. PCV valve	4	3	2	1
	2. rebuild air injection systems	4	3	2	1
	3. rebuild spark control system	4	3	2	1
F. Diagnosis	of malfunctions of the above listed parts and systems	4	3	2	1
G. Other	1. _____ _____	4	3	2	1
	2. _____ _____	4	3	2	1
	3. _____ _____	4	3	2	1
	4. _____ _____	4	3	2	1

Unit 3. Electrical system (including ignition).

Sub-heading	Operation or principle	Importance of technical knowledge			
		Essential	Highly desirable	Desirable	Relatively nonessential
A. Battery	1. function	4	3	2	1
	2. service	4	3	2	1
B. Charging system					
	1. generator or alternator	4	3	2	1
	2. adjustment of regulator	4	3	2	1
	3. polarize system	4	3	2	1
	4. wiring	4	3	2	1
C. Starting system					
	1. starter motor	4	3	2	1
	2. solonoid	4	3	2	1
	3. wiring and cables	4	3	2	1
D. Ignition system					
	1. distributor	4	3	2	1
	2. coil	4	3	2	1
	3. spark plugs	4	3	2	1
	4. wiring (primary and secondary)	4	3	2	1
	5. ignition switch	4	3	2	1
	6. ballast resistor	4	3	2	1

Unit 3. Electrical system (continued)

Sub-heading	Operation or principle	Importance of technical knowledge			
		Essential	Highly desirable	Desirable	Relatively nonessential
E. Convenience and safety systems	1. lighting circuits	4	3	2	1
	2. electric wiper	4	3	2	1
	3. heater-defroster-air conditioner	4	3	2	1
	4. electric seats	4	3	2	1
	5. electric windows	4	3	2	1
	6. gauges and indicator lights	4	3	2	1
	7. overdrive circuits	4	3	2	1
	8. horns	4	3	2	1
F. Diagnosis	of malfunctions of the above listed electrical components and circuits	4	3	2	1
G. Other	1. _____				
	_____	4	3	2	1
	2. _____				
	_____	4	3	2	1
	3. _____				
	_____	4	3	2	1
	4. _____				
	_____	4	3	2	1

Unit 4. Power trains (except automatic transmissions).

Sub-heading	Operation or principle	Importance of technical knowledge			
		Essential	Highly desirable	Desirable	Relatively nonessential
A. Clutches	1. clutch operation	4	3	2	1
	2. throw-out and pilot bearing	4	3	2	1
B. Standard transmissions	1. rebuild, 3 speed	4	3	2	1
	2. rebuild, 4 speed	4	3	2	1
	3. synchronizers	4	3	2	1
	4. overdrive	4	3	2	1
C. Drive line	1. universal joints (conventional and constant velocity)	4	3	2	1
	2. shaft alignment	4	3	2	1
D. Differentials	1. conventional 3rd member	4	3	2	1
	2. limited-slip 3rd member	4	3	2	1
	3. replace axle bearing	4	3	2	1
	4. torque absorption	4	3	2	1
E. Diagnosis	of malfunctions of all the above listed components or principles	4	3	2	1

Unit 4. Power trains (continued).

Sub-heading	Operation or principle	Importance of technical knowledge			
		Essential	Highly Desirable	Desirable	Relatively nonessential
F. Other	1. _____				
	_____	4	3	2	1
	2. _____				
	_____	4	3	2	1
	3. _____				
	_____	4	3	2	1
	4. _____				
	_____	4	3	2	1

Unit 5. Automatic transmission.

A. General	1. Planetary gear sets	4	3	2	1
	2. hydraulics	4	3	2	1
	3. torque convertors	4	3	2	1
B. General Motors					
	1. rebuild and adjust the Turbo 400	4	3	2	1
	2. rebuild and adjust the Turbo 300	4	3	2	1
	3. rebuild and adjust the aluminum case Power-glide	4	3	2	1

Unit 5. Automatic transmissions (continued).

Sub-heading	Operation or principle	Importance of technical knowledge			
		Essential	Highly desirable	Desirable	Relatively nonessential
C. Ford	1. rebuild and adjust the C-4	4	3	2	1
	2. rebuild and adjust the C-6	4	3	2	1
D. Chrysler	1. rebuild and adjust the Torque-flight (aluminum case)	4	3	2	1
E. Diagnosis	of malfunctions in the above transmissions or components	4	3	2	1
F. Other	1. _____ _____	4	3	2	1
	2. _____ _____	4	3	2	1
	3. _____ _____	4	3	2	1
	4. _____ _____	4	3	2	1

Unit 6. Brakes, Steering, Suspension (including alignment).

Sub-heading	Operation or principle	Importance of technical knowledge			
		Essential	Highly desirable	Desirable	Relatively nonessential
A. Brakes	1. repair and rebuild brake cylinders including tandem master cylinders	4	3	2	1
	2. turn drums or disc	4	3	2	1
	3. reline shoes	4	3	2	1
	4. contour grind lining	4	3	2	1
	5. bleed brakes	4	3	2	1
	6. adjust service and parking brakes	4	3	2	1
	7. rebuild power assist units	4	3	2	1
	8. installing relined shoes or friction pads	4	3	2	1
B. Steering	1. rebuild conventional steering gear	4	3	2	1
	2. rebuild power steering pump	4	3	2	1
	3. rebuild intregal or coaxial steering gears	4	3	2	1
	4. rebuild "slave cylinder" or linkage-assist power steering units	4	3	2	1
	5. replace idler arm and/or tie rod ends	4	3	2	1

Unit 6. Brakes, Steering, Suspension (continued).

Sub-heading	Operation or principle	Importance of technical knowledge			
		Essential	Highly desirable	Desirable	Relatively nonessential
	6. repair or adjust swing steering columns	4	3	2	1
C. Suspension	1. rebuild front suspension	4	3	2	1
	2. check and adjust camber, caster and toe-in on front and rear suspension where applicable	4	3	2	1
	3. shock absorbers	4	3	2	1
	4. wheel balancing	4	3	2	1
	5. independent rear suspension	4	3	2	1
D. Diagnosis	of malfunctions of the above listed components or adjustments	4	3	2	1
E. Other	1. _____ _____	4	3	2	1
	2. _____ _____	4	3	2	1
	3. _____ _____	4	3	2	1
	4. _____ _____	4	3	2	1

Unit 7. Miscellaneous - convenience and safety.

Sub-heading	Operation or principle	Importance of technical knowledge			
		Essential	Highly desirable	Desirable	Relatively nonessential
A. Vacuum circuits	1. headlight covers	4	3	2	1
	2. trunk locks	4	3	2	1
	3. door locks	4	3	2	1
	4. heater, air conditioning ventilator controls	4	3	2	1
B. Safety	1. diagnostic lane or center	4	3	2	1
	2. state safety inspection	4	3	2	1
	3. brake malfunction indicator	4	3	2	1
	4. "key-in-ignition" buzzer	4	3	2	1
	5. warning flashers	4	3	2	1
C. Convenience	1. air conditioning	4	3	2	1
	2. automatic head light dimmers	4	3	2	1
	3. speed controls and warning devices	4	3	2	1
	4. radio and stereo	4	3	2	1
D. Diagnosis	of malfunctions in the above listed systems of components	4	3	2	1

Unit 7. Miscellaneous (continued).

Sub-heading	Operation or principle	Importance of technical knowledge			
		Essential	Highly desirable	Desirable	Relatively nonessential
E. Other	1. _____				
	_____	4	3	2	1
	2. _____				
	_____	4	3	2	1
	3. _____				
	_____	4	3	2	1
	4. _____				
	_____	4	3	2	1

Part III

In the blanks below please indicate approximately what percentage of your total auto mechanics program time is devoted to instruction in each of the below listed phases.

_____% for engine repair.

_____% for fuel systems.

_____% for electrical systems (including ignition).

_____% for power trains (excluding automatic transmissions).

_____% for automatic transmissions.

_____% for brakes, steering, suspension (including alignment).

_____% for miscellaneous instruction.

PART IV

Please indicate below additions to your auto mechanics curriculum which you hope will be included within the next 5 years. Example: Automotive air-conditioning, alignment rack, brake service center, etc.

Thank you.

A-2 Special Questionnaire Pages

AUTO MECHANICS QUESTIONNAIRE

PART I

Please complete the general information about your place of employment by filling in the blanks with the appropriate information.

Name of employer:_____Town:_____

Number of auto mechanics employed at this location: full time_____ part time_____.

Your title:_____. (Example: Service manager, front endmechanic, etc.)

Number of years you have been involved with auto mechanics:_____.

PART II

Please repond to this questionnaire with regard to the way your shop is equipped and the type of work performed in it. Please evaluate the worth of each item listed below by circling the number 4, 3, 2, 1, which best describes in your estimation, the extent to which a future auto mechanic, in your shop, would need to be knowledgeable about that particular operation or principle. At the end of each section there is space provided for you to add operations which you may feel should be included. Also, please give your estimation of the importance that each item you add would be to a future employee in your shop.
Thank you.

PART III

In the blanks below, please indicate approximately what percentage of the total repair business performed in your shop is in each of the areas described.

_____% for engine repair and rebuild.

_____% for fuel systems.

_____% for electrical systems (including ignition).

_____% for power trains (excluding automatic transmissions).

_____% for automatic transmissions.

_____% for brakes, steering, suspension (including alignment).

_____% for miscellaneous repairs.

PART IV

Please indicate below additional areas of service you feel will be offered by your shop within the next 5 years. Example: Automotive air conditioning, diagnostic lane etc.

_____

_____

_____

_____

_____

_____

_____

Thank you.

A-3 Letter of Transmittal

Dear Mr.

I am in the process of developing a written trade competency examination for future auto mechanic teachers and I am interested in determining what the questions on the examination should include. I would like to solicit a few minutes of your time to help me determine the most important areas of technical knowledge for a future auto mechanics teacher to have. This questionnaire is in no way an evaluation of any auto mechanics program but merely a means of obtaining a list of the needed teacher qualifications in schools of various sizes and locations within Colorado.

Your careful evaluation of the importance of each of the listed operations or principles as well as the addition of any others you may feel important will be appreciated.

I hope you can see your way clear to complete this questionnaire and return it to me in the self addressed, postage paid envelope provided for your convenience. Your prompt response will be most helpful and appreciated so that this research project may move forward on schedule.

Thank you very much for your time and effort.

Sincerely,

William Crain
Graduate Student
Colorado State University

A-4 Letter of Transmittal

Dear Mr.

I am in the process of developing a written trade competency examination for future auto mechanic teachers. I am interested in determining what the questions on the examination should include. I would like to solicit a few minutes of your time to help me determine the most important areas of technical knowledge for a future auto mechanics teacher to have.

I am interested in learning what individuals, like yourself, who are employed in the auto repair business feel an auto mechanics teacher should be knowledgeable about and to what extent. Even though your job may be in a specialized phase of auto repair, I encourage you to respond to as many items in the questionnaire as you feel qualified to answer. This questionnaire is in no way an evaluation of your skills or knowledge but merely a means of determining what knowledge of auto repair is the most essential to an auto mechanics teacher.

Your careful evaluation of the importance of each of the listed operations or principles as well as the addition of any other items you may feel important will be appreciated.

I hope you can see your way clear to complete this questionnaire and return it to me in the self addressed, postage paid envelope provided for your convenience. Your prompt response will be most helpful and appreciated so that this research project may move forward on schedule.

Thank you very much for your time and effort.

Sincerely,

William Crain
Graduate Student
Colorado State University

A-5 Follow-up Letter

Dear Mr.

I am sending you a duplicate copy of the questionnaire I sent out a few weeks ago. As of this mailing, I have not received the original questionnaire by return mail. Perhaps it has been side-tracked for some reason or another.

I would appreciate it very much if you would take a few minutes to complete the enclosed questionnaire and return it in the self-addressed, postage paid envelope provided.

Thank you very much for your help on this research project.

Very truly yours,

William Crain

Enclosure

APPENDIX B

TRIAL FORM OF THE AUTO MECHANICS OCCUPATIONAL COMPETENCY EXAMINATION AND RELATED MATERIALS

The sample documents contained herein are as follows:

Exhibit	Explanation	Page
B-1	Auto Mechanics Trade Competency Examination. The 116 question trial examination sent to all participants	99
B-2	Letter of transmittal. The letter accompanying the examination to auto mechanic teachers	130
B-3	Letter of transmittal. The letter accompanying the examination to technicians	131
B-4	Letter of transmittal. The letter accompanying the examination to service managers	132
B-5	Follow-up post card, side 1. A double post card was used for the three follow-up reminders. The date and the number of weeks elapsed since the examination was mailed changed with each mailing	133
B-6	Follow-up post card, side 2. The reverse side of the double post card used for follow-up reminders	134
B-7	Score reply letter. The letter used to send the participant's score to those who requested to know the results of their effort	135

APPENDIX B

TRIAL FORM OF THE AUTO MECHANICS OCCUPATIONAL COMPETENCY EXAMINATION AND RELATED MATERIALS
(Continued)

Exhibit	Explanation	Page
B-8	Answer key. The correct answers for the 116 questions on the trial form of the examination	136

B-1 Auto Mechanics Trade Competency Examination

AUTO MECHANICS TRADE COMPETENCY EXAMINATION

This examination is comprised of questions covering the repair of 1967 and later automobiles. Each question has four (4) possible responses (a, b, c, d). ONLY ONE response correctly completes the statement or answers the question. Please follow the examples and identify the response you feel is correct by placing a check mark (✓) in the parenthesis beside the response of your choice. You are also asked to critique any question or questions you feel need revised or omitted. Three columns located along the extreme left hand edge of each page are provided for a quick check (✓) critique of each question. If you wish to make additional comments about any question, feel free to write across the critique columns and/or between questions. Please answer all questions on this examination that are clear enough to understand.

EXAMPLES

Critique Columns		
Question not clear	Response not clear	Question not necessary

I. The voltage regulator is placed in the charging circuit to:

( ) a. protect the alternator
( ) b. protect the ignition system.
(✓) c. protect the battery and accessories.
( ) d. regulate the current flow.

II. A sprague assembly is a specific type of a:

(✓) a. over-running clutch.
( ) b. gear set.
( ) c. dog clutch.
( ) d. fluid coupling.

The correct answer to example I above is response "c", whereas the correct answer to example II above is response "a". Remember, the questions are built around standard equipment components found on 1967 and later passenger cars. Remember also to critique any question that you feel needs to be revised or omitted, and that each question has only one (1) correct answer or response. You may proceed on to the rest of the examination.

Critique Columns		
Question not clear	Response not clear	Question not necessary

1. A cracked or leaking cylinder head may be suspected if:
   ( ) a. air bubbles rise to the top of the radiator when the engine is running.
   ( ) b. coolant is found in the crankcase.
   ( ) c. either a or b.
   ( ) d. neither a or b.

2. When rebuilding brake cylinders, they should be honed to:
   ( ) a. the next oversize.
   ( ) b. produce a 45° cross-hatch.
   ( ) c. clean and polish the bore.
   ( ) d. help the new cups break in.

3. An alternator charging system does not use a cut-out relay because:
   ( ) a. of inductive reactance.
   ( ) b. of the function of the diodes.
   ( ) c. there is not a ground in the circuit.
   ( ) d. the field relay takes its place.

4. Torque convertors:
   ( ) a. should be serviced whenever they are removed from the vehicle.
   ( ) b. are not serviceable by the mechanic.
   ( ) c. develop their greatest torque multiplication at high vehicle speeds.
   ( ) d. a and c above.

Critique Columns		
Question not clear	Response not clear	Question not necessary

5. A by-pass fuel filter is designed to:
   ( ) a. decrease fuel volume to the carburetor.
   ( ) b. provide for cool fuel in the engine compartment.
   ( ) c. decrease fuel pump requirements at high speed.
   ( ) d. filter the fuel twice.

6. When installing relined brake shoes on a vehicle, the mechanic should:
   ( ) a. rebuild the wheel cylinders.
   ( ) b. clean and lubricate the wear pads on the backing plate.
   ( ) c. install the primary shoe towards the front of the vehicle.
   ( ) d. a, b and c above.

7. A conductor is:
   ( ) a. made of glass.
   ( ) b. a material that transmits electricity.
   ( ) c. a high resistance material.
   ( ) d. a safety device.

8. When checking crankshaft end play:
   ( ) a. use a dial indicator.
   ( ) b. use "plastigage".
   ( ) c. use an outside micrometer.
   ( ) d. either b or c above.

Critique Columns		
Question not clear	Response not clear	Question not necessary

9. The device mounted on the carburetor air horn has three jobs, to:
( ) a. filter fuel, silence intake air noise, and arrest flames.
( ) b. filter air, reduce air pollution, and silence intake air noise.
( ) c. filter air, silence intake air noise, and arrest flames.
( ) d. filter fuel and air, and silence intake air noise.

10. Essentially all light circuits containing more than 1 bulb are wired:
( ) a. in series to ground.
( ) b. together and then to ground.
( ) c. in parallel to ground.
( ) d. in polarity.

11. Excessive valve stem to rocker arm clearance may lead to possible:
( ) a. valve breakage.
( ) b. valve noise.
( ) c. valve burning.
( ) d. both a and b above.

12. A grinding or squealing noise when the clutch pedal is partially depressed (transmission in neutral) may be caused by the:
( ) a. pilot bearing.
( ) b. release bearing.
( ) c. front transmission bearing.
( ) d. engine thrust bearing.

Critique Columns		
Question not clear	Response not clear	Question not necessary

13. A vibration most noticeable between 50 and 70 mph. could be caused by:
( ) a. excessive caster.
( ) b. excessive camber.
( ) c. a wheel(s) out of balance.
( ) d. weak shocks.

14. All electrical tools should be:
( ) a. oiled regularly.
( ) b. operated on 115 AC.
( ) c. grounded.
( ) d. reversable.

15. When a battery uses an excessive amount of water, the probable cause is the:
( ) a. battery is sulfated.
( ) b. battery is run down.
( ) c. battery is being over charged.
( ) d. battery is being under charged.

16. When taking a cylinder leakage test, the maximum amount of leakage should be:
( ) a. 0%
( ) b. 10% or less.
( ) c. 20% or less.
( ) d. 30% or less.

17. Tie rod ends are supplied with:
( ) a. zerks or oil cups.
( ) b. internal or external threads.
( ) c. right or left hand threads.
( ) d. tapered and straight shanks.

Critique Columns		
Question not clear	Response not clear	Question not necessary

18. The purpose of an economizer valve is to supply:

( ) a. more fuel during a load condition.
( ) b. less fuel during a load condition.
( ) c. fuel at idle.
( ) d. fuel on deacceleration.

19. When disconnecting a battery, which cable should always be disconnected first and reconnected last?

( ) a. It does not matter.
( ) b. The cable to the insulated side of the circuit.
( ) c. The ground cable.
( ) d. The shortest cable.

20. One essential tool, or piece of equipment needed to remove a rear wheel bearing from an axle shaft is a:

( ) a. hack saw.
( ) b. press.
( ) c. torque wrench.
( ) d. impact wrench.

21. If an engine is noisy with a regular, single clicking sound when idling, you would adjust the:

( ) a. connecting rods.
( ) b. valve clearance.
( ) c. ignition timing.
( ) d. spark plugs.

Critique Columns		
Question not clear	Response not clear	Question not necessary

22. In order to establish the neutral or "no-light" position for the pressure differential switch, the mechanic should repair the system damage:

( ) a. bleed the damaged system and then open a bleed screw in the other system and carefully depress the brake pedal until the indicator light goes off.

( ) b. bleed the damaged system and the indicator light will turn off automatically.

( ) c. unscrew the electrical contact several turns, bleed the damaged system, open a bleed screw in the other system and carefully depress the brake pedal until the plunger centers itself and then tighten up the electrical contact.

( ) d. either a or c depending on the style of switch used.

23. During normal part throttle operation, the fuel supply to the engine is metered by the:

( ) a. off idle ports.

( ) b. main metering jets.

( ) c. the power valve.

( ) d. needle valve.

24. Disc brake friction pads come in:

( ) a. oversize only.

( ) b. undersize only.

( ) c. standard size only.

( ) d. primary and secondary lining.

Critique Columns		
Question not clear	Response not clear	Question not necessary

25. A rod bearing knock will show up as a:

( ) a. light metallic double knock.
( ) b. chatter or rattling noise.
( ) c. dull, heavy metallic knock.
( ) d. light knock or pound with the engine at a floating or steady speed.

26. During high-speed operation, when the throttle is wide open, the fuel supplied to the engine is discharged through the:

( ) a. idle port.
( ) b. low speed port.
( ) c. main nozzle.
( ) d. throttle valve.

27. The Ford C-4 compared to the Ford C-6 automatic transmission has:

( ) a. fewer bands and clutch packs.
( ) b. the same number of each.
( ) c. more bands and less clutch packs.
( ) d. one additional sprague.

28. Drive shaft alignment should be checked when the driver complains of:

( ) a. a vibration in relation to vehicle speed.
( ) b. right rear tire wear.
( ) c. short universal joint life.
( ) d. a and c above.

Critique Columns		
Question not clear	Response not clear	Question not necessary

29. As the battery runs down, or discharges, the specific gravity of the electrolyte:
( ) a. goes up.
( ) b. goes down.
( ) c. remains relatively unchanged.
( ) d. is not directly related.

30. With the Bendix self-energizing brake system, the:
( ) a. braking occurs equally on both shoes.
( ) b. primary shoe energizes secondary shoe.
( ) c. shoes are anchored at the bottom.
( ) d. secondary shoe is energized first.

31. A piston that has the lower end of the skirt smaller than the top of the skirt is said to be:
( ) a. normal.
( ) b. collapsed.
( ) c. cam ground.
( ) d. heavy duty.

32. It is dangerous to use a file:
( ) a. unless it is double-cut.
( ) b. without a handle.
( ) c. unless it is single-cut.
( ) d. unless it is half-round.

33. Air in the hydraulic system causes:
( ) a. a sticking master cylinder.
( ) b. a sticking wheel cylinder.
( ) c. a spongy primary shoe.
( ) d. a spongy brake pedal.

Critique Columns		
Question not clear	Response not clear	Question not necessary

34. The ballast resistor found in the ignition system of a 12 V vehicle is:

( ) a. heat sensitive.
( ) b. by-passed when the engine is being cranked.
( ) c. used to increase the life of the points.
( ) d. a, b, and c above.

35. When idling, all the fuel burned by the engine passes:

( ) a. through the idle circuit(s).
( ) b. the idle-speed set-screw.
( ) c. through the venturi.
( ) d. the high idle cam.

36. A stuck governor valve can prevent a transmission from:

( ) a. up shifting.
( ) b. down shifting.
( ) c. going into reverse.
( ) d. a and b above.

37. If the engine fails to crank and the battery and connections are good, the next item to check for would be a:

( ) a. defective starter switch or switch circuit.
( ) b. bent starter shaft.
( ) c. loose bushing.
( ) d. grounded field.

38. The parts of a carburetor that control fuel delivery, thus maintaining the proper fuel level in the reservoir include the:

( ) a. inlet and outlet valves.
( ) b. fuel nozzle and venturi.
( ) c. float and float valve.
( ) d. accelerator pump and choke.

Critique Columns		
Question not clear	Response not clear	Question not necessary

39. The pitman shaft is:
( ) a. not matched to the worm and therefore sold separately.
( ) b. adjusted by means of a screw protruding through the cover plate.
( ) c. splined to the pitman arm.
( ) d. a, b, and c above.

40. A grounded circuit most often identifies:
( ) a. an unintentional grounding of a circuit before it reaches the "load".
( ) b. a circuit involving a poor ground.
( ) c. a broken wire.
( ) d. one close to the battery.

41. A solid knock that is heard under a very heavy engine load may be caused by a:
( ) a. loose main bearing.
( ) b. loose rod bearing.
( ) c. loose wrist pin.
( ) d. piston slap.

42. The carburetor power circuit may be operated mechanically or by:
( ) a. a metering rod.
( ) b. intake-manifold vacuum.
( ) c. a linkage to the throttle.
( ) d. a spring.

43. The "split" hydraulic brake system is:
( ) a. primary and secondary braking.
( ) b. two separate braking systems.
( ) c. two-shoe application.
( ) d. vacuum over hydraulic.

Critique Columns		
Question not clear	Response not clear	Question not necessary

44. Controls for the stator pitch are electrically operated in:
( ) a. the torque-flight.
( ) b. some turbo hydra-matics.
( ) c. the power-glide.
( ) d. the Ford C-6.

45. Differential backlash is adjusted by moving the:
( ) a. pinion gear.
( ) b. carrier side bearings.
( ) c. axle gears.
( ) d. bearing caps.

46. A growler is used to locate shorts in the:
( ) a. field coil.
( ) b. armature.
( ) c. brush ring.
( ) d. solenoid.

47. The accelerating pump is designed to:
( ) a. overcome the lag in fuel response.
( ) b. increase fuel mileage.
( ) c. balance air/fuel ratio.
( ) d. increase air flow.

48. Generally speaking, a brake drum for passenger car use should not have its inside diameter turned or enlarged more than:
( ) a. .040".
( ) b. .050".
( ) c. .060".
( ) d. .070".

Critique Columns		
Question not clear	Response not clear	Question not necessary

49. Adding plate area to a battery cell increases:
( ) a. voltage.
( ) b. current availability or storage capacity.
( ) c. cell resistance.
( ) d. electrolyte capacity.

50. Maintenance of a typical exhaust system includes:
( ) a. replacement of broken or deteriorated components.
( ) b. servicing the heat riser valve.
( ) c. adjusting back pressure.
( ) d. a and b above.

51. The spark control valve found in many emission control systems:
( ) a. cannot be adjusted.
( ) b. can be adjusted.
( ) c. can be rebuilt.
( ) d. should be replaced every 10,000 miles.

52. In addition to being tilted inward or outward from the center of the car, the top of the steering axis may also be tilted forward or backward from the verticle (tilted toward or away from the driver). Backward tilting from the verticle is called:
( ) a. positive caster.
( ) b. positive camber.
( ) c. negative caster.
( ) d. negative camber.

Critique Columns		
Question not clear	Response not clear	Question not necessary

53. Switches are usually connected in:
( ) a. series with the load.
( ) b. parallel to the load.
( ) c. across the circuit.
( ) d. none of the above.

54. If any two of the three members of a planetary gear set are locked together, the unit will be in:
( ) a. overdrive.
( ) b. free wheeling.
( ) c. direct drive.
( ) d. reverse.

55. The purpose of a torque wrench is to:
( ) a. measure bolt size.
( ) b. loosen tight bolts.
( ) c. test strength of bolts and nuts.
( ) d. tighten bolts and nuts evenly.

56. To correct a heavy heel contact on the drive side, the:
( ) a. ring gear is moved toward the pinion.
( ) b. pinion gear is moved away from the ring gear center line.
( ) c. ring gear is moved away from the pinion.
( ) d. pinion gear is moved closer to the ring gear center line.

Critique Columns		
Question not clear	Response not clear	Question not necessary

57. When the exhaust valve on #5 cylinder has just closed on an inline, six-cylinder engine, which of the cylinders have just fired?

( ) a. #2
( ) b. #6
( ) c. #1
( ) d. #4

58. An American made V-8 engine with the firing order of 1 2 7 8 4 5 6 3 may be timed, with the use of a timing light and the original timing marks, on either:

( ) a. number 1 or 3 cylinder.
( ) b. number 1 or 4 cylinder.
( ) c. number 1 or 5 cylinder.
( ) d. number 1 or 8 cylinder.

59. An intermittent or no assist problem encountered with a power steering unit may be traced to:

( ) a. an improperly aligned front end.
( ) b. a low fluid level.
( ) c. a rough running engine.
( ) d. none of the above reasons.

60. Which is <u>not</u> a possible cause for a sticking valve:

( ) a. burned valve.
( ) b. cocked valve spring.
( ) c. bent valve stem.
( ) d. carbon deposits.

Critique Columns		
Question not clear	Response not clear	Question not necessary

61. The unloader adjustment is made to:

( ) a. open the choke valve for additional air during flooded starts.
( ) b. calibrate the choke valve opening as the engine warms up.
( ) c. vent the fuel bowl at curb idle.
( ) d. vent the air horn.

62. A battery with a specific gravity of 1.280 can be considered:

( ) a. fully charged.
( ) b. three fourths charged.
( ) c. half charged.
( ) d. discharged.

63. A hollow, muffled, bell-like sound when the engine is cold would most likely be:

( ) a. loose rod bearings.
( ) b. loose main bearings.
( ) c. piston slap.
( ) d. loose generator.

64. Hard engine starting when cold could be caused by:

( ) a. a defective power valve.
( ) b. a weak bi-metal choke housing spring.
( ) c. fuel level too high.
( ) d. any of the above.

65. Crankcase dilution may be caused by:

( ) a. lean mixture
( ) b. unburned gasoline.
( ) c. detonation.
( ) d. pre-ignition.

Critique Columns		
Question not clear	Response not clear	Question not necessary

66. When assembling a valve body, you should use:
( ) a. transmission fluid.
( ) b. a heavy grease.
( ) c. an engine oil.
( ) d. cleaning solvent.

67. The carburetor atmospheric vent is open under:
( ) a. a load position.
( ) b. a high speed position.
( ) c. an idle position.
( ) d. both a and b.

68. "Bleeding" of the hydraulic brake system is an essential procedure in order to provide:
( ) a. compressible bubbles.
( ) b. a solid column of non-compressible fluid.
( ) c. a free-flowing liquid.
( ) d. a backstop.

69. Valve guide to stem clearance is checked with a:
( ) a. dial indicator.
( ) b. feeler gauge.
( ) c. outside micrometer.
( ) d. plastigage.

70. The voltage regulator operates to prevent excessive generator output or voltage by inserting resistance into the:
( ) a. generator charging circuit.
( ) b. battery main circuit.
( ) c. generator ground circuit.
( ) d. generator field circuit.

Critique Columns		
Question not clear	Response not clear	Question not necessary

71. The idle air by-pass system is designed to:

( ) a. control the volume of air into the venturi.
( ) b. eliminate a slight throttle opening at idle.
( ) c. eliminate hot engine hard starting.
( ) d. eliminate idle stall on A/C equipped cars.

72. Valve springs should be replaced if they are deformed in any way, or if they deviate from the specified tension by more than:

( ) a. 15%.
( ) b. 10%.
( ) c. 20%.
( ) d. 5%.

73. In a Turbo-400, a no drive condition in any forward range could possibly be caused by a defective:

( ) a. modulator.
( ) b. forward clutch.
( ) c. intermediate clutch.
( ) d. detent solenoid.

74. Engine overheating would <u>not</u> be caused by:

( ) a. a loose fan belt.
( ) b. insufficient coolant.
( ) c. a restricted heater hose.
( ) d. a defective thermostat.

Critique Columns		
Question not clear	Response not clear	Question not necessary

75. The type of front suspension design that normally wears out the lower ball joint first is one that:

( ) a. has the spring between the frame and the lower control arm.
( ) b. has the spring above the upper control arm.
( ) c. uses a torsion bar.
( ) d. either a or c.

76. An insufficient number of oscillations in the intermediate section of a scope pattern would indicate:

( ) a. burned contact points.
( ) b. high resistance in the coil secondary wire.
( ) c. a defective coil or condenser.
( ) d. excessive coil out-put.

77. Excessive clearance between the oil pump body and gears could result in a:

( ) a. sticking oil by-pass valve.
( ) b. overheating oil pump.
( ) c. drop in oil pressure.
( ) d. noise.

78. Constant velocity universal joints found on passenger cars are:

( ) a. a single joint.
( ) b. not repairable.
( ) c. a double cross and roller joint.
( ) d. used to provide flexing in two directions without a loss of speed.

Critique Columns		
Question not clear	Response not clear	Question not necessary

79. The aluminum case Powerglide transmission incorporates:

( ) a. a front and rear oil pump.
( ) b. 2 clutch packs and 2 bands.
( ) c. 2 clutch packs and 1 band.
( ) d. an electrically controlled stator.

80. If the engine will not turn over when starting is attempted, turn on the lights and again attempt to start; if the lights dim or go out the problem is likely to be:

( ) a. that the battery is dead or defective.
( ) b. the ignition system is defective.
( ) c. that the rings are worn.
( ) d. a short in the cranking system.

81. A piston ring with a notch cut around the inside should be placed with the notch:

( ) a. up.
( ) b. down.
( ) c. either way.
( ) d. up on V-8's and down on all others.

82. Idler arms:

( ) a. swing on a thread, a bushing or a bearing.
( ) b. when loose, effect the camber and caster settings.
( ) c. swing on a ball and socket.
( ) d. are attached to the lower control arms.

Critique Columns		
Question not clear	Response not clear	Question not necessary

83. The top piston ring and its' groove wears the fastest because:

( ) a. very little oil reaches it.
( ) b. of hot gases and combustion pressure.
( ) c. foreign material in the air lodges in this area.
( ) d. a and c above.

84. A low reading on a fuel pump volume test could indicate:

( ) a. a clogged fuel filter.
( ) b. a defective fuel pump.
( ) c. restriction at the fuel pick-up in the tank.
( ) d. any of the above.

85. In a conventional distributor, the centrifugal advance moves the:

( ) a. breaker plate opposite shaft rotation.
( ) b. cam lobes opposite shaft rotation.
( ) c. breaker plate ahead in the direction of shaft rotation.
( ) d. cam lobes ahead in the direction of shaft rotation.

86. Which of the following is <u>not</u> a part of the choke circuit?

( ) a. piston.
( ) b. thermostat spring.
( ) c. off-set air valve.
( ) d. metering rod.

Critique Columns		
Question not clear	Response not clear	Question not necessary

87. Brake shoes should not be relined, or reused, if they:
( ) a. have bonded lining on them.
( ) b. show any signs of wear or distortion.
( ) c. have been used for more than 2 years or 24,000 miles.
( ) d. have been drilled for riveted lining.

88. In threading a hole, the proper tool to use is a:
( ) a. tap.
( ) b. reamer.
( ) c. bit.
( ) d. die.

89. During an overhaul, after the pistons have been removed from the engine, the mechanic should:
( ) a. remove the old rings and inspect for groove wear.
( ) b. remove the ridge from the top of the cylinder.
( ) c. mark each piston and/or rod in the order they came out of the engine.
( ) d. do both a and b above.

90. When adjusting multiple carburetors equipped with solid linkage, care must be taken to assure all carburetors:
( ) a. have a separate fuel supply pump.
( ) b. have automatic chokes.
( ) c. reach the idle and full throttle positions simultaneously.
( ) d. a, b, and c above.

Critique Columns		
Question not clear	Response not clear	Question not necessary

91. One high firing line on the scope could indicate:
( ) a. a corroded spark plug wire tower in the distributor cap.
( ) b. excessive resistance in a spark plug wire.
( ) c. excessive gap in a spark plug.
( ) d. any of the above.

92. New brake lining should be contour ground before installation to:
( ) a. prevent brake fade.
( ) b. assure the brake drum will fit over the new shoes.
( ) c. match the curvature of the lining with that of the drum.
( ) d. b and c above.

93. An increase in compression when oil is put into a cylinder indicates:
( ) a. loose wrist pin.
( ) b. bent rod.
( ) c. worn rings.
( ) d. blown head gasket.

94. Electrically operated fuel gauges are of two types:
( ) a. balancing coil and hydrostatic.
( ) b. bimetal-thermostat and hydrostatic.
( ) c. balancing coil and bimetal-thermostat.
( ) d. induction and hydrostatic.

Critique Columns		
Question not clear	Response not clear	Question not necessary

95. A shock absorber should be considered defective if:

( ) a. the vehicle bounces over once before stabilizing.

( ) b. when stroking a shock absorber a lag is felt when changing directions.

( ) c. leakage around the seal is noticeable.

( ) d. any of the above symptoms are present.

96. The valves should be removed from an automatic transmission valve body:

( ) a. anytime it is removed from the transmission.

( ) b. when sticking valves are suspected.

( ) c. when there are metal cuttings in the transmission oil pan.

( ) d. both b and c.

97. A faulty PCV valve will:

( ) a. effect idle stability.

( ) b. increase rpm's.

( ) c. decrease rpm's.

( ) d. effect exhaust control valve action.

98. A cold running engine indicates a possible:

( ) a. over filled radiator.

( ) b. incorrect ignition timing.

( ) c. fan belt too tight.

( ) d. open thermostat.

Critique Columns		
Question not clear	Response not clear	Question not necessary

99. The decimal equivalent of 3/8 of an inch is:

( ) a. .421.
( ) b. .375.
( ) c. .4375.
( ) d. .453.

100. The fast idle cam is rotated by linkage connected to the:

( ) a. throttle
( ) b. idle adjustment screw.
( ) c. choke shaft or valve.
( ) d. dash pot.

101. When an electric wiper is shut off, but the blades do not return to the "park" position, the:

( ) a. blade adjustment should be checked.
( ) b. the blades should be replaced.
( ) c. the park circuit should be checked.
( ) d. a and c above.

102. The last alignment angle to be set is:

( ) a. caster.
( ) b. camber.
( ) c. toe-in.
( ) d. does not matter.

Critique Columns		
Question not clear	Response not clear	Question not necessary

103. To keep cylinder bore distortion and leakage to a minimum when installing a head:
( ) a. use the correct gasket sealing compound.
( ) b. torque the head bolts to the proper tension and in the proper order.
( ) c. break the engine in with cold water running through the radiator and cooling system.
( ) d. mix oil in the fuel to provide extra lubrication for the rings.

104. If gears clash when shifting, it may mean that the:
( ) a. gears are too tight.
( ) b. gears are too loose.
( ) c. clutch is not completely releasing.
( ) d. clutch is slipping.

105. Applying a pressure of 100 psi on a piston of 2 sq. in. total area will result in a force of:
( ) a. 50 pounds.
( ) b. 100 pounds.
( ) c. 200 pounds.
( ) d. 98 pounds.

106. If the polarity is reversed on a vehicle equipped with an alternator:
( ) a. the rectifier diodes may be changed.
( ) b. the engine won't start.
( ) c. the engine "kicks back."
( ) d. the engine stalls at high speed.

Critique Columns		
Question not clear	Response not clear	Question not necessary

107. Brake pedal pulsation largely occurs from:

( ) a. out-of-round drums.
( ) b. bell mouthed drums.
( ) c. scored drums.
( ) d. heat checked drums.

108. When a shift involving a synchronizer causes clashing of gears, the mechanic should:

( ) a. check the clutch adjustment
( ) b. check the cluster or counter gear.
( ) c. check the blocker rings.
( ) d. a and c above.

109. A rocker arm shaft should be installed with the oil holes facing:

( ) a. up.
( ) b. down.
( ) c. sideways.
( ) d. any of the above.

110. Excessive wear on the inside of the tire could indicate too much:

( ) a. negative camber.
( ) b. negative caster.
( ) c. positive caster.
( ) d. positive camber.

111. A limited slip differential differs from a conventional differential in that it:

( ) a. contains a "clutch pack" or "sliding wedge".
( ) b. contains two pinion shaft bearings.
( ) c. requires two axle gears.
( ) d. a and b above.

Critique Columns		
Question not clear	Response not clear	Question not necessary

112. When cleaning or rebuilding a carburetor, the mechanic should:

( ) a. use new gaskets.
( ) b. clean all metal parts thoroughly.
( ) c. compare all adjustments to specifications and correct if necessary.
( ) d. a, b and c above.

113. The Turbo-350 transmission differs from a Turbo-400 in that it uses:

( ) a. 3 clutch packs and 1 band opposed to 3 clutch packs and 2 bands in the Turbo-400.
( ) b. 4 clutch packs and no bands opposed to 3 clutch packs and 1 band in the Turbo-400.
( ) c. a front and a rear oil pump opposed to only a rear oil pump in the Turbo-400.
( ) d. only a front oil pump opposed to a front and rear oil pump in a Turbo-400.

114. Low engine oil pressure is often a warning of a:

( ) a. worn oil pump.
( ) b. worn bearings.
( ) c. clogged oil screen.
( ) d. any of the above.

Critique Columns		
Question not clear	Response not clear	Question not necessary

115. A standard three speed transmission with a grinding noise in first and second, but not in high could indicate:

( ) a. a defective front transmission bearing.
( ) b. a defective counter (cluster) gear bearing.
( ) c. a defective in-put to output shaft bearing.
( ) d. any one of the above could cause the problem.

116. When a "riveted in" ball joint must be replaced, it is necessary to:

( ) a. cut the rivets and bolt the replacement joint in place.
( ) b. replace the entire control arm with a new arm and joint.
( ) c. cut the rivets and weld the replacement joint in place.
( ) d. either a or b is recommended.

Do you feel that this examination will distinguish between an individual with at least five years of trade experience and one lacking such experience:

( ) yes.
( ) not sure.
( ) no.
( ) other comments: _____

_____

If you would like to have your score sent to you, please provide the following information. (please print)

Name: _____

Address: _____

City: _____

State: _____

Zip Code: _____

B-2 Letter of Transmittal

Dear Mr.

I am in the process of developing an auto mechanic trade competency examination which may possibly be used in the future as an aid in screening of new auto mechanic teacher applicants. Enclosed is a copy of the examination based on suggestions from service managers, auto mechanics and auto mechanic teachers. I would appreciate it very much if you would take this examination and critique the questions. This critique is necessary so that when I revise the examination in the next few weeks I can either rewrite or omit all unclear or unnecessary questions. You need not put your name on the examination unless you desire to do so.

For your convenience, there are three critique columns along the left hand edge of each page. A check mark (✓) in the appropriate critique column to the left of each question indicating why it needs revised or dropped along with a check mark (✓) in the parenthesis beside the response of your choice is all that is needed. If you feel that a question is good and does not need revised, leave all three critique columns blank but remember to mark the correct answer to that question with a (✓) in the appropriate parenthesis. On the other hand if you want to make additional comments do so by writing your comments across all the critique columns and/or between the questions. Please answer all the questions that are clear enough to understand.

A stamped, self addressed envelope is enclosed for your convenience in returning the examination. I want to thank you for your help in this project.

Sincerely,

William Crain
(Acting) Head, Auto Mechanics Dept.
Southern Colo. State College

B-3 Letter of Transmittal

Dear Mr.

Some time ago I contacted you and/or your service manager concerning an auto mechanics trade competency examination that I am developing for possible future use in screening auto mechanic teacher applicants. Enclosed is a copy of the examination based on suggestions from service managers, auto mechanics and auto mechanic teachers. I would appreciate it very much if you would take this examination and critique the questions. This critique is necessary so that when I revise the examination in the next few weeks I can either rewrite or omit all unclear or unnecessary questions. You need not put your name on the examination unless you desire to know your score. If you want to know the number of answers you marked right or wrong I will be happy to send you this information if you will supply your name and address in the space provided on the last page of the examination. Your score will be compiled only for your information and will not be used in any other way.

For your convenience, there are three critique columns along the left hand edge of each page. A check mark (✓) in the appropriate critique column to the left of each question indicating why you feel it needs revised or dropped along with a check mark (✓) in the parenthesis beside the response of your choice is all that is needed. If you feel that a question is good and does not need revised, leave all three critique columns blank but remember to mark the correct answer to that question with a (✓) in the appropriate parenthesis. On the other hand, if you want to make additional comments do so by writing your comments across all the critique columns and/or between the questions.

A stamped, self addressed envelope is enclosed for your convenience in returning the examination. I want to thank you for your help in this project.

Sincerely,

William Crain
(Acting) Head, Auto Mechanic Dept.
Southern Colorado State College

B-4 Letter of Transmittal

Dear Mr.

Some time ago I contacted you and asked for your help in validating an auto mechanics trade competency examination I am developing. As you may remember I am primarily developing this examination to be used as an aid in screening future auto mechanic teacher applicants. Enclosed is a copy of the examination based on suggestions from service managers, auto mechanics and auto mechanic teachers. I would appreciate it very much if you would review this examination and comment as to its worth. I have endeavored to cover the most important areas of the vehicle as identified by those service managers, mechanics and teachers. The questions are intended to differentiate between a person with auto mechanic experience and one who has merely "tinkered around with" or read about the trade.

For your convenience, there are three critique columns along the left hand edge of each page. A check mark (✓) in the appropriate critique column adjacent to the question you feel needs revised or omitted is all that is necessary. If you feel that a question is good and does not need revised, leave all three columns blank. On the other hand, if you want to make additional comments do so by writing your comments across all the critique columns and/or between the questions. You need not answer the questions, i.e. take the examination or put your name on it unless you want.

A stamped, self addressed envelope is enclosed for your convenience in returning the examination. I want to thank you for your help in this project.

Sincerely,

William Crain
(Acting) Head, Auto Mechanics Dept.
Southern Colorado State College

B-5 Follow-up Post Card, Side 1

April 22, 1971

Dear Fellow Worker:

Approximately four weeks ago I sent you a copy of an auto mechanics trade competency examination that I am developing. I ask that you take the examination and comment or critique all the questions which you felt were not clear or necessary. As of now, I have not received your copy of the examination. I would appreciate your returning of the attached post card indicating the status of your participation in this study.

Sincerely,

William Crain

Bill Crain

R. R. 3 Box 83

Pueblo, Colorado 81004

B-6 Follow-up Post Card, Side 2

Name:_____

Address:_____ Zip Code:_____

- ☐ I will participate in the study but I need more time to complete the examination.
- ☐ I have already completed the examination and it is currently in the mail.
- ☐ I have misplaced the examination. Please forward me an additional copy.
- ☐ Other:_____

Participant's name

and address.

B-7 Score Reply Letter

Dear Mr.

I have scored your returned competency examination and have come up with a total of _____ correct answers out of 116 possible, according to the answers I believe to be correct. All questions which were either left blank or marked with what I believe to be an incorrect answer were counted as incorrect.

Your comments and/or critique marks will help me to refine or clearify those questions and answers which were not clear and hard for many to understand.

The help you have given this research project is greatly appreciated. Thank you.

Sincerely,

B-8 Answer Key

Question	Key	Question	Key	Question	Key	Question	Key	Question	Key
1	C	29	B	57	A	85	D	113	A
2	C	30	B	58	B	86	D	114	D
3	B	31	B	59	B	87	B	115	D
4	B	32	B	60	A	88	A	116	D
5	B	33	D	61	A	89	A		
6	D	34	D	62	A	90	C		
7	B	35	A	63	C	91	D		
8	A	36	D	64	B	92	D		
9	C	37	A	65	B	93	C		
10	C	38	C	66	A	94	C		
11	D	39	D	67	C	95	D		
12	B	40	A	68	B	96	D		
13	C	41	A	69	A	97	A		
14	C	42	B	70	D	98	D		
15	C	43	B	71	D	99	B		
16	C	44	B	72	B	100	C		
17	C	45	B	73	B	101	D		
18	A	46	B	74	C	102	C		
19	C	47	A	75	D	103	B		
20	B	48	C	76	C	104	C		
21	B	49	B	77	C	105	C		
22	D	50	D	78	C	106	A		
23	B	51	B	79	C	107	A		
24	C	52	A	80	A	108	D		
25	D	53	A	81	A	109	B		
26	C	54	C	82	A	110	A		
27	C	55	D	83	D	111	A		
28	D	56	D	84	D	112	D		

APPENDIX C

FINAL FORM OF THE AUTO MECHANICS OCCUPATIONAL COMPETENCY EXAMINATION AND RELATED MATERIALS

The sample documents contained herein are as follows:

Exhibit	Explanation	Page
C-1	Auto Mechanics Trade Competency Examination. The 88 question final examination sent to all participants	140
C-2	Score request page. Page attached to all examinations except those sent to post-secondary students	155
C-3	Letter of transmittal. The letter accompanying the examination to all participants and supervisors, except for group mailings to post-secondary students	156
C-4	Personal Data Section. The personal data sheet that accompanied all examinations sent to technicians and post-secondary students	158
C-5	Teachers Personal Data Section. The personal data sheet that accompanied all examinations sent to industrial arts and vocational teachers	159
C-6	Confidential Rating Form. The rating form sent to the immediate supervisor for each technician and student that received a copy of the examination	161
C-7	Auto Mechanic Teacher Confidential Rating Form. The rating form sent to the immediate supervisor for each teacher that received a copy of the examination	163

APPENDIX C (Continued)

Exhibit	Explanation	Page
C-8	Confidential Code Break Down. The code break-down sheet which accompanied the rating form(s) sent to each supervisor so they would know which employee the form(s) were designated for	165
C-9	Letter of request. The request and follow-up letter sent to a random sample of post-secondary schools requesting student participation in this study	166
C-10	School reply post card. Side 1 and 2 of the reply post card which accompanied the school request letter	167
C-11	Letter of transmittal. Return letter to the auto mechanic instructors requesting examinations for their sophomore, post-secondary students	168
C-12	Roster Sheet. A roster which accompanied the examinations to cooperating post-secondary schools to aid the instructor in keeping the students and examination numbers aligned	169
C-13	Answer sheet. Used to record each participant's answers	170
C-14	Score reply card. Side 1 and 2 of the post card used to notify participants, who requested it, of their raw score on the examination	172
C-15	Participant follow-up post card, side 1. A double post card was used for the three follow-up reminders. The date and the number of weeks elapsed since the examination was mailed changed with each mailing	173

APPENDIX C (Continued)

Exhibit	Explanation	Page
C-16	Participant follow-up post card, side 2. The reverse side of the double post card used for follow-up reminders	174
C-17	Supervisor follow-up post card, side 1. A double post card was used for the three follow-up reminders. The date and the number of weeks elapsed since the examination was mailed changed with each mailing	175
C-18	Supervisor follow-up post card, side 2. The reverse side of the double post card used for follow-up reminders	176
C-19	Answer key. The correct answers for the 88 questions on the final form of the examination	177

C-1 Auto Mechanics Trade Competency Examination

AUTO MECHANICS TRADE COMPETENCY EXAMINATION

This examination is comprised of questions covering the repair of 1967 and later automobiles. Each question has four (4) possible responses (a, b, c, d). ONLY ONE response correctly completes the statement or answers the question. There is no penalty for wrong answers, so please answer all 88 questions on this exam. A pencil is recommended so that you can erase if you accidentally mark the wrong response. Read each question and the responses carefully and completely before marking the answer.

Directions:

1. Please complete the personal data sheet found on the last page of this exam following the directions printed on it.
2. Look at EXAMPLES I and II below. After reading each question and the responses carefully, mark the response of your choice by placing an X across the appropriate letter (a, b, c or d).
3. After you have finished the EXAMPLES, read the paragraph at the bottom of this page and then continue on with the rest of the examination.

EXAMPLES

I. The voltage regulator, or limiter, is placed in the charging circuit to:
   a. protect the alternator.
   b. protect the ignition system.
   c. protect the battery and accessories.
   d. regulate the current flow.

II. A sprague assembly is a specific type of a:
   a. over-running clutch.
   b. gear set.
   c. dog clutch.
   d. fluid clutch.

The correct answer to example I above is response "c", whereas the correct answer to example II above is response "a". Remember, the questions are built around standard equipment components found on 1967 and later passenger cars. Remember too that each question has only one (1) correct answer or response. You may continue on until you have completed the total exam. Good Luck!

1. A cracked or leaking cylinder head may be suspected if:
   a. air bubbles rise to the top of the radiator when the engine is running.
   b. the engine backfires through the carburetor.
   c. coolant is found in the crankcase.
   d. either a or c.

2. An alternator charging system does not use a cut-out relay because:
   a. of inductive reactance.
   b. of the function of the diodes.
   c. the field relay takes its place.
   d. the indicator light relay takes its place.

3. A by-pass fuel filter is designed to:
   a. decrease fuel volume to the carburetor.
   b. provide for cool fuel in the engine compartment.
   c. decrease fuel pump requirements at high speed.
   d. filter the fuel twice.

4. When installing relined brake shoes on a vehicle, the mechanic should:
   a. rebuild the wheel cylinders.
   b. clean and lubricate the wear pads on the backing plate.
   c. install the primary shoe towards the front of the vehicle.
   d. a, b and c above.

5. A grinding or squealing noise when the clutch pedal is partially depressed (transmission in neutral) may be caused by the:
   a. pilot bearing
   b. release bearing.
   c. transmission main shaft bearing.
   d. engine thrust bearing.

6. In a conventional distributor, the centrifugal advance moves the:
   a. breaker plate opposite shaft rotation.
   b. cam lobes opposite shaft rotation.
   c. breaker plate ahead in the direction of shaft rotation.
   d. cam lobes ahead in the direction of shaft rotation.

7. An engine piston that has the top end of the skirt smaller than the bottom of the skirt is said to be:
   a. normal.
   b. collapsed.
   c. cam ground.
   d. wearing abnormally.

8. When taking a cylinder leakage test, the maximum amount of leakage should be:
   a. 0%
   b. 10% or less.
   c. 20% or less.
   d. 30% or less.

9. Tie rod ends are supplied with either:
   a. zerks or oil cups.
   b. internal or external threads.
   c. right or left hand threads.
   d. tapered or straight shanks.

10. If an engine is noisy with a regular, single clicking sound when idling, you would expect this to be caused by improperly adjusted:
   a. fan belt tension.
   b. valve clearance.
   c. ignition timing.
   d. spark plug gap.

11. The Ford C-4 compared to the Ford C-6 automatic transmission has:
   a. fewer bands and more clutch packs.
   b. the same number of each.
   c. more bands and less clutch packs.
   d. one additional sprague.

12. During high-speed operation, when the throttle is wide open, the fuel supplied to the engine is discharged through the:
   a. idle port.
   b. off idle port.
   c. main nozzle.
   d. throttle valve.

13. During normal part throttle operation, the fuel supply to the engine is metered by the:
   a. off idle ports.
   b. main metering jets.
   c. the economizer valve.
   d. needle valve.

14. Drive shaft alignment should be checked when the driver complains of:
   a. a vibration in relation to vehicle speed.
   b. rapid rear tire wear.
   c. short universal joint life.
   d. a and c above.

15. As the battery runs down, or discharges, the specific gravity of the electrolyte:
    a. goes up.
    b. goes down.
    c. remains relatively unchanged.
    d. is not directly related.

16. Excessive clearance between the oil pump body and gears could result in:
    a. a sticking oil by-pass valve.
    b. excessive oil pressure.
    c. drop in oil pressure.
    d. causing the oil to foam.

17. A piston ring with a notch cut around the inside should be placed with the notch:
    a. up.
    b. down.
    c. either way.
    d. up if it is used as the top ring and down for the 2nd, 3rd, etc.

18. It is dangerous to use a file:
    a. unless it is double-cut.
    b. without a handle.
    c. on soft metals.
    d. on case hardened metals.

19. Air in the hydraulic system causes:
    a. a sticking master cylinder.
    b. an inoperative brake indicator light.
    c. a spongy primary shoe.
    d. a spongy brake pedal.

20. The ballast resistor found in a 12V ignition system of a vehicle is:
    a. effected by heat.
    b. by-passed when the engine is being cranked.
    c. used to increase the life of the points.
    d. a, b, and c above.

21. If the starter motor fails to turn and the battery and connections are good, the next item to check for would be a:
    a. defective starter switch or switch circuit.
    b. defective starter drive.
    c. damaged flywheel teeth.
    d. grounded field.

22. The parts of a carburetor that control fuel delivery, thus maintaining the proper fuel level in the reservoir include the:
    a. float valve and throttle valves.
    b. fuel nozzle and venturi.
    c. float and float valve.
    d. accelerator pump and float.

23. The pitman shaft is:
    a. not part of a matched set and therefore sold separately.
    b. adjusted by means of a screw protruding through the cover plate.
    c. splined to the pitman arm.
    d. a, b, and c above.

24. A grounded circuit most often identifies:
    a. an unintentional grounding of a circuit before it reaches the "load".
    b. a circuit involving a poor ground.
    c. a broken wire.
    d. one close to the battery.

25. A solid knock that is heard under a very heavy engine load may be caused by a:
    a. loose main bearing.
    b. loose rod bearing.
    c. loose wrist pin.
    d. piston slap.

26. The carburetor power circuit may be operated mechanically or by:
    a. a metering rod.
    b. intake-manifold vacuum.
    c. a linkage to the throttle.
    d. a spring.

27. The "split" hydraulic brake system is:
    a. primary and secondary braking.
    b. two separate braking systems.
    c. two-shoe application.
    d. vacuum over hydraulic.

28. A growler is used to locate shorts in the:
    a. field coil.
    b. armature.
    c. brush ring.
    d. rotor.

29. The accelerator pump is designed to:
    a. overcome the lag in fuel response.
    b. improve cold engine starts.
    c. balance air/fuel ratio.
    d. supply fuel to the carburetor.

30. Generally speaking, a brake drum for passenger car use should not have its inside diameter turned or enlarged more than:
    a. .040".
    b. .055".
    c. .060".
    d. .070".

31. Adding plate area to a battery cell increases:
    a. voltage.
    b. current availability or storage capacity.
    c. the sulfation rate.
    d. the specific gravity of the electrolyte.

32. Maintenance of a typical exhaust system includes:
    a. replacement of broken or deteriorated components.
    b. draining condensation from the system.
    c. servicing the heat riser valve.
    d. a and c above.

33. In addition to being tilted inward or outward from the center of the car, the top of the tire, or steering axis may also be tilted forward or backward from the verticle (tilted toward or away from the driver). Backward tilting from the verticle is called:
    a. positive caster.
    b. positive camber.
    c. negative caster.
    d. negative camber.

34. Switches are usually connected in:
    a. series with the load.
    b. parallel to the load.
    c. across the circuit.
    d. any of the above ways.

35. If any two of the three members of a planetary gear set are locked together, the unit will be in:
    a. overdrive.
    b. free wheeling.
    c. direct drive.
    d. reverse.

36. The purpose of a torque wrench is to:
    a. measure engine torque.
    b. prevent twisting off bolts.
    c. test the strength of bolts and nuts.
    d. tighten bolts and nuts evenly.

37. An intermittent or no assist problem encountered with a power steering unit may be traced to:
    a. a vacuum leak at the control valve.
    b. a low fluid level.
    c. a rough running engine.
    d. none of the above reasons.

38. Which cylinder has just fired when the exhaust valve on #6 cylinder has just closed on an engine using a firing order of 18436572?
    a. #1.
    b. #5.
    c. #3.
    d. #7.

39. The unloader adjustment is made to:
    a. open the choke valve for additional air during flooded starts.
    b. calibrate the choke valve opening as the engine warms up.
    c. vent the fuel bowl at curb idle.
    d. vent the air horn.

40. A battery with a specific gravity of 1.280 can be considered:
    a. fully charged.
    b. three fourths charged.
    c. half charged.
    d. discharged.

41. A hollow, muffled, bell-like sound when the engine is cold would most likely be a:
    a. loose rod bearings.
    b. loose main bearings.
    c. piston slap.
    d. loose heat riser valve.

42. Crankcase dilution may be caused by:
    a. lean mixture.
    b. unburned gasoline.
    c. detonation.
    d. pre-ignition.

43. When assembling a valve body, you should use:
    a. transmission fluid.
    b. a heavy grease.
    c. an engine oil.
    d. cleaning solvent.

44. The carburetor atmospheric vent is open under:
    a. load position.
    b. a high speed position.
    c. an idle position.
    d. both a and b.

45. "Bleeding" of the hydraulic brake system is an essential procedure in order to provide:
    a. compressible bubbles.
    b. a solid column of non-compressible fluid.
    c. a free-flowing liquid.
    d. clean fluid to the wheel cylinders.

46. Valve guide to stem clearance is checked with a:
    a. dial indicator.
    b. feeler gauge.
    c. outside micrometer.
    d. bore gauge.

47. The voltage regulator operates to prevent excessive generator or alternator voltage output by inserting resistance into the:
    a. generator or alternator charging circuit.
    b. battery main circuit.
    c. generator or alternator ground circuit.
    d. generator or alternator field circuit.

48. The idle air by-pass system is designed to:
    a. control the volume of air into the venturi.
    b. eliminate a slight throttle opening at idle.
    c. eliminate hot engine hard starting.
    d. eliminate idle stall on A/C equipped cars.

49. Engine overheating would <u>not</u> be caused by:
    a. a loose fan belt.
    b. insuffience coolant.
    c. a restricted heater hose.
    d. a defective thermostat.

50. The type of front suspension design that normally wears out the lower ball joint first is one that:
    a. has the spring between the frame and the lower control arm.
    b. has the spring above the upper control arm.
    c. uses a torsion bar.
    d. either a or c.

51. An insufficient number of oscillations in the intermediate section of a scope pattern (1 or 2) would indicate:
    a. burned contact points.
    b. high resistance in the coil secondary wire.
    c. a defective coil or condenser.
    d. a defective spark plug or wire.

52. A low reading on a fuel pump volume test could indicate:
    a. a clogged fuel filter.
    b. a defective fuel pump.
    c. restriction at the fuel pick-up in the tank.
    d. any of the above.

53. Differential backlash is adjusted by moving the:
    a. pinion gear.
    b. carrier side bearings.
    c. axle gears.
    d. bearing caps.

54. Power flow through an aluminum case Power-glide transmission is achieved with the use of:
    a. a front and a rear oil pump.
    b. 2 clutch packs and 2 bands.
    c. 2 clutch packs and 1 band.
    d. an electrically controlled stator.

55. Controls for the stator pitch are electrically operated in:
    a. the torque-flight.
    b. some turbo hydra-matics.
    c. the power-glide.
    d. the Ford C-6.

56. Idler arms:
    a. swing on a thread, a bushing or a bearing.
    b. when loose, effect the camber and caster settings.
    c. swing on a ball and socket.
    d. are attached to the lower control arms.

57. The top piston ring and its' groove wears the fastest because:
    a. very little oil reaches it.
    b. of hot gases and combustion pressure.
    c. foreign material in the air lodges in this area.
    d. a and c above.

58. Constant velocity (CV) universal joints found on passenger cars are:
    a. a single joint.
    b. interchangeable with a regular "U" joint.
    c. a double cross and roller joint.
    d. used to provide flexing in two directions without a loss of speed.

59. With the Bendix self-energizing brake system, the:
    a. braking occurs equally on both shoes.
    b. primary shoe energizes the secondary shoe.
    c. shoes are anchored at the bottom.
    d. secondary shoe is energized first.

60. Which of the following is <u>not</u> a part of the choke circuit?
    a. piston.
    b. vacuum brake.
    c. high idle cam.
    d. metering rod.

61. Brake shoes should not be relined, or reused, if they:
    a. have bonded lining on them.
    b. show any signs of wear of distortion.
    c. have been used for more than 2 years or 24,000 miles.
    d. have been drilled for riveted lining.

62. In threading a hole, the proper tool to use is a:
    a. tap.
    b. thread chaser.
    c. thread gauge.
    d. die.

63. During an overhaul, after the pistons have been removed from the engine, the mechanic should:
    a. remove the old rings and inspect for groove wear.
    b. remove the ridge from the top of the cylinder.
    c. mark each piston and/or rod in the order they came out of the engine.
    d. do both a and b above.

64. When adjusting multiple carburetors equipped with solid linkage, care must be taken to assure all carburetors:
    a. are receiving an adequate supply of fuel.
    b. have automatic chokes.
    c. reach the idle and full throttle positions simultaneously.
    d. a, b, and c above.

65. One high firing line on the scope could indicate:
    a. a corroded spark plug wire tower in the distributor cap.
    b. excessive resistance in a spark plug wire.
    c. excessive gap in a spark plug.
    d. any of the above.

66. An increase in compression when oil is put into a cylinder indicates:
    a. burned valves.
    b. poor cylinder wall lubrication.
    c. worn rings.
    d. blown head gasket.

67. Electrically operated fuel gauges are of two types:
    a. balancing coil and hydrostatic.
    b. bimetal-thermostat and hydrostatic.
    c. balancing coil and bimetal-thermostat.
    d. induction and hydrostatic.

68. A shock absorber should be considered defective if:
    a. the vehicle bounces over once before stabilizing.
    b. when stroking a shock absorber a lag is felt when changing directions.
    c. leakage around the seal is noticeable.
    d. any of the above symptoms are present.

69. The valves should be removed from an automatic transmission valve body:
    a. anytime it is removed from the transmission.
    b. when sticking valves are suspected.
    c. when there are metal cuttings in the transmission oil pan.
    d. both b and c.

70. A faulty PCV valve will:
    a. effect idle stability.
    b. increase rpm's.
    c. decrease rpm's.
    d. effect exhaust control valve action.

71. A cold running engine indicates a possible:
    a. plugged up radiator.
    b. incorrect ignition timing.
    c. fan belt too loose.
    d. open thermostat.

72. The decimal equivalent of 3/8 of an inch is:
    a. .421.
    b. .375.
    c. .250.
    d. .453.

73. The fast idle cam is rotated by linkage connected to the:
    a. throttle.
    b. idle adjustment screw.
    c. choke shaft or valve.
    d. dash pot.

74. When an electric wiper is shut off, but the blades do not return to the "park" position, the:
    a. blade adjustment should be checked.
    b. the blades should be replaced.
    c. the park circuit should be checked.
    d. a and c above.

75. The last alignment angle to be set is:
    a. caster.
    b. camber.
    c. toe-in.
    d. steering axis inclination.

76. In an effort to keep cylinder bore distortion and coolant leakage to a minimum when installing a head, the mechanic should:
    a. use the correct gasket sealing compound.
    b. torque the head bolts to the proper tension and in the proper order.
    c. break the engine in under normal driving conditions.
    d. mix oil in the fuel to provide extra lubrication for the rings.

77. If gears clash when shifting, it may mean that the:
    a. gears are too tight.
    b. gears are too loose.
    c. clutch is not completely releasing.
    d. clutch is slipping.

78. Applying a pressure of 100 psi on a piston of 2 sq. in. total area will result in a force of:
    a. 50 pounds.
    b. 100 pounds.
    c. 200 pounds.
    d. 102 pounds.

79. If the polarity is reversed on a vehicle equipped with an alternator:
    a. the rectifier diodes may be damaged.
    b. the engine won't start.
    c. the battery may be charged backwards.
    d. corrosion at the battery terminals increase.

80. Brake pedal pulsation largely occurs from:
    a. out-of-round drums.
    b. worn brake lining.
    c. scored drums.
    d. heat checked drums.

81. When a shift involving a synchronizer causes clashing of gears, the mechanic should:
    a. check the clutch adjustment.
    b. check the cluster or counter gear.
    c. check the blocker rings.
    d. a and c above.

82. a rocker arm shaft should be installed with the oil holes facing:
    a. up.
    b. down.
    c. toward the push rods.
    d. any of the above.

83. Excessive wear on the inside of the tire could indicate too much:
    a. negative camber.
    b. negative caster.
    c. positive caster.
    d. positive camber.

84. A limited slip differential differs from a conventional differential in that it:
    a. contains a "clutch pack" or "sliding wedge."
    b. contains two pinion shaft bearings.
    c. requires light engine oil as a lubricant.
    d. a and b above.

85. When cleaning or rebuilding a carburetor, the mechanic should:
    a. completely disassemble the unit.
    b. clean all metal parts thoroughly.
    c. compare all adjustments to specifications and correct if necessary.
    d. a, b, and c above.

86. The Turbo-350 transmission differs from a Turbo-400 in that it uses:
    a. 3 clutch packs and 1 band opposed to 3 clutch packs and 2 bands in the Turbo-400.
    b. 4 clutch packs and no bands opposed to 3 clutch packs and 1 band in the Turbo-400.
    c. a front and a rear oil pump opposed to only a rear oil pump in the Turbo-400.
    d. only a front oil pump opposed to a front and rear oil pump in a Turbo-400.

87. Low engine oil pressure is often a warning of:
    a. a worn oil pump.
    b. worn bearings.
    c. an air leak at the oil pick-up screen.
    d. any of the above.

88. When a "riveted in" ball joint must be replaced, it is necessary to:
    a. cut the rivets and bolt the replacement joint in place.
    b. replace the entire control arm with a new arm and joint.
    c. cut the rivets and press the replacement joint in place.
    d. either a or b is recommended.

C-2 Score Request Page

_____ Please send me my score on this exam. (Please provide a change of address if you want your score sent some place other than where this exam was sent.)

Correct address: Street:_____

City, State, and Zip_____

Please return the exam and the personal data sheets in the self addressed, postage paid envelope provided.
Thank you very much for your help with this project.

C-3 Letter of Transmittal

R. R. 3 Box 83
Pueblo, Colo. 81004

Dear Mr.

I am in the process of developing an auto mechanic trade competency examination which may possibly be used in the future as an aid in screening of new auto mechanic teacher applicants. To validate this exam I need help and information from individuals who are closely related to the auto mechanics trade. Specifically I need auto mechanics and auto mechanic teachers to take the exam and fill out a short personal data sheet indicating their trade training, work experience etc. and I need a completed rating form from the supervisor of each individual who is taking the exam. By having three types of information about this exam: 1) the scores of those who have taken the exam, 2) work and training background for those who have taken the exam and 3) supervisor's estimates as to how the results will turn out I can make various correlation tests or comparisons between the three types of data to determine if the exam can distinguish between various automotive backgrounds.

Your name was chosen at random to participate in this project from a list of auto mechanics and teachers within the test area. All names have been omitted and each has been assigned a number to help keep this information anonymous.

If you are a mechanic or teacher you will find enclosed a copy of the examination based on suggestions from service managers, auto mechanics and auto mechanic teachers and a personal data sheet. If you are a supervisor you will find a rating form for each person under your supervision who was randomly chosen to receive an exam. I would appreciate it very much if you would complete the enclosed materials and return them in the stamped, self addressed envelope within the next two weeks.

It is important that I receive all three types of information for each person involved in this research project in order for any of it to be of value. If you take the exam and you are interested in knowing how many questions you answered correctly, please check the appropriate box at the end of the exam and I will be happy to send this information to you as soon as it is available.

C-3 Letter of Transmittal (Continued)

I want to thank you for your help in this project.

Sincerely,

William Crain
(Acting) Head Auto Mechanics Dept.
Southern Colorado State College

C-4 Personal Data Section

Personal Data Section

Directions: Below are questions pertaining to some personal data about yourself which will help in the analysis of this research. All information obtained for this research will be kept strictly confidential, your name has been eliminated from this examination, and you have been assigned a number which will help keep each examination anonymous. Please complete the following questions as clearly as possible. When applicable, please use the box (□) and include only one digit per box. Example: Age □ □. Thank you.

1. Participant's number. □ □ □
   1 2 3

2. Age. □ □
   4 5

3. How many years of work experience and/or training have you had as an auto mechanic? (please round to the nearest whole year)

   a. Work experience. □ □
      6 7

   b. Training. □ □
      8 9

4. If you have an area of repair that you have specialized in, please name it. Example: automatic transmissions, engine repair, tune-up etc. (If you have no specialization, please write in the word "general").

   _____.
   18

5. Briefly outline or describe your training, including service schools attended, and/or experience as an auto mechanic. Example: I have had 1 year of auto mechanics training in high school and 2 years in college, or I had 1 year of auto mechanics in high school and I have worked in an independent garage for 7 years. I have attended the G.M. Training Center 5 times and 2 local clinics.

   _____

   _____

   _____
   19-22

C-5 Teachers Personal Data Section

Teachers Personal Data Section

Directions: Below are questions pertaining to some personal data about yourself which will help in the analysis of this research. All information obtained for this research will be kept strictly confidential, your name has been eliminated from this examination, and you have been assigned a number which will help keep each examination anonymous. Please complete the following questions as clearly as possible. When applicable, please use the box (□) and include only one digit per box. Example: Age □ □. Thank you.

1. Participant's number. □ □ □
   1 2 3

2. Age. □ □
   4 5

3. How many years of work experience as an auto mechanic did you have before you started to teach? (Please round to the nearest whole year). □ □
   6 7

4. How many years of experience in teaching auto mechanics have you had at the: (Please round to the nearest whole number.)

   a. secondary level? □ □
      10 11

   b. post-secondary level? □ □
      12 13

5. How many years have passed since you were last employed as an auto mechanic? □ □
   14 15

   Was your last employment in the trade on a part-time ___ or full-time ___ basis?
   16 17

6. If during your most recent years of employment as an auto mechanic you had no specialty, please write in the word "general." If you specialized in a particular phase of repair, please indicate what specialty it was. Example: automatic transmissions, engine repair, tune-up etc. _____

_____

18

7. Briefly outline or describe your auto mechanic experience and training, including service schools attended, that enabled you to become certified to teach auto mechanics. Example: I worked as a line mechanic in a dealership for 7 1/2 years "or" I worked 2 years after school at a used car lot as a mechanic, in an independent garage full time for 4 years and I had my own shop for 3 years "or" I had 'X' number of college credits of training as an auto mechanic. I also attended 3 classes at the G.M. Training Center.

_____

_____

_____

_____

19-22

C-6 Confidential Rating Form

CONFIDENTIAL RATING FORM

Directions: Please include only one (1) individual's rating on this form. Please rate this person by placing an "X" in the appropriate box indicating, in your opinion, his technical knowledge in each of the phases of automotive repair listed below. If this person has not performed in some of the phases of repair listed below since he has been under your supervision and you do not know his ability in these phases, please mark the column "Do not know". Please answer only item numbers 18-30. Thank you.

1. Participant's number: ☐ ☐ ☐ (1 2 3) 2. Supervisor's number: ☐ ☐ ☐ (4 5 6)

3. Employer or school number: ☐ ☐ ☐ (7 8 9)

4. Town number: ☐ ☐ ☐ (10 11 12)

5. His main area of training or work has been on American ___ (18) or foreign ___ (19) automobiles.

	Supervisor's evaluation of this person's technical knowledge in each of the below listed phases of auto mechanics.						
	5 Is exceptionally well informed with up-to-date information.	4 Is well informed and information is usually up-to-date.	3 Has a working knowledge and some up-to-date information.	2 Knows a few basic operations but very few specifics.	1 Knows very little about the area.	0 Do not know.	
6. Engine repair and rebuild							20
7. Power trains (except automatic trans.)							21
8. Automatic transmissions							22
9. Brakes (power, disc, conventional)							23
10. Alignment (total steering system)							24
11. Automotive electricity . .							25
12. Fuel system (carburetion)							26
13. Automotive serv. (simulated garage work). .							27
14. Automotive diagnosis (total automobile).							28
15. Automotive air conditioning							29
16. Overall rating as a mechanic							30

C-7 Auto Mechanic Teacher Confidential Rating Form

AUTO MECHANIC TEACHER CONFIDENTIAL RATING FORM

Directions: Please include only one (1) teacher's rating on this form. Please rate this teacher by placing an "X" in the appropriate box indicating, in your opinion, his technical knowledge in each of the phases of auto instruction listed below. If this teacher has not taught in some of the phases of instruction listed below since he has been under your supervision and you do not know his ability in these phases, please mark the column "Do not know". Please answer only items 13-30. Thank you.

1. Teacher's number: ☐ ☐ ☐ (1 2 3)
2. Supervisor's number: ☐ ☐ ☐ (4 5 6)
3. School number: ☐ ☐ ☐ (7 8 9)
4. Town number: ☐ ☐ ☐ (10 11 12)
5. Secondary_____(13) or post-secondary_____(14) school.
6. This person is classified as a vocational teacher_____(15), industrial arts teacher_____(16), combination_____(17).
7. His main area of training and teaching has been on American_____(18), foreign_____(19) automobiles.

	Supervisor's evaluation of this teacher's technical knowledge in each of the below listed phases of auto instruction.						
	5 Is exceptionally well informed with up-to-date information.	4 Is well informed and information is usually up-to-date.	3 Has a working knowledge and some up-to-date information.	2 Knows a few basic operations but very few specifics.	1 Knows very little about the area.	0 Do not know.	
8. Engine repair and rebuild . .							20
9. Power trains (except automatic trans)							21
10. Automatic transmissions . .							22
11. Brakes (power, disc, conventional)							23
12. Alignment (total steering system)							24
13. Automotive electricity . . .							25
14. Fuel system (carburetion) . .							26
15. Automotive serv. (simulated garage work) . . .							27
16. Automotive diagnosis (total automobile)							28
17. Automotive air conditioning							29
18. Overall rating as a teacher							30

C-8 Confidential Code Break Down

CONFIDENTIAL CODE BREAK DOWN

Note: The following information is provided so that you may identify those individuals, under your supervision, who were chosen at random to participate in this research and for which a rating form is enclosed.

	Participant's Number (On Rating Form)	Participant's Name
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____
6.	_____	_____

C-9 Letter of Request

R.R. 3 Box 83
Pueblo, Colo. 81004

Dear Mr.

I am contacting you to ask for your help in validating an auto mechanics trade competency examination I am developing. I am primarily developing this examination to be used as an aid in screening future auto mechanic teacher applicants. In addition to auto mechanics and auto mechanic teachers, I need to administer this examination to at least 100 sophomore, post-secondary vocational auto mechanic students. This is where I am asking for your assistance.

Here is what would be involved.

1. I would send you an exam, answer sheet, personal data sheet and a rating form for all your sophomore, post-secondary vocational auto mechanic students, and one for you too if you would like. I will also furnish a roster sheet for your records.

2. You would have your students take the exam, preferably during class or as an assignment, and complete the personal data sheet. You would complete a brief rating form on each. The personal data sheet and the rating form is necessary to provide information for cross correlations between and within groups.

3. Collect and package the completed exams, answer sheets, rating forms and personal data sheets and return them to me for scoring. I will pay postage both ways.

4. If you desire to know your student's scores, I will send them to you upon request.

Enclosed is a post card for your reply. Please mark the appropriate box and return the card if you are, or are not interested in participating in this project.

Thank you.

Sincerely,

C-10 School Reply Post Card

☐ I am interested in participating in your project. Please send me materials for _____ sophomore, post-secondary vocational auto mechanic students and _____ instructors.

☐ No, I do not want to involve my students, or myself in this project.

_____
signed

Side 1

Mr. Bill Crain

R.R. 3 Box 83

Pueblo, Colo. 80114

Side 2

C-11 Letter of Transmittal

R.R. 3 Box 83
Pueblo, Colo. 81004

Dear Mr.

I am sending under separate cover _____ auto mechanic trade competency examinations, answer sheets, rating forms, personal data sheets and a roster sheet as you requested for your sophomore, post-secondary vocational auto mechanic students. I believe you can return all of these materials, when completed, in the same container. I am enclosing a return address label and a sufficient amount of postage for your convenience in returning the completed items. For any of the information to be of value, I must have all 4 items (the exam, answer and personal data sheet and rating form) for each participating individual returned. You may also return the roster sheet if you desire to have the raw scores for your students.

There is no time limit on this exam. I would anticipate that it should not take more than one and one half or two hours to complete. Although the exam does not require an answer sheet, I have enclosed answer sheets for your students to use which will greatly facilitate the scoring of the completed exam.

Thank you for your help.

Sincerely,

William Crain
(Acting) Head, Auto Mechanics Dept.
Southern Colorado State College

C-12 Roster Sheet

ROSTER SHEET

Sophomore, Post-Secondary Vocational Auto Mechanic Students

Directions: As the numbered exams, and corresponding answer and personal data sheets are passed out, write down the student's name adjacent to his number. In this way, you can provide the appropriate information on the correspondingly numbered rating form for that student.

___Please send me the raw scores, when compiled, for these students.

___I do not care to have the scores for these students.

Student's Name	Exam Number	Raw Score
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		

C-13 Answer Sheet

Auto Mechanics Trade Competency Examination

Participants Number:_____ Date:_____

Directions: Read the SAMPLE and note how the correct response is marked with an X. If you change your mind, erase your first mark completely. Note the EXAMPLE section where you are to mark the responses of your choice to EXAMPLES I and II on the exam. Also note that the answer spaces are arranged from top to bottom in four columns.

SAMPLE	EXAMPLES	SCORES
S1. A Chevrolet is a:		
a. Ford product.		1.___ 5.___
b. G.M. product.	I. a b c d	2.___ 6.___
c. Chrysler product.		3.___ 7.___
d. Am. Motors product.	II. a b c d	4.___ T.___
S1. a X c d		

1. a b c d	17. a b c d	33. a b c d	49. a b c d
2. a b c d	18. a b c d	34. a b c d	50. a b c d
3. a b c d	19. a b c d	35. a b c d	51. a b c d
4. a b c d	20. a b c d	36. a b c d	52. a b c d
5. a b c d	21. a b c d	37. a b c d	53. a b c d
6. a b c d	22. a b c d	38. a b c d	54. a b c d
7. a b c d	23. a b c d	39. a b c d	55. a b c d
8. a b c d	24. a b c d	40. a b c d	56. a b c d
9. a b c d	25. a b c d	41. a b c d	57. a b c d
10. a b c d	26. a b c d	42. a b c d	58. a b c d
11. a b c d	27. a b c d	43. a b c d	59. a b c d
12. a b c d	28. a b c d	44. a b c d	60. a b c d
13. a b c d	29. a b c d	45. a b c d	61. a b c d
14. a b c d	30. a b c d	46. a b c d	62. a b c d
15. a b c d	31. a b c d	47. a b c d	63. a b c d
16. a b c d	32. a b c d	48. a b c d	64. a b c d

C-13 Answer Sheet (Continued)

65. a b c d
66. a b c d
67. a b c d
68. a b c d
69. a b c d
70. a b c d
71. a b c d
72. a b c d
73. a b c d
74. a b c d
75. a b c d
76. a b c d
77. a b c d
78. a b c d
79. a b c d
80. a b c d
81. a b c d
82. a b c d
83. a b c d
84. a b c d
85. a b c d
86. a b c d
87. a b c d
88. a b c d

C-14 Score Reply Card

I have scored your returned auto mechanics trade competency examination and have come up with a total of _____ correct answers out of a possible 88. All questions which were either left blank or marked with what I believe to be an incorrect answer were counted as incorrect.

The help you have given this research project is greatly appreciated. Thank you.

Sincerely,

Side 1

Participant's name

and address

Side 2

C-15 Participant Follow-up Post Card, Side 1

April 22, 1972

Dear Fellow Worker:

Approximately five weeks ago I sent you a copy of an auto mechanics trade competency examination that I am developing. I ask that you take the examination and complete the personal data section on the back page. As of this date I have not received your copy of the examination. I have, however, received a rating form for many participants who have not yet returned a completed exam. I must also have a completed exam from all participants in order for any of this data to be complete and usable. I would appreciate your returning of the attached post card indicating the status of your participation in this study and/or the completed exam and data sheet. I would appreciate receiving these items by May 6, 1972. Thank you for your assistance.

Sincerely,

Mr. Bill Crain

R.R. 3 Box 83

Pueblo, Colo. 81004

C-16 Participant Follow-up Post Card, Side 2

Name:_____ No._____

Address:_____ Zip_____

_____ I will participate in the study but I need more time to complete the examination.

_____ I have already completed the examination and it is currently in the mail.

_____ I have misplaced the examination. Please forward me an additional copy.

_____ Other:_____

_____

Participant's name

and address

C-17 Supervisor Follow-up Post Card, Side 1

April 22, 1972

Approximately five weeks ago I sent you an evaluation form for specific auto mechanic teachers or auto mechanics under your supervision. I have received completed exams from many participants but I must also have an evaluation for each of these people, from their supervisor, in order for the data to be complete and usable. As of this date I have not received your completed evaluations. I would appreciate your returning of the attached post card indicating the status of your participation in this study and/or the completed evaluation form(s). I would appreciate receiving these items by May 6, 1972. Thank you for your assistance.

Sincerely,

Mr. Bill Crain

R.R. 3 Box 83

Pueblo, Colo. 81004

C-18 Supervisor Follow-up Post Card, Side 2

Name:_____ No._____

Address:_____ Zip:_____

____ I will participate in the study but I need more time to complete the evaluation(s).

____ I have already completed the evaluation(s) and it is currently in the mail.

____ I have misplaced the evaluation(s). Please forward me an additional copy.

____ Other:_____

_____

Supervisor's name

and address

C-19 Answer Key

Question	Key	Question	Key	Question	Key	Question	Key
1	D	30	C	59	B	88	D
2	B	31	B	60	D		
3	B	32	D	61	B		
4	D	33	A	62	A		
5	B	34	A	63	A		
6	D	35	C	64	C		
7	A	36	D	65	D		
8	C	37	B	66	C		
9	C	38	A	67	C		
10	B	39	A	68	D		
11	C	40	A	69	D		
12	C	41	C	70	A		
13	B	42	B	71	D		
14	D	43	A	72	B		
15	B	44	C	73	C		
16	C	45	B	74	D		
17	A	46	A	75	C		
18	B	47	D	76	B		
19	D	48	D	77	C		
20	D	49	C	78	C		
21	A	50	D	79	A		
22	C	51	C	80	A		
23	D	52	D	81	D		
24	A	53	B	82	B		
25	A	54	C	83	A		
26	B	55	B	84	A		
27	B	56	A	85	D		
28	B	57	D	86	A		
29	A	58	C	87	D		

APPENDIX D

RAW SCORE DATA

Item Number	Number Correct	Proportion Passing	Responses				Key
			A	B	C	D	
1	168	.812	16	1	20	168	D
2	33	.159	11	151	33	6	C
3	66	.319	45	66	42	48	B
4	172	.831	13	3	15	172	D
5	180	.870	16	180	6	3	B
6	79	.382	72	20	34	79	D
7	84	.406	84	46	39	34	A
8	103	.498	14	73	103	13	C
9	156	.754	26	11	156	13	C
10	194	.937	4	194	7	2	B
11	77	.372	46	39	77	29	C
12	187	.903	1	4	187	14	C
13	144	.696	27	144	25	8	B
14	174	.841	15	3	14	174	D
15	183	.884	7	183	11	3	B
16	198	.957	2	1	198	6	C
17	145	.700	145	24	3	34	A
18	180	.870	2	180	11	14	B
19	196	.947	2	4	5	196	D
20	150	.725	13	25	14	150	D
21	179	.865	179	8	4	16	A
22	185	.894	5	4	185	13	C
23	125	.604	8	19	51	125	D
24	177	.855	177	8	18	3	A
25	132	.638	132	46	8	20	A

APPENDIX D (Continued)

Item Number	Number Correct	Proportion Passing	Responses				Key
			A	B	C	D	
26	171	.826	8	171	22	4	B
27	166	.802	18	166	9	14	B
28	195	.942	5	195	0	6	B
29	173	.836	173	3	15	15	A
30	177	.855	16	6	177	6	C
31	182	.879	11	182	6	8	B
32	193	.932	5	2	6	193	D
33	140	.676	140	13	46	6	A
34	152	.734	152	12	5	36	A
35	155	.749	25	9	155	15	C
36	204	.986	0	2	1	204	D
37	160	.773	14	160	8	21	B
38	103	.498	103	48	35	17	A
39	144	.696	144	43	14	5	A
40	182	.879	182	10	4	10	A
41	144	.696	10	7	144	46	C
42	192	.928	5	192	6	4	B
43	167	.807	167	5	20	14	A
44	134	.647	9	10	134	50	C
45	186	.899	2	186	11	8	B
46	138	.667	138	14	10	43	A
47	159	.768	28	9	11	159	D
48	44	.213	52	68	42	44	D
49	185	.894	9	3	185	6	C
50	114	.551	53	24	12	114	D
51	145	.700	22	18	145	15	C
52	182	.879	2	18	3	182	D

APPENDIX D (Continued)

Item Number	Number Correct	Proportion Passing	Responses				Key
			A	B	C	D	
53	128	.618	47	128	6	22	B
54	110	.531	43	37	110	8	C
55	137	.662	32	137	16	10	B
56	119	.575	119	31	29	24	A
57	104	.502	22	79	0	104	D
58	81	.391	7	10	81	102	C
59	150	.725	30	150	10	14	B
60	149	.720	15	36	3	149	D
61	174	.841	13	174	9	9	B
62	189	.913	189	3	0	14	A
63	98	.473	98	9	54	43	A
64	145	.700	19	3	145	38	C
65	172	.831	3	14	15	172	D
66	196	.947	5	3	196	2	C
67	125	.604	29	27	125	20	C
68	138	.667	9	13	45	138	D
69	155	.749	12	28	8	155	D
70	145	.700	145	7	22	29	A
71	200	.966	0	4	1	200	D
72	184	.889	8	184	4	6	B
73	166	.802	25	11	166	3	C
74	154	.744	14	5	32	154	D
75	183	.884	8	8	183	6	C
76	201	.971	2	201	4	0	B
77	183	.884	5	8	183	11	C
78	158	.763	30	14	158	1	C
79	179	.865	179	6	18	2	A

APPENDIX D (Continued)

Item Number	Number Correct	Proportion Passing	Responses				Key
			A	B	C	D	
80	187	.903	187	7	6	6	A
81	147	.710	21	7	30	147	D
82	112	.541	49	112	19	25	B
83	158	.763	158	18	4	25	A
84	153	.739	153	10	6	36	A
85	192	.928	7	3	5	192	D
86	97	.469	97	39	18	32	A
87	152	.734	17	38	0	152	D
88	82	.396	109	9	5	82	D

APPENDIX E

STATISTICAL FORMULAS

The Pearson product moment correlation formula used in the treatment of data in this study was

$$r_{xy} = \frac{\Sigma xy}{\sqrt{(\Sigma x^2)\ (\Sigma y^2)}}$$

The Kuder-Richardson inter-item consistency formula used in the treatment of data in this study was:

$$r_{11} = \left(\frac{n}{n-1}\right)\ \frac{\sigma T^2 + \Sigma pq}{\sigma T^2}$$

The Guttman split-half formula used in the treatment of data in this study was:

$$r_{11} = 2\left(1 - \frac{\sigma a^2 + \sigma b^2}{\sigma T^2}\right)$$

The analysis of variance formulas used for the treatment of data in this study were:

$$SS_g = \frac{(\Sigma X_1)^2}{K_1} + \frac{(\Sigma X_2)^2}{K_2} + \frac{(\Sigma X_3)^2}{K_3} + \frac{(\Sigma X_4)^2}{K_4} - \frac{(\Sigma X)^2}{N}$$

$$SS_t = \Sigma X^2 - \frac{(\Sigma X)^2}{N}$$

$$SS_w = SS_t - SS_g$$