1989

An analysis of the importance of selected applied physics concepts as prerequisites to training in automotive technology

Patrick Michael McCleskey
University of Northern Iowa

Order Number 9022221

An analysis of the importance of selected applied physics concepts as prerequisites to training in automotive technology

McCleskey, Patrick Michael, D.I.T.

University of Northern Iowa, 1989

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

AN ANALYSIS OF THE IMPORTANCE OF
SELECTED APPLIED PHYSICS CONCEPTS AS PREREQUISITES
TO TRAINING IN AUTOMOTIVE TECHNOLOGY

A Dissertation
Submitted
In Partial Fulfillment
of the Requirements for the Degree of
Doctor of Industrial Technology

Approved:

Rex W. Pershing, Ed.D., Advisor

Charles D. Johnson, Ed.D., Co-Advisor

Arnold J. Freitag, M.S.

Glenn L. Hansen, Ph.D.

Robert R. Hardman, Ed.D.

Patrick Michael McCleskey
University of Northern Iowa

August 1989

AN ANALYSIS OF THE IMPORTANCE OF

SELECTED APPLIED PHYSICS CONCEPTS AS PREREQUISITES

TO TRAINING IN AUTOMOTIVE TECHNOLOGY

An Abstract of a Dissertation

Submitted

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Industrial Technology

Approved:

Rex W. Pershing, Ed.D.
Advisor

John W. Somervill, Ph.D.
Dean of the Graduate College

Patrick Michael McCleskey

University of Northern Iowa

July 1989

ABSTRACT

The purpose of this study has been to develop information that may be useful in the preparation of curriculums and materials dedicated to the remediation of applied physics knowledge and skill deficits demonstrated by entering automotive technology students. The problem was to identify and rank-order the importance of applied physics concepts within the mechanical, fluidal, electrical/electronic, thermal, and chemical domains that are foundational to training in automotive technology.

A questionnaire containing 77 concept statements with a corresponding graphic rating scale was administered via mailed correspondence to all 196 of California's full-time community college automotive instructors. Of these, 130 (66.33%) were returned. For each survey item, a response frequency distribution, high-to-low response percentage value, mean value, and standard deviation was calculated. Concept statements were then rank-ordered by high-to-low response percentage value within groups and overall. Response frequency distributions for each survey item were then analyzed for statistical significance against a Chi square distribution at the .01 level. Rank-order amongst groups was established using grand mean values.

Results found 67 questionnaire items rated as important prerequisites to training in automotive

technology. Of these 21 were critically important. The category rated as having the greatest importance was electrical/electronic, followed closely by mechanical, at a distance by fluidal, with chemical and thermal nearer the bottom. Both theoretical and applied concepts within the electrical/electronic group were ranked as important. Within the remaining four areas, however, theoretical knowledges and skills were found to have low importance.

Conclusions of this study are: (a) learning success of automotive technology students is positively related to pre-course knowledges and skills in applied physics; (b) the high to low rank-order of curricular emphasis amongst the five applied physics domains is electrical/electronics, mechanical, fluidal, chemical, and thermal; (c) entering automotive technology students should possess fundamental applied knowledges in all five applied physics areas while (d) important theoretical knowledges and skills appear to be concentrated in the electrical/electronic domain.

Recommendations include: (a) applied physics coursework should be a prerequisite to automotive training and (b) remedial coursework in applied physics should be a part of the automotive technology curriculum.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

BACKGROUND AND PROBLEM

Background of the Problem

In less than 20 years the automobile has evolved from a relatively simple machine with a minimal electrical system for ignition, lighting, and accessories into a sophisticated network of mechanical, fluidal, electrical, electronic, and thermal systems and subsystems (Motor Vehicles Manufacturers Association, 1985). The rate of change in engineering, manufacture, and service of automotive technology has been extremely rapid. Today's vehicles have micro-processor controlled engines, braking, transmissions, ride-control, climate-control, and driver information systems (Coleman, 1985). Other experts (Allen, 1984; Choulochas & McKenney, 1986; Flax, 1987; Grosse, 1983; Heyler, 1988; and others) suggest that these innovations are merely the cutting edge for things to come. Choulochas and McKenney (1986) have pointed out that:

> A revolution in technology. . .has brought about an equally dramatic increase in training requirements. not only will more sophisticated systems be

> introduced, but these will come at an unprecedented pace. Training experts see the need for a qualitatively different kind of service technician. The mechanic of the past will be replaced by the highly skilled service technician, trained in many phases of the emerging electronic and computer technology. . . .If brought to state-of-the-art levels of technology, [vocational education] could provide a solution to an increasingly apparent problem. (p.63)

As will be demonstrated by this study's Review of the Literature, this "increasingly apparent problem" is manifested in the inability of America's automotive training institutions to keep pace with industry's ever-increasing demand for this new type of worker. Jacobs (1987) suggests that the root of this problem lies in the fact that far too many students enter postsecondary automotive training with deficiencies in conceptual knowledge of computers and applied physics that are prerequisite to learning state-of-the-art automotive technology.

Statement of the Problem

The problem of this study was to analyze the importance of selected mechanical, fluidal, electrical/ electronic, thermal, and chemical concepts as prerequisites to training in automotive technology.

Definition of Terms

For the purposes of this study the following definitions were used and are defined to add clarity:

Applied Physics Concepts denotes categories of knowledge dealing with "the properties and interrelationships ships of matter and energy. . .including the study of force, motion, heat light, sound, electricity, magnetism, radiation, and atomic energy" (Barnhart, 1986, p. 495). The principal subsets of applied physics are: mechanics, fluidics, electricity/electronics, and thermodynamics. For the purposes of this study, fundamental knowledge of electronic computer architecture, operation, and programming as well as selected chemical transformations are included under this heading.

Automotive Maintenance and Repair Industry is an inclusive term denoting activities undertaken by businesses and individuals in the correction of problems and the performance of preventive maintenance to automobiles, light trucks, and other gasoline and diesel powered vehicles (Dictionary of Occupational Titles: 620.261-010).

There are eight recognized specializations within the industry. These are: engine repair, engine performance, electrical systems, manual transmission and rear axle, automatic transmission, brakes, suspension and steering, and heating and air conditioning (Losh, 1981).

Automotive Technology denotes the study of the tools, materials, and processes common to the automotive maintenance and repair industry. Of special concern to this study are those specializations within the profession which require extensive knowledge of modern state-of-the-art automotive systems.

Automotive Technology Instructors denotes individuals who are employed full-time in California's community colleges expressly to give instruction in automotive technology.

Automotive Technology Programs is an inclusive term denoting either of the two classifications (automotive mechanics or automotive technology) listed in the 21st edition of The College Blue Book--Occupational Education (1987) offering vocational coursework in automotive maintenance and repair within California's community college system.

State-of-the-art automotive technology denotes the most current advances in automotive design and engineering which have been incorporated into today's automobiles. Most typically, this will be directly related to the presence of computer or microprocessor-controlled electromechanical devices.

Purpose of the Study

The purposes of this study were to:

1. Develop information that may be useful to guidance counselors, administrators, and curriculum specialists regarding the importance of selected applied physics concepts as prerequisites to training in automotive technology

2. Develop information that may be useful in the preparation of curriculums and materials dedicated specifically to the remediation of applied physics knowledge and skill deficits demonstrated by entering automotive technology students.

Statement of Need

The need for this study was based on the following factors:

1. America's automotive maintenance and repair industry has a present and future need for technicians who have the skills necessary to maintain and repair modern state-of-the-art automobiles. "Never," says Jacobs (1987),

"has the demand on vocational [automotive] programs been stronger or more urgent" (p. 30). Considering this, automotive training programs have both a present and future need for students who possess the academic preparation required to learn modern state-of-the-art automotive technology. Fierer (1979) states that:

> Students entering training in the profession must be well rounded in cognitive, reading, and problem solving skills. They must be given a better background in mathematics and the basic sciences of physics and chemistry including fluid power, electricity/electronics, and related subjects. (p. 2)

This observation is supported by Jacobs, Peek, Shoemaker, Steiger, and Thomas (cited in Jacobs, 1987) and by the Occupational Outlook Handbook (U.S. Department of Labor Statistics, 1987). Choulochas and McKenney (1986) agree but add to the list the need for computer competencies.

William E. Brock, the United States Secretary of Labor, speaking about the condition af the American workforce in the period spanning now through the year 2000, recognizes the pervasiveness of this problem:

> There will be a job for every qualified young person who wants one. The catch word is "qualified". Will we have the workforce we need? At the moment the answer is no, unless we change. . . .The real problem is not a labor shortage, but a skill shortage, as many new workforce entrants [will] not have the appropriate education and other training for entry-level jobs. (p. 26)

In a Review and Synthesis of Research and Development in Technical Education, Brooking and Reindeau (1980) suggest that studies be undertaken in curriculum and program development for new and changing technologies, particularly in the area of:

> how to teach under-prepared students (academically) [parenthesis in original]. . .for successful entry into quality rigorous programs. . .[especially those students] who have little preparation in the mathematics and science base required by modern technology programs. (p. 89)

Choulochas, McCourt, and Oettmeier (cited in Kahn, 1982) add that:

> The job of the secondary school is to lay the foundation. The postsecondary system doesn't have the time to do that. [The postsecondary system] has all [it] can handle staying up with the technology. The two systems have to work together. (p. 26)

2. There is a significant number of institutions, instructors, and trainees who may be potentially impacted by this study. The Bureau of Labor Statistics (1986) reports that there are approximately 992,000 persons employed nation-wide in America's automotive maintenance and repair industry. More than 3000 automotive training programs are offered in America's high schools, community colleges, public and private vocational-technical institutions, and in some four-year colleges (Jacobs, 1987). An aggregate of slightly more than 100,000

individuals complete these programs annually. In spite of these large numbers, spokespersons of the automotive maintenance and repair industry--Boord (1984), Choulochas & McKenney, (1986), Fierer, (1979, 1981), Grosse (1983), Heyler (1988), Steigers (1988), and many others--believe that there is now, and will in the future be, a dearth of qualified automotive technicians.

This study has identified and rank-ordered selected applied physics concepts that are fundamental to learning state-of-the-art automotive technology. This is of significance to automotive training, to the automotive maintenance and repair industry, and to the public.

Research Questions

The research questions to be answered in this study were:

1. What do automotive technology instructors perceive to be the importance of selected mechanical concepts as prerequisites to training in automotive technology?

2. What do automotive technology instructors perceive to be the importance of selected fluidal concepts as prerequisites to training in automotive technology?

3. What do automotive technology instructors perceive to be the importance of selected electrical/electronic concepts as prerequisites to training in automotive technology?

4. What do automotive technology instructors perceive to be the importance of selected thermal concepts as prerequisites to training in automotive technology?

5. What do automotive technology instructors perceive to be the importance of selected chemical concepts as prerequisites to training in automotive technology?

6. For those concepts identified in research questions #1 through #5 above, what is the rank-order of each concept within each category on the variable "importance as a prerequisite to training in automotive technology"?

7. For those concepts identified in research questions #1 through #5 above, what is the overall rank-order of each concept without regard to category on the variable "importance as a prerequisite to training in automotive technology?"

Assumptions

The following assumptions were made in pursuit of this study:

1. A high level of homogeneity exists amongst California's community college automotive technology curriculums.

2. The concepts listed on the survey instrument represented an accurate and valid summation of applied physics concepts that are relevant to training in automotive technology.

3. The population of this study possessed the best available qualified knowledge of prerequisites to training in automotive technology.

4. The perceptions of automotive technology instructors selected as respondents in this study would be valid and reliable.

5. The survey instrument used in this study would provide the data necessary to answer the research questions.

6. The results of this study would be important to administrators and/or guidance counselors.

7. The results of this study would be important to the improvement of automotive programs and curriculums.

Limitations of the Study

This study was conducted in view of the following limitations:

1. Communication with the participants was primarily by mail.

2. Variations of the perceptions of the respondents may have been influenced by variables beyond the control of this study.

3. The data obtained in this study was based on the responses of the participants.

4. The generalizability of the results of this study are limited to California's community college automotive technology programs.

Delimitations of the Study

This study is subject to the following delimitations:

1. The population of this study was automotive instructors who were employed full-time in automotive technology programs within California's community colleges as identified by the 21st edition of The College Blue Book --Occupational Education (1987).

2. The subject matter content of this study was delimited to the perceptions of the respondents regarding

the importance of specific mechanical, fluidal, electrical/ electronic, thermal, and chemical concepts as prerequisites to training in California's community college automotive technology programs.

3. Statistical analyses applied to the data collected in this study were delimited to response frequency distributions, calculated percentage values, mean values, standard deviations, rank-orders, and Chi square goodness-of-fit tests.

Statement of Procedures

There were seven distinct phases involved in the planning and execution of this study. These are presented graphically in Figure 1 and listed briefly below.

The beginning phase involved (a) selecting a topic of significance to this researcher and to the knowledge base of automotive technology, (b) completing an extensive review of the literature in order to identify worthwhile and researchable problems, (c) selecting and describing the research problem, (d) developing an appropriate research format and methodology, and (e) the development and submission of a research proposal for the review and approval of this researcher's Doctoral Advisory Committee.

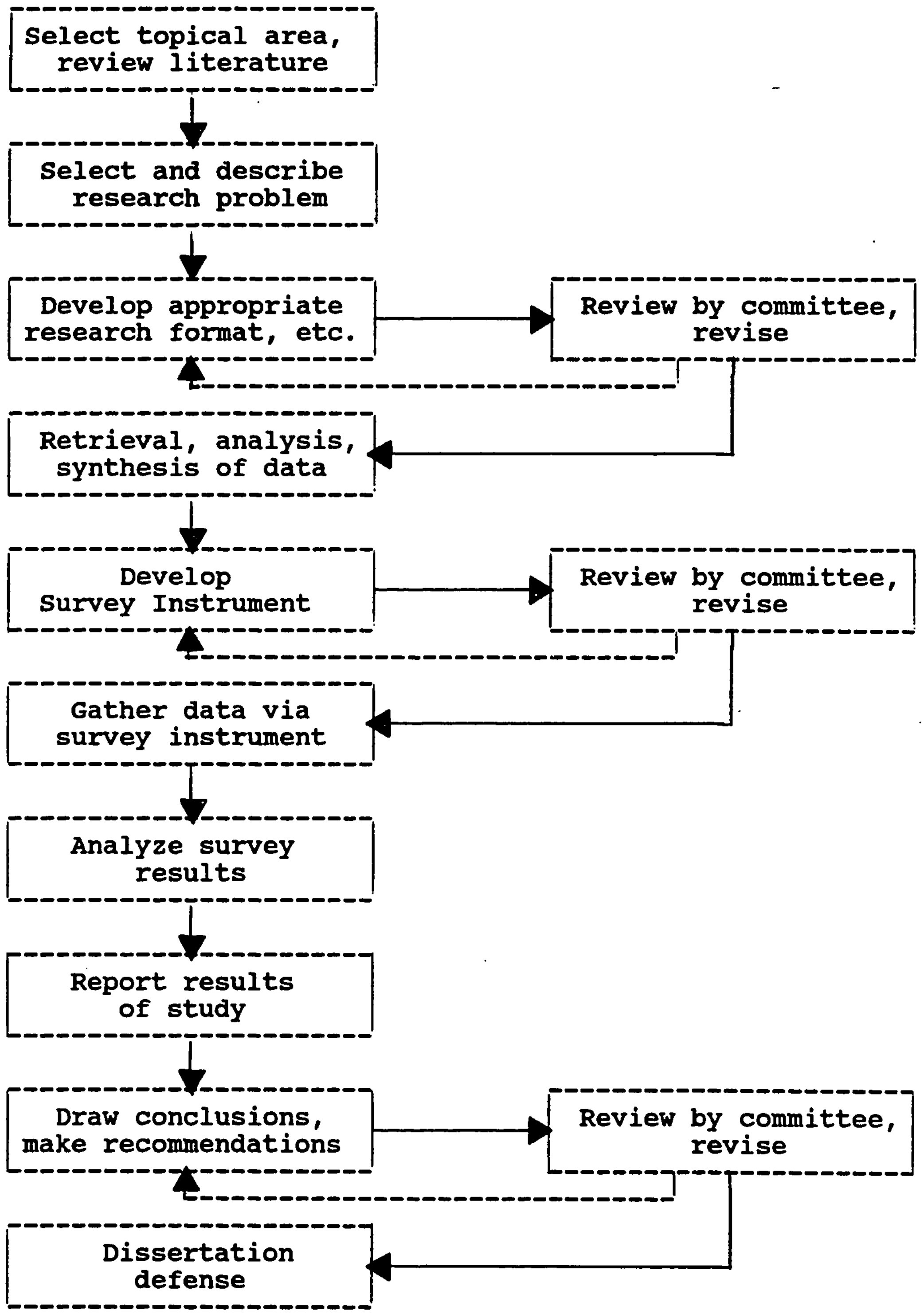

Figure 1. Research Procedures Flow Chart

The second phase of this study involved the further location, retrieval, analysis, and synthesis of available data. The third phase concerned the development of the survey instrument. The fourth phase involved the actual survey of the population of this research. The fifth phase was to analyze the results of the survey. The sixth phase was to report the results of the survey. The seventh and final phase was to draw conclusions and make recommendations based on the research findings.

Organization of the Study

Chapter 1 provides a general description of the study. It includes:

1. An introduction to the problem.
2. A statement of the problem.
3. Definitions of special terminology to be used.
4. A statement of the purpose of the study.
5. A statement of the need for the study.
6. Delineation of the research questions.
7. A statement of assumptions.
8. A statement of limitations.
9. A statement of delimitations.
10. A statement of procedures.

11. An explanation of the organization of the study.

Chapter 2 reviews literature related to this study. It includes a discussion of:

1. The development of automotive training.
2. Curriculum in automotive technology.
3. Related research.

Chapter 3 treats the methodological design of this study. It includes a thorough explication of:

1. Research design methodology.
2. Subject selection procedures.
3. Survey instrument design and development procedures.
4. Survey instrument validation procedures.
5. Survey instrument reliabilty measures.
6. The data collection plan.
7. Data analysis methods and procedures.

Chapter 4 analyzes and presents the results of this research as they relate to the research questions. Chapter 5 summarizes findings, draws conclusions, and makes recommendations.

CHAPTER 2

REVIEW OF THE LITERATURE

The problem of this study was to analyze the importance of selected applied physics concepts as prerequisites to training in automotive technology. Four bodies of literature were pertinent to this problem. The first is a brief chronicle of the efforts of public and private educational institutions to match the manpower needs of America's automotive maintenance and repair industry. The second section discusses efforts to standardize automotive training curriculums. The third section looks at the relationship of the task analysis process to curriculum development in automotive technology and examines a number of significant automotive task analyses. The final section discusses related studies.

One Hundred Years of Automotive Training

The automobile as a practical invention appeared in America in the late 1880's and by the turn of the 20th

Century more than 8000 motor vehicles of all types were registered (Rae, 1980). Nearly all of these first cars were truly one-of-a-kind. Each represented the craftsmanship and engineering skill of its maker. The automotive industry was in its formative stage and, as such, the rate of innovation and change was extremely rapid. Because these vehicles were hand-made, spare parts were essentially non-existent. Repairing cars required individuals possessed of an array of diverse skills. When a malfunction occurred, the mechanic typically diagnosed the problem, removed and replaced parts, and most often was also required to rebuild or manufacture the parts (Renzelman, 1982).

In these early days of the automobile, skilled automobile repairmen were extremely scarce. Most auto mechanics crossed-over from the engineering, machinist, blacksmith, and, particularly, the bicycle making trades (Prosser, 1949). Far too many, however, had no formal training at all (Flink, 1970). A few automobile manufacturers did institute training courses dedicated to the driving, maintenance, and repair of their cars. Notable among these was Packard in 1903, Locomobile in 1904, and Pierce-Arrow in 1906. As a rule, though, most manufacturers provided only negligible instruction in these areas (Flink, 1970).

Ransom E. Olds produced 425 vehicles in 1901 and another 5,000 in 1905. In 1908, Henry Ford began mass-producing the Model T and William Durant began the company that was to become General Motors. By this time, the one-of-a-kind automobile had given way to the production of standardized vehicles with standardized parts (Kennedy, 1941). This fact was of extreme significance to the auto mechanic's profession. Automobile repairman were now relieved of the necessity of being a machinist as well as a mechanic. This factor helped to set auto mechanics clearly apart from the machinists trades from which had spawned them.

This era was also a time of change in public-supported education. The Morrill Acts had created the "smokestack" land grant colleges with their new practical curriculums and scientific instruction in agriculture and the <u>mechanic arts</u> (Sinclair, in C. Pursell (Ed), 1984). Manual training had become manual arts and was on its way to becoming industrial arts (Bennett, 1937). Formal training in technical subjects was becoming increasingly popular. In these times America began to demonstrate an increasing fascination for the automobile and, as a result, automotive subject matter began to command a large portion of "mechanic arts" coursework. Specific courses in automotive maintenance and repair had not yet become a distinct part of the curriculum, however (Castle, 1935).

Within the educational domain several new types of schools appeared. Bennett (1937) lists "(a) the prevocational or industrial school, (b) the continuation school, (c) the part-time cooperative school, (d) the day vocational or trade school, and (e) the apprenticeship or corporation school" (p. 528).

In 1903 and 1904 a number of automobile training schools were established by the Young Men's Christian Association (YMCA) in Boston, Cleveland, Detroit, and New York City to provide instruction in the driving, maintenance, and repair of motor vehicles (Flink, 1970). Combined enrollments exceeded 2,000 individuals. The New York School of Automotive Engineers was founded in 1905 and had graduated some 1,500 graduates by 1908 (Flink, 1970). In 1909, the Hebrew Technical Institute of New York offered a course in automotive engineering and electricity and a trade school in Buffalo, New York, offered a course in automotive mechanics (Roberts, 1965). Curriculum for this latter course is said by Bennett (1937) to have been derived from an "advisory committee of four persons, two from labor and two representing employers" (p. 534).

In spite of above examples, training in automotive mechanics in the pre-World War I era remained almost non-existant (Castle, 1935). It was the Smith-Hughes Act of 1917 and America's entrance into World War I that put impetus to the task. Upon entering the War, the U.S. Government ordered a survey to determine the type of personnel in shortest supply. Being exceeded only by radio repairmen, the number two item on this list was automobile repairman. Estimating a deficit of some 200,000 mechanics, it was decided that the training of this force could be most effectively facilitated under the provisions of the Smith-Hughes Act.

World War I became an historical fact and by 1920 there were estimated to be 281,700 professional automotive repairmen (Kahler & Hamburger, 1948) attending to 8 million motor vehicles of all types (Foster, 1980). The Smith-Hughes Act offered Federal dollars in exchange for the addition of vocational coursework in the public school. As a result, during the 1920's the numbers of vocational courses in the high school curricula grew rapidly. In many of America's larger cities, purely vocational high schools came into being. In both the junior and the senior high school automotive training courses were amongst the most popular (Castle, 1935).

In 1921, one of the first articles dedicated to automotive curriculum appeared in the Industrial Arts Magazine and as America's infatuation with the automobile continued to increase through the 1920's, so did the numbers of articles dealing with automotive training. According to Renzelman (1982) the principal topics treated by these articles centered mainly on "program start-up costs, the lack of adequate teaching materials, the difficulties of hiring suitable teachers, and course content" (p. 16).

Renzelman (1982) also notes the appearance of automotive parts businesses in the middle of the decade. Before this time, parts had been available only through authorized dealers. Of significance to automotive training was the introduction of "technical upgrading clinics" sponsored by the various auto parts manufacturing and marketing firms.

In 1928, Horning published the results of his study of automotive coursework in the junior high school:

1. Auto mechanics may be considered as having permanent value in the junior high school since over half of the systems having junior high schools offer auto mechanics. Twelve per cent of the systems will install or extend auto mechanics within the year. Less than 1 per cent of the schools have found the course impractical.
2. The principal objectives of auto mechanics are: First, general training; second, exploratory; third, utilizer's appreciation.
3. The average-size class is increasing in numbers. The present median is 20.
4. The median duration of the course in auto mechanics is one semester of from 18 to 20 weeks, having five 55-minute periods per week.
5. The most popular methods of instruction are: First, individual instruction; second, class instruction. Blackboard demonstration and job sheets are used by an equal number. The unit operation is coming into favor for shopwork.
6. Auto mechanics is the most popular title for the automobile courses.
7. The majority of automobile courses are taught without a text.
8. The subject matter covers the mechanics of the automobile rather thoroughly. Over 50 per cent extend the course into the broader fields of the automotive industry.
9. One third of the supervisors favor auto mechanics as a prescribed [mandatory for boys] course. (p. 159)

Horning also lists nine automobile mechanics textbooks in print at that time.

As noted above, throughout the 1920's, the provisions of the Smith-Hughes Act had a wide-reaching positive impact. On the negative side, however, tenets of Smith-Hughes specifically excluded industrial arts from sharing in the benefits of the Act (Roberts, 1965). This created a schism within the ranks of industrial education. As a result, by the end of the decade automotive coursework in the high school had come to occupy the two-part mold that still characterizes it today: Industrial arts curriculum was geared to prevocational experiences, occupational orientation, and the development of owner/operator automotive maintenance skills. It was meant to be general education. In contrast, course content of vocational programs was intended specifically to equip the student with skills necessary for successful entry into the automotive maintenance and repair industry. It was job-specific training.

Statistics show that by 1930 the numbers of automotive repairmen had grown to 394,169 and the numbers of registered motor vehicles had reached 23,059,000 (Castle, 1935). The principal source of training auto mechanics had become the public supported junior and senior high school. In 1930, as has been the case throughout the history of the automobile, there was a widening gap in the supply of and demand for well trained mechanics. Noting this disparity, Bedell and Carpenter (1930) offered some suggestions that they believed might alleviate the problem. Graduates of vocational courses in automotive mechanics, they pointed out, should possess the following competencies:

> . . .a good mechanic must understand and be able to use precision instruments necessary for making mechanical, electrical, and chemical measurements. A good mechanic mush have a sufficient knowledge of the fundamentals of the general sciences, physics, mechanics, dynamics, chemistry, and mathematics in their application to his work. (p. 329)

In 1931, the American Vocational Association set up a committee charged with: (a) standardizing automotive instruction in the high schools and (b) differentiating between school and trade courses (Selvidge, 1931). In due course the committee produced two separate lists identifying recommended learning experiences for each of the two types of courses.

In 1934, four articles appeared in issues of the Industrial Arts--Vocational Education magazine debating the rationale for and legitimate content of automotive training in the high school. Drucker (1934) stated that:

> The aim of the course is to present the basic principles of science as applied to the automobile and to provide [the student] an opportunity to visualize the principles by definite projects. (p. 142)

Vance (1934) observed that there was "a great variation in actual teaching methods and. . .just what should be taught." One thing that all automotive teachers seemed to be able to agree upon, though, was that a "Model T Ford was absolutely necessary" (p. 209).

In the mid 1930's, Claude (1935) noted a number of trends underway in automotive training. In the junior high school, he related, educators had come to realize that students did not possess the maturity required for trade courses. At this level, survey courses "utilizing lecture, reading, and cut-away models" were becoming prevalent. In the high school, Claude reported:

> A number of years ago, a school shop in which trade auto mechanics was taught was purely a repair shop. Now, however, demonstration, lecture, and academic rooms are found adjoining the shop and there is a growing appreciation that the subject of auto mechanics is exceedingly rich in source material for teaching science, mathematics, and other academic subjects. (p. 333)

Echoing Bedell and Carpenter's message of 1930, Claude noted that, in 1935, the gap between the supply of and demand for competent auto mechanics was widening.

In the late 1930's technological improvements in the automobile produced a significant change within the automotive maintenance and repair industry itself. Heretofore, automobile design had favored infrequent but intensive maintenance and/or repair. In contrast, the newer models were engineered with frequent lubrication, tune-ups, and light maintenance work in mind (Goodrich, 1937). In a 1937 article, Goodrich listed several steps that a school might undertake to prepare students for employment in these new types of businesses, the two most significant being: (a) train students in the use of scientific instruments, and (b) spend more time and effort on training diagnostic abilities rather than manipulative skills.

The Depression of the 1930's had its effect on the public school curriculum. In spite of the push of the industrial arts factions or a non-vocational emphasis in high school automotive courses, all through the 1930's the vocational emphasis became more prominent. Olsen (1939) offers the following rationale:

> The minimum entering age into industry has climbed from sixteen years in 1929 to nineteen years in 1938. Because of this fact, the high schools are crowded with boys from sixteen to nineteen who would normally be at work. These boys naturally seek industrial training. . . (p. 233)

In 1940, the U. S. Office of Education listed 3,202 trade and industrial courses in 109 different trades being taught across the nation. The most frequently appearing of these was auto mechanics. Statistics showed 359 courses being taught in 45 states with a total enrollment of 26,929 students. Subject matter covered what, in those days, amounted to three separate trades: mechanics, electrical, and autobody (Kahler & Hamburger, 1948).

Prosser (1949) strongly promoted the use of the "school trained boy" as the source of supply for new workers in the automotive repair industry. The following is an account of his perception of the status of automotive training in the 1940's:

> . . .At the present time there is no national association which either conducts or uses any approved school for recruits, learners, or qualified mechanics in this business; nor is there any national association specifically interested, as an organization, in training for the business. Consequently, the preparation of new recruits will always be a local matter. . . .There are no plant schools. . .[and] local associations of dealers or garage owners have nowhere established their own schools and thus far have shown little realization of the need for any systematic instruction of workers. They have given little encouragement to the training efforts of auto departments in all day schools. Part time classes are conspicous by their absense. . . . Most training of garage hands is done by circulars giving special information about new cars and their unique features, and by visits from the control office when necessary.
>
> There are few occupations where the pick up method of learning is so universal and so costly. Car owners complain bitterly about the service they get on their cars, but no constructive steps have been been taken by the trade to remedy the trouble, the greatest of which is the ignorance and carelessness of workmen. (pp. 382-383)

Prosser's (1949) characterizations probably represent an accurate account of the first fifty years of automotive training. Forces were already in place, however, that would bring forth a great deal of change in vocational automotive training.

At the end of World War II, the numbers of individuals "mustered-out" of the armed forces and guaranteed an education by the "G.I. Bill" greatly increased the number of technical schools and courses of study (Prosser, 1949). Both Prosser and McCarthy (1951) advocated the use of Smith-Hughes funds for the development and implementation of standardized curriculums and instructional procedures in automotive training. McCarthy expressed a belief that "Smith-Hughes wishes to prevent the development of half-baked [italics in original] mechanics of which there is usually a liberal supply" (p. 51).

Near the end of the Second World War and for a short time thereafter, educators debated the direction that American public supported education ought to take in response to the increasing complexity of the technological world (Henninger, 1959; Lamb, 1945; McCarthy, 1951; Prosser, 1949). Increasing the numbers of technical institutes was seen as a possible solution. In 1946, Smith and Beckley (1948) conducted a survey of 180 technical institutes across the nation and found that three offered complete programs of study in auto mechanics. Emerson reported in 1950 that automotive coursework and programs had begun to be offered at the postsecondary level in both two-year and four-year colleges.

After World War II, higher order automotive trade training was beginning to be seen as beyond the capability of the high school. As early as 1946 the American Vocational Association (AVA) appointed a select committee consisting of educators and invited industry experts to study the matter. The outcome was the formation of the Automotive Industry-Vocational Education Conference on Public Schools Automotive Instruction. The preliminary report of this conference was distributed at the 1948 AVA convention and the final report published by the Automobile Manufacturers Association (AMA) in 1949 under the title Automotive Instruction in Your Community. In 1951, the AVA and AMA issued a joint report entitled Standards for Automotive Service Instruction in Schools. This was the first of many curriculum guides that would be issued jointly in the years to come. As Renzelman (1982) points out, these events mark the beginnings of cooperative efforts by industry and education to standardize curriculums and instructional procedures in automotive training.

During the 1950's, the numbers of cars and trucks in the United States increased by more than 50% while the number of automobile mechanics increased by only 3% ("The American Repairman," 1965). Recognizing this shortage, the automotive industry increased its involvement in training efforts.

The first of a chain of General Motors Service Training Centers was opened in Detroit on September 8, 1953 (Mitchell, 1954). The mission of these centers was to "keep mechanics employed by authorized General Motors dealers up-to-date on a systematic basis" (p. 28). In the same year General Motors addressed the need to attract and prepare capable young men for the automotive industry by (a) officially endorsing the Standards for Automotive Service Insruction in Schools which had been prepared jointly by the AVA and AMA two years earlier and (b) preparing a counselor's guide for the enlightenment of students and counselors alike (Mitchell, 1954).

Early in the 1950's, the AMA commissioned the University of Michigan to complete a seven-year study aimed at relieving the serious shortage of competent mechanics. Of express concern was the designing of a test that would identify prospective mechanics from the general secondary school population (Motor Vehicles Manufacturers Association, 1974). During the decade, the AMA was also instrumental in securing "college credit for automotive industry courses for teachers, college scholarships for prospective teachers of automotive mechanics, [and] summer programs for instructors" (Williams, 1961, p. 12).

In 1957, the American Society for Engineering Education (ASEE) completed a survey of community college and technical institute curriculums. This study demonstrated an increasing acceptance of automotive technology within the postsecondary milieu (Henninger, 1959).

During 1958, General Motors provided training to more than 40,000 auto mechanics from independent garages and service stations throughout the nation (Ward's Automotive World, 1958).

Throughout the entire post World War II era, the automobile industry made extensive efforts to narrow the gap between the supply of and demand for skilled mechanics. In the 1950's, as always, the rate of technological change in the automobile quickened its pace. General automotive mechanics were being replaced by specialists, particularly in the areas of tune-up, front-end alignment, and automatic transmissions (Renzelman, 1982).

Through the 1960's and 1970's, the training efforts by the automobile manufacturers continued to increase. In 1961 alone, "five million man-hours of specialized instruction were given by the training facilities of the auto industry to technicians employed by dealers" (Williams, 1961, p. 13).

In 1966, Turner reported a shortage of 50,000 skilled mechanics. In the same year, Morical (1966) argued that the root of the automotive mechanic shortage lay in the notion that the wrong students were coming into automotive training. Most students of automotive technology, he suggested, were academically unequal to the learning task. What automotive training programs needed was its fair share of capable learners.

In 1967, Ford Motor Company reported 840 graduates of its newly organized training program for mechanics employed by authorized dealers (Motor Vehicles Manufacturers Association, 1974).

In 1969, Ellinger (1969), reiterated the half-century old maxim about what a well-trained automotive mechanic ought to know. The student, he stated:

> . . .must have a good math and science background so that he can understand the physical laws. He should be able to apply these laws to automotive problems . . . . (p. 19)

Ellinger further noted that automotive students needed to understand computers and physics, especially mechanics, heat, light, sound, fluids, and chemistry.

Gathering speed in 1970, a trend toward cooperative training arrangements between automotive industry and educational institutions was underway. Typical of these programs, General Motors (GM) dealerships joined forces with high school vocational programs to provide on-the-job training. Trainees took classes at the high school in the mornings and worked for pay in the dealers service departments in the afternoons. Upon high school graduation, the students became full-time employees of the dealerships ("GM Dealers Participate," 1970).

The 1970's, too, was a decade marked by considerable research in automotive task analysis. Numerous studies were undertaken across the nation by federal, state, and private institutions. The most significant of these was the Automotive Mechanics Training Evaluation Project (AMTEP) sponsored by the Motor Vehicle Manufacturers Association and completed in 1979 (Losh, 1981). This study validated a list of 437 tasks commonly performed by journeyman auto mechanics.

In 1972, the National Institute for Automotive Service Excellence (ASE) was founded. Under this program, participating automotive technicians, diesel mechanics, and autobody repairers were tested in any one or all eight automotive or truck specializations. Since its inception, ASE has certified the possession of minimum skill levels for more than 300,000 of America's 992,000 automotive repairmen (Mitchell Automechanics, 1986).

Chrysler Corporation responded to the continuing shortage of skilled automotive mechanics by opening its Mo-Tech Automotive Education Center in 1973 ("Real World Training," 1988).

In 1979, in cooperation with Michigan's Delta Community College, General Motors launched its Automobile Service Education Program (ASEP) (Grosse, 1983). Under this agreement, General Motors trained the school's instructors and contributed substantial amounts of equipment, supplies, products and vehicles. Each of the entry-level students was trained specifically in GM product lines and was given part-time work for pay in local dealerships. This pilot program was a great success and by

May, 1986, the number of ASEP programs across the nation had risen to 35 (Choulochas & McKenney, 1986). Fleischman (1985) reported that GM planned to have 50 ASEP's in place by 1988 with a total of 1,000 program graduates.

Weiner reported in 1981 that the ratio of motor vehicles to motor vehicle repairers was 200 to 1. In this same year, the National Automotive Technicians Education Foundation (NATEF) was founded. An outgrowth of the AMTEP research, NATEF was charged with developing and encouraging automotive technical education. Specifically, its mission was to "examine the structure and resources of automobile technician training programs and evaluate them in relation to nationally accepted standards of quality" (Motor Vehicle Manufacturers Association, 1985). As of November 30, 1988, 263 of America's 3000 automotive training programs have become NATEF certified and another 1,557 are in the certification process (NATEF, 1988).

Seeing GM's success with ASEP, Ford Motor Company inaugurated an industry/education cooperative training program of its own. Calling its program Automotive Student Service Education Training (ASSET), Ford began piloting this program in four widely located technical schools in 1985 ("Co-op Training," 1985). Like ASEP, ASSET provides entry-level students with in-class training in the sponsoring manufacturers product lines, provides on-the-job training for pay, and assures the graduate a well-paying job upon graduation.

In 1987, the U. S. Department of Labor Statistics reported that there are approximately 992,000 persons employed nationwide in America's automotive maintenance and repair industry. Geographically, the distribution of these workers was in about the same proportion as the general population. Twenty-seven percent were employed by new and used car dealerships, 15.3% by automotive repair shops, 10.1% by gasoline service stations, 6.0% by auto and home supply stores, and 5.9 percent by machinery, equipment, and supplies wholesalers. The remaining 35.7% were employed in governmental and private organizations which repaired their own fleets of vehicles. Of this group, 24.5% were aged 16-24, 67.1% 25-54, with the remaining 8.4% being 55 and older.

In 1987, Chrysler Corporation put in place its response to GM's ASEP and Ford's ASSET. Named the "Chrysler Dealer Apprentice Program (CAP)", this program is very much like its two predecessors except that it requires its students to demonstrate, at minimum, 9th grade mathematics and 10th grade reading skills (Knox & Lorenzo, 1987).

In August, 1988, the Society of Automotive Engineers (SAE) held a Conference and Exposition on Future Transportation Technology. One of the highpoints on the agenda was the proposed founding of a Society of Automotive Technicians (SAT). This new organization will be operated within SAE for the purposes of (a) motivating qualified students to enter qualified training programs, and (b) gathering together the training providers from the many and varied companies and interests and "stop re-inventing the training wheel" (Heyler, 1988, p. 4).

In November, 1988, a letter from the Motor Vehicles Manufacturers Association was sent to every secondary school in America bearing the following message:

> The automotive service industry is extremely concerned about the availability and quality of automotive training programs in light of expected critical technician shortages. Projections indicate that tens of thousands of new positions will become available each year in this high-tech industry. (MVMA, 1988, November, p. 1)

The cars of the future, says Coleman (1985), will continue the trend towards being smaller, lighter, and more fuel efficient. They will make increasing use of four cylinder internal combusion engines and front-wheel drive. They will embody the leading edge of technology, especially in the use of microprocessor-controlled engines, brakes, transmissions, cruise control, ride-control, climate-control, and driver information systems. This observation is supported by Boord (1984), Choulochas & McKenney (1985), Fierer (1979), Flax (1987), Grosse (1983), Jacobs (1987), Womack & Jones (1984), and many, many others.

More than 100 years ago, H. G. Wells noted that the history of mankind has been a race between education and catastrophe (Wells, in Puchinski, 1971). Automotive training is far behind, but gaining.

Curriculum in Automotive Technology

A curriculum is the sum total of all objectives, content, and learning activities arranged in a particular sequence in order to achieve a particular instructional goal (Motor Vehicles Manufacturers Association, 1985). Curriculum in vocational automotive technology is typically the sum total of (a) high school coursework in automotive and related subjects and (b) a postsecondary program in automotive technology. A totally articulated curriculum would include:

1. basic skills (reading, communication, and computational skills) to complement other instruction;
2. basic service procedures (checking fluid levels, brake service);
3. theory (four-stroke cycle operation, electricity, electronics, hydraulics);
4. specialty service procedures (engine rebuilding, transmission overhaul);
5. related instruction (economics);
6. shop management (accounting, personnel management);
7. customer relations and merchandising (marketing, salesmanship);
8. related trade instruction (welding, machine shop). (Motor Vehicles Manufacturers Association, 1985, p. 19)

<u>Ideally</u>, the above represents an adequate preparation for entry into the automotive maintenance and repair industry. In the <u>real</u> world, however, the above is almost never put into practice. For the most part, burgeoning auto mechanics come to postsecondary automotive technology programs academically underprepared. This observation is supported by Jacobs, Peek, Shoemaker, Steiger, and Thomas (cited in Jacobs, 1987) and many others. "Never," says Jacobs (1987), "has the demand on vocational education programs been stronger or more urgent. And never, some believe, have secondary schools been less able to handle the load" (p. 30).

From state to state across America and within each state extreme variation exists in the scope and sequence of secondary curriculums for automotive technology. This is evidenced in the review of "Significant Automotive Task Analyses" which follows on page 44. At the postsecondary level, however, there appears to be a great deal of uniformity. This has resulted from the development of the National Institute for Automotive Service Excellence (ASE) standards for automotive technician certification and from the curriculum standards of the National Automotive Technician Education Foundation (NATEF).

The NATEF Curriculum is set out on Figure 2 and described below:

> Because preparation for employment in the automotive service industry is the primary program goal, a basic course which leads directly to employment or further training is the basis of the program structure. . . . This basic course provides the skills needed to obtain employment in the automotive service industry. The course is structured to familiarize the student with the automobile, its systems, their operation and interrelation. The course also provides hands on experience in performance of a set of basic tasks required for daily maintenance of the vehicle. These basic knowledges, skills, and abilities should make the student employable in a dealership entry level position, a mass merchandiser operation, service station, or other organization which requires lower level of skills or starts people at the bottom regardless of the training that they have received.
>
> Completion of the basic course will. . .allow the student to move directly into training in the specialty areas. . .The program structure for

specialty training coincides with major subsystems of the automobile and the National Institute for Automotive Service Excellence (ASE) mechanic/ technician test areas. . .Dictionary of Occupational Titles (DOT) and codes associated with the courses are also given. (Losh, 1981, pp. 5-6)

Basic Automotive (DOT Code 915.467-010): 200 hours of instruction in "Automotive Service Station Attendant" subject matter.

Automotive Technician (DOT Code 620.261-010): 1080 hours of instruction including 200 hours of basic instruction. Includes all 437 tasks included in the specialty areas listed below.

Suspension and Steering (DOT 620.281-038): 100 hours of instruction. 54 tasks.

Brake Specialist (DOT Code 620.281-026): 80 hours of instruction. 36 tasks.

Heating and Air Conditioning Specialist (DOT Code 620.281-010): 100 hours of instruction. 57 tasks.

Engine Performance Specialist (DOT Code 620-218-066): 240 hours of instruction. 111 tasks.

Automatic Transmission Specialist (DOT Code 620.281-062): 100 hours of instruction. 24 tasks.

Electrical System Specialist (DOT Code 620.281-022): 200 hours of instruction. 73 tasks.

Manual Transmission and Rear Axle Specialist (DOT Code 620.261-010): 140 hours of instruction. 46 tasks.

Engine Repair Specialist (DOT Code 620.261-010): 120 hours of instruction. 39 tasks.

Figure 2. National Automotive Technician Education Foundation Curriculum Standards

By design, the NATEF program is concerned only with curriculum standards. Related instruction and delivery methods are left to the discretion of local instutitions implementing the program.

California's Community College Automotive Curriculums and Credential Requirements

As noted in Chapter 1 under the heading "Assumptions", the population of this study was assumed to possess the best qualified knowledge of the prerequisites to training in automotive technology. Two principal factors underpinned this assumption. The first dealt with an apparent high level of homogeneity amongst California's community college automotive curriculums and the second concerned the credentials that enable one to teach vocational automotive technology.

In order to support the claim to uniformity amongst curricula, catalog descriptions of automotive technology programs and coursework listed by the 72 California community colleges offering vocational automotive training were reviewed. One of these programs specialized in automotive racing, one specialized in the maintenance and repair of foreign cars, and a few offered product-specific programs such as Ford's ASSET, GM's ACEP, and/or Chrysler's

CAP. Despite all of these variations, nearly all of these programs were--at the same time--either NATEF certified or were in the NATEF certification process. Because of this latter factor, very little variation was found from program to program in content, hours, or intended outcomes. For California's community college automotive programs, the NATEF curriculum had become the recognized unifying standard. California's community college automotive technology programs and curriculums are very much the same.

There are three types of credentials which authorize an individual to give instruction in vocational automotives in California's community colleges. O'Hagen (personal communication, April 11, 1989) described these as "basic", "special limited services", and "pre-Fisher [Act]" credentials. The requirements that an individual must satisfy in order to obtain any one of them is indeed formidable.

There are two sets of requirements for the "basic" credential, either one of which must be satisfied. These are (a) a Master's Degree and two years of related professional experience; or (b) a Bachelor's Degree and four years of related professional experience. It is also a requirement that academic degrees and technical experience be in closely related fields.

Obtaining the "special limited service credential" requires the possession an Associate's Degree and six years of industry experience, both occuring within a narrowly defined vocational area. Holders of this credential are also required to complete a prescribed list of pedagogical coursework.

"Pre-Fisher [Act] credentials" refer to credentials granted when different credentialing regulations were in force. Instructors possessing credentials falling into this category are required to satisfy the conditions of the law as they existed when the credential was obtained. These requirements vary greatly.

The types and numbers of credentials possessed by the respondents to this study are set out in Chapter 4 as Table 2.

Significant Automotive Task Analyses

Curriculum in automotive technology--what will be or ought to be taught--derives principally from a task analysis of the occupation (Losh, 1981). Mager and Beach (1967) define the task analysis process in the following:

> A task is a logically related set of actions required for the completion of a job objective. Stated another way, a task is a complete job element. A job or vocation requires a number of tasks. . . .
>
> The first step in the task analysis is listing all the tasks that might be included in a job. You can probably think of most of them just by thinking about the job awhile and by looking at your job description. But you will do a better job if you. . .talk with individuals working at the job, or watch them actually doing the job. (p. 10)

Phelps and Lutz (1977) suggest that a task analysis will most often have an hierarchy of three basic levels. These are the cluster, the task, and elements of the task. An occupation can be divided into a number of clusters, each cluster can be subdivided into a number of tasks, and each task can be subdivided into task elements. These task elements are classified as knowledges, skills, and basic skills and/or concepts. They add that once tasks are identified and listed in a task inventory, they can be validated by an external review source.

Throughout the history of automotive training, there have been numerous task analyses of the occupation. A few of the more significant of these are summarized below.

Abramson Study

In 1978, the New York State Department of Education commissioned the development of an Instructional Support System--Occupational Education (ISSOE): Automotive

Mechanics Content Validation Study. As the title indicates, the purpose of this research was to identify and validate a task list to be used to train entry-level automotive technicians. Using a group of New York University automotive faculty, a list of 117 tasks grouped within seven clusters was generated. The method used to validate this list involved a statistical comparison of the ISSOE tasks with two previously validated task lists. The ones selected for comparison were the Military Occupational Survey for Wheel Vehicle Mechanics and the one set out in the Soldier's Manual for Wheel Vehicle Mechanics. The study sought content validity.

Of the original list of 117 identified tasks, 81 were determined to be valid. Of significance was the identification of certain tasks as related academic instruction. Overall, however, the final lists of tasks and related instruction were overly concise. These factors limit the value of this research.

American National Standard for Training of Automotive Mechanics for Passenger Cars, Recreational Vehicles, and Light Trucks

In 1979, the American National Standards Institute formed a committee to redefine their automotive training standards which had been in force since 1973. This select committee was composed of 28 representatives from various organizations which represented a broad cross-section of America's transportation industry. The stated purpose was to "establish a practical and current basis for the design or modification of automotive repair training courses that by their nature provide for specific performance measures for mechanics" (p. 7).

The report of this study provided no evidence of a literature review. The committee did, however, identify an extensive list of tasks which were categorized within nine job clusters. Within each cluster there were three skill levels. These were specified as basic, advanced, and specialist. (The manner that was used to format the task list prevents an accurate count of their numbers). No data collection methodology or evidence of field validation of tasks was presented.

Of significance to automotive trainers, each task includes a generic description of fundamental skills, knowledges, and information that "the mechanic must possess and be able to apply in order to carry out the tasks prescribed" (p. 9). The depth of these descriptions leaves much to be desired, however.

Auto Mechanics Training Evaluation Project (AMTEP)

Commissioned in 1979 by the Motor Vehicle Manufacturers Association and completed in 1981 by the Southern Association of Colleges and Schools: Commission on Occupational Education Institutions, this research was undertaken to "identify, develop, and validate those performance, program, and personal standards judged necessary to operate and evaluate a quality automobile mechanic/technician training program" (Losh, 1981, p. 1).

This study undertook an extensive review of existing literature, developed a list of program standards, and identified and validated a task list. The latter involved a survey of hundreds of auto mechanics whose competence had been certified by the National Institute of Automotive Service Excellence (ASE). This population was widely scattered in 32 locations nationwide. The population was chosen because they were considered to have possessed the best knowledge of tasks inherent to automotive technology. The project validated 437 tasks which were categorized within the eight recognized ASE automotive specializations.

Automotive Mechanic: Task List and Competency Record

Completed in 1976, the Minnesota State Department of Education--Division of Vocational and Technical Education produced a task list and competency record intended for use by the vocational automotive instructor. This research was undertaken expressly to promote articulation between secondary and postsecondary automotive training programs. The task list was generated by a working committee of automotive mechanics and industry representatives. No evidence of task validation was presented.

The study produced 479 tasks which were grouped into 12 categories. The report strongly promoted the use of the "competency record" which had been developed expressly to track the student's progress through the articulated curriculum.

Borcher and Leiter Study

In 1973, The Ohio State University Center for Vocational and Technical Education was commissioned by the National Institute of Education to identify and validate a task list to be used in automotive curriculum development. By design, this study sought the idenfication of supervisorial as well as technician-level tasks common to the automotive maintenance and repair industry.

The population of the study consisted of 139 independent garages and 12 new car dealerships, all within the State of Ohio. The method employed included a literature review, formulation of the task list, and validation of the tasks via mailed survey.

The study validated 329 tasks grouped in 17 categories. Of these, 140 were supervisorial in nature. The remaining list of automotive tasks was concise, but not overly so. Setting this study apart from most others, time spent and frequency of performance for each task was delineated. This information is particularly useful to curriculum development.

Brewer Study

Brewer (1983) completed a study which was, in essence, a revalidation of the task list produced by the Automotive Mechanics Training Evaluation Project (AMTEP). Brewer stated that "the purpose of the study was to determine required entry-level tasks for automobile mechanics as identified by employers and postsecondary vocational instructors and the ranking of each task" (p. 5). The population was composed of three groups. The first consisted of 267 automotive businesses in Dallas County, the second group was composed of 100 automotive businesses in Tarrant County, and the final group consisted of 18 postsecondary automotive instructors, all within the State of Texas.

The literature review was limited to a discussion of the historical development of vocational curriculum and an examination of 18 task analyses that Brewer felt worthy of summary and annotation. Data for this investigation was obtained via a mailed questionnaire synthesized by the researcher from the AMTEP (Losh, 1980) study and the Dallas County Community College District's Auto Mechanics Articulation Guide (1972). Data analyses consisted of tabulations, rank-orders, and simple comparisons between groups.

Conclusions of this study included: (a) most of the 426 tasks listed on the survey were considered to be entry-level requirements for the auto mechanic's profession and (b) there were significant differences in the perceptions of employers and instructors regarding the rank order of the importance of tasks. Implications for educators included the notion that emphases in automotive curriculums may be incorrectly placed.

Connor and Thoman Study

Completed in 1975 and titled "An Analysis of the Auto Mechanic Occupation", this study appears to have been conducted contemporaneously with the Borcher and Leiter study outlined above. The task clusters are identical in both studies. Taking a different slant, however, The Ohio State University's Trade and Instructional Materials Laboratory made a detailed analysis of the skills and knowledges necessary to the performance of various tasks involved in the diagnosis, maintenance, and repair of automotive systems.

The tasks are not actually reported-out by the study. Instead they are replaced by broad statements which are extremely limited in scope. Of significance to curriculum development, though, each of the 39 broad task areas are complete with specifications for related instruction in safety, mathematics, communication, science, tools and equipment, and performance skills.

Dillenbeck Study

The main purpose of this 1980 study was to demonstrate the need for subject matter content and skills continuum articulation between Michigan's institutions of secondary and postsecondary education. Vocational automotives was used as the medium. The report contains 310 tasks in 20 clusters and specifies the roles of the secondary and postsecondary institutions in the occupational preparation of the student. The task list was generated by a faculty steering committee and was reviewed by other faculty and an advisory committee from industry. This list was then field tested and validated.

Essentially, the entire study was undertaken to promote what has today become known as a "two-plus-two" articulated curriculum. It has value for the purpose intended. The final report contains the task list, a copy of an articulation agreement, and an analysis of the entire articulation process.

State Articulated Instructional Objectives Guide for Occupational Education Programs: State Pilot Model for Automotive Mechanics

The Federal Bureau of Occupational and Adult Education sponsored a joint study by North Carolina's State Departments of Public Instruction and Community Colleges. Completed in 1977, the purpose of this research was to enhance the level of articulation between secondary and postsecondary automotive training programs within the State. Using a committee of automotive industry personnel, this investigation generated a task list in excess of 200 items which were grouped into 15 blocks of instruction. No evidence of field validation or methods of data analysis were presented.

The report of this study, published under the above title, is an important resource for automotive instructors and curriculum developers. It includes instructional objectives, expected outcomes, approximate instructional time, related information, and evaluative instruments for each task. A "student record" of task performance was also specified. The level of instruction for each task--secondary or postsecondary--was suggested and, most importantly, high school and community college academic coursework to support automotive training were specified.

Zion Study

Zion (1985) completed a task analysis of entry-level skills and knowledges required in the automotive collision and repair industry in California. The study employed a mailed questionnarie to gather data from 5,992 automotive collision repair businesses and 38 community college automotive collision repair training programs. Of secondary interest was an analysis of the divergence of perceptions between the two groups. A task list was assembled from the data and a Chi square analysis performed to ascertain any statistically significant differences between the groups.

The study identified 71 entry-level tasks of which 48 were validated. The study also reported a strong level of disagreement between the two groups of respondents regarding the importantce of the remaining 23 entry-level skills.

Related Research

Carter Study

Carter (1977) investigated the relationship that certain pre-course variables had to post-course outcomes in a beginning college-level auto mechanics course. The pre-course variables were occupational experience, mental ability, manual dexterity, pre-course knowledge, and pre-course application ability. Post-course outcomes were post-course knowledge and post-course application ability. The population of this study consisted of four separate sections of identical beginning auto mechanics courses taught by the same instructor at Northwestern State University, Ft. Polk, Lousiana, during the 1976-77 school year.

The literature reviewed in this study was limited to establishing the uniqueness of the study, the development of the research instruments, and to related studies. The data collection method consisted of a pre-test, post-test design which employed both standardized and researcher-developed instruments. Statistical treatments included simple and multiple analyses.

Results of this study demonstrated a significant positive correlation between learning and: (a) pre-course knowledge, (b) mental ability, (c) occupational experience, and (d) pre-course application. The best combination of predicting variables was pre-course knowledge and mental ability. No predictive ability was correlated with manual dexterity.

Drost Study

This study, commissioned by the Iowa State Department of Public Instruction: Division of Vocational Education, was completed in 1970 by the Iowa State University of Science and Technology. The purposes of the study were to analyze the auto mechanic's profession with respect to jobs performed, time spent in major areas, level of training expected, skills and competencies needed, and desirable personal characteristics. This study surveyed 242 individuals employed in 40 automotive service shops. Strictly speaking, this study did not generate a task list. There were, however, 118 questionnaire items that dealt with automotive tasks, related academic instruction, and employability skills.

Significant results included: (a) automotive employers wished to hire mechanics who possessed high levels of skill (i.e., they did not wish to train them themselves), (b) more than two thirds of all service managers prefered entry-level employees who had completed a postsecondary automotive training program, (c) ability to use automotive test and repair equipment was highly important, and (d) fundamental technical (applied science) skills were also viewed as highly important. Writing skills, algebra, and geometry, on the other hand, were rated as unimportant to the effective functioning of an automotive maintenance and repair technician.

Garcia Study

Automotive technicians who are engaged in the maintenance and repair of state-of-the-art automobiles are, in the purest sense, electromechanical technicians. Considering this, Garcia's (1988) and Yu's (1987) (discussed below) investigations of fundamental concepts needed by electromechanical technology graduates for entry-level employment in related industry are significant to this investigation.

Garcia (1988) surveyed a random sample of 589 of the 9,211 members of the Instrument Society of America. Literature reviewed was concentrated in the five areas of (a) the history of four-year industrial technology programs, (b) research related to the task analysis methodology, (c) electronics evolution, (d) fiber optics and fluids development, and (e) related studies. Data for this study was collected via a researcher-developed questionnaire. Data analysis was limited to mean values, standard deviations, and rank-orders.

This study identified 91 concepts of which 41 were validated as fundamental to functioning as an entry-level electromechanical technologist. Findings included: (a) there is a significant need for electromechanical technology graduates in the computer, instrumentation, automation, and robotics fields, (b) electromechnical technologists need to be prepared in a broad-based comprehensive program which includes mathematics, physics, chemistry, manufacturing, economics, and management, (c) electromechanical technology programs must provide a background in applied physics with an emphasis on electronics, and (d) fiber optics was found to have low importance for today's electromechanical technologist.

Renzelman study

In 1982, Renzelman employed a Delphi panel consisting of 38 automotive engineers to project technological innovations and resultant service requirements that are likely to occur within the automotive industry in the period 1982-1992.

Literature reviewed in pursuit of this study was limited to a brief historical account of the technological development of the automobile and the parallel development of curriculum in automotive training. Data for this study was collected over two Delphi rounds using a researcher-developed instrument. Descriptive statistics were used to analyze the level of importance of identified technological innovations and service requirements.

Results of this study suggested that today's and tomorrow's automotive technicians must possess high levels of basic educational and problem solving skills, be able to use sophisticated test equipment, and have a working understanding of the interrelated systems and subsystems with which they will work.

Yu study

In 1987, Yu completed a study designed to identify and validate technical competencies needed by electromechanical technicians. The population of this study was comprised of 140 instructors teaching nationwide in 57 two-year technical colleges and institutions offering coursework in electromechanical technology.

Six bodies of literature were reviewed. They included a discussion of: (a) the impact of technology on society, technology's impact on education; (b) an engineering and technical education outlook; (c) robotics; (d) curriculum develoment in electromechanical technology; and (e) the "National Model Robotics/Automated Systems Technician Curriculum". A researcher-developed mailed questionnaire was employed to collect data for this study. Statistical analyses were limited to mean values, standard deviations, and rank-orders.

Essentially a task analysis, this study identified 105 competencies within eight instructional areas, 93 of which were validated (23 were rated "essential" and 70 were deemed "desireable"). The major educational implications of the study were that electromechanical technology programs (a) should be generic in nature and (b) must use a broad knowledge-based, systems-oriented approach.

Observations Drawn From the Literarure Review

The above chronicle of events, observations, and ideas extant in the literature of automotive training has provided ample support for the following observations:

1. There has always been far more automobiles in need of repair than there has been qualified auto mechanics to repair them. As a function of percentage over time, the disparity between the supply of and the demand for this commodity has continually widened.

2. As the technological complexity of automobiles has increased, the grade level at which vocational instruction has been given has moved continually upward. Since the mid-1960's, vocational automotive training has shifted steadily toward the postsecondary institution.

3. Subject matter content of automotive training programs recommended by automotive curriculum experts has seldom been on a par with the subject matter content actually taught. As a rule, actual instruction has been on a much lower plane.

4. The academic preparation of the typical student of vocational automotives has seldom been equal to the technical difficulty of the subject matter.

5. Subject matter experts have continually asserted the necessity that an automotive mechanic possess practical knowledge of the physical sciences. In contemporary times, knowledge of computers has been added to this list.

6. There is a need to identify applied physics concepts that are fundamental to automotive training.

Summary

Until the end of the First World War, formal training in the automotive arts was practically unknown. During the 1920's, vocational training in auto mechanics became a part of both the junior and senior high school curriculums. During the 1930's, vocational automotives was eliminated from the junior high school and near the decade's end, unemployed youth packed high school vocational automotive programs. During the 1940's much debate was given to the ineffectiveness of high school vocational automotive curriculums and the need for postsecondary vocational-technical institutes. In the 1950's, the automobile manufacturers began to train their own mechanics in their own facilities and to promote cooperative efforts between themselves and educational institutions. The 1960's saw a widening of the efforts began in the 1950's and the founding of numerous postsecondary vocational automotive programs. In the 1970's, motor vehicle manufacturers began to invest heavily in cooperative training programs, research in automotive curriculum was a high priority, and a national program of automotive certification was begun. In the 1980's, the results of research projects and experimental programs of the 1970's were implemented into ACEP, ASSET, CAP, NATEF, and similar programs. As America approaches the 1990's, dramatic high-tech changes in the automobile are demanding an equally dramatic change in automotive training.

Within the literature there are many studies which addressed curriculum development in automotive training. For the most part this research has been concerned with task analyses of the automotive maintenance and repair profession. Of these, the most significant has been the Automotive Mechanics Training Evaluation Project (AMTEP) which resulted in the standardization of postsecondary automotive training curriculums and produced the National Automotive Training Education Foundation (NATEF).

Nearly all task analyses reviewed in this study addressed the same problem: that being, "what" a student should be like or be able to do as a result of instruction.

A few studies were found which did examine "how to teach" automotive subject matter and/or "what" skills and knowledges are fundamental to automotive instruction. In all cases, however, inquiry in these areas was ancillary to other research. No studies were found which described tasks, skills, or knowledges related to automotive microprocessor technology. Findings and recommendations of investigations concerning prerequisites to automotive training were either insignificant or inconclusive.

A review of related research revealed a number of significant results. Carter (1977) demonstated a positive correlation between pre-course knowledge and post-course learning and application. Drost (1970) reported that auto mechanic employers preferred to hire entry-level employees who were adequately skilled (i.e., did not need to be trained), possessed fundamental understanding of applied science, and had completed a postsecondary training program. Garcia (1988) identified and field validated 41 technical competencies needed by electromechanical technologists. Garcia also reported the need to provide electromechanical technicians with a background in applied physics with an emphasis on electricity/electronics. Renzelman (1982) provided some analysis of the history of automotive training, reported an analysis of the future of automotive technology, and set out implications for automotive trainers. Yu (1987) identified and validated 93 competencies needed by electromechanical technicians and concluded that electromechanical technician programs should be generic, broad-based, and should employ a systems-oriented approach.

Finally, a number of conclusions were drawn from the literature reviewed in the pursuit of this study. The entire literature review supports the need to identify and rank-order foundational learnings that are prerequisites to training in automotive technology.

CHAPTER 3

RESEARCH METHODOLOGY

The problem of this study was to determine the importance of selected mechanical, fluidal, electrical/ electronic, thermal, and chemical concepts as prerequisites to training in automotive technology. This chapter describes techniques and procedures that were utilized to collect, analyze, and display data relevant to this problem.

Research Design

The principal objective of this study was to develop information that may be useful in the preparation of curriculums and materials dedicated specifically to the remediation of applied physics knowledge and skill deficits demonstrated by entering automotive technology students. Of the many possible alternatives, a descriptive research design was seen as having the greater capability for achieving this purpose. Best (1981) states that

> Descriptive research describes what is [italics in original]. It involves the description, recording,

> analysis, and interpretation of conditions that exist. It involves some type of comparison or contrast and attempts to discover relationships between existing nonmanipulated variables. (p. 25)

Lang and Heiss (1984) further define descriptive research as "studies that seek to explain or predict. Variables and existing conditions are used with no manipulation" (pp. 176-177). Gay (1981) states that descriptive research involves collecting data to test hypotheses or answer questions concerning the current status of the subject of the study.

Data for this type of research, relate Clover and Balsley (1984), can be collected by use of a mailed questionnaire. The advantages of this method include low relative cost, an ability to cover a widely scattered population, more careful responses, elimination of interviewer biasing of responses, and respondent anonymity. Because the population of this study was spread across much of the State of California, the mailed questionnaire was the most practical way to obtain the needed data.

Survey Population

The population of this study was composed of automotive instructors who: (a) were employed full-time in automotive technology programs within California's community colleges during the spring 1989 semester and (b) taught coursework in automotive technology. As noted above under the heading "Assumptions", this group was assumed to possess the best available qualified knowledge of prerequisites to training in automotive technology. A concensus survey of this population was considered the most adequate means for obtaining data relevant to this study. Procedures that were employed in the selection of these subjects are presented graphically in Figure 3 and discussed below.

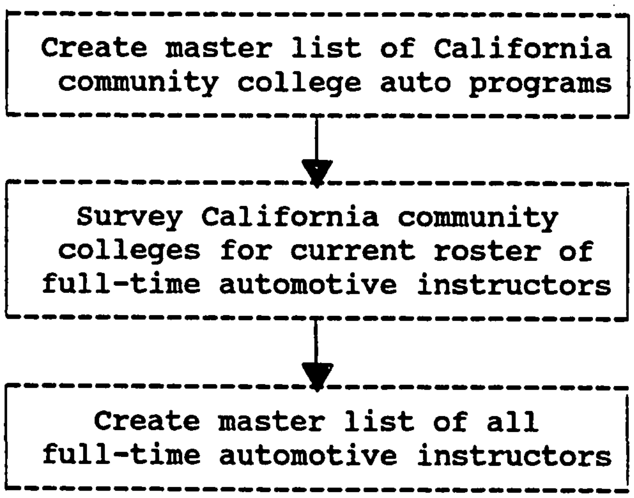

Figure 3. Survey Population Selection Procedures Flow Chart

Sample Selection Procedures

Using the 21st edition of The College Blue Book--Occupational Education, a master list of California community colleges having programs in automotive mechanics/technology was established. This list included respective institution names, telephone numbers, and mailing addresses. Using mailed correspondence, each institution was contacted and asked to provide the names and teaching areas of all full-time and part-time instructors. Those institutions not responding within 15 days were mailed a second request. After 30 days from the initial mailing, nonresponding institutions were contacted by telephone in order to obtain the needed data. From this assembled information a final master list of California community college full-time automotive technology instructors was compiled. Assuming a minimum of three full-time instructors per community college, it was estimated that the final master list would contain a minimum of 192 individuals. Similar studies Brewer, 1983, Garcia, 1988, Helzer, 1986, Zion, 1985) employing a mailed questionnaire to obtain data from similar respondents experienced response rates greater than 50 percent. Assuming a return rate of 50 percent or greater, the above process was projected to produce, at mininum, 100 usable questionnaires.

Design and Development of the Survey Instrument

In order to gather the data necessary to answer the research questions a closed-end survey questionnaire (Appendix A) was developed. The steps involved in its construction are illustrated on Figure 4 and described below:

1. A thorough review of relevant literature was undertaken by this researcher and a list compiled of relevant computer, electrical, electronic, mechanical, fluidic, thermal, and chemical concepts that may have had potential importance to learning state-of-the-art automotive technology.

2. Each element of the above list was then analyzed against the 437 standards of the National Automotive Technicians Education Foundation (NATEF) Curriculum for relevance and probable importance.

3. The initial list was then consolidated into a first draft of the survey questionnaire and submitted to a first panel of experts for additions, deletions, and/or comments. This first panel was composed of six

postsecondary automotive and/or electromechanical instructors whose reputation and credentials indicated

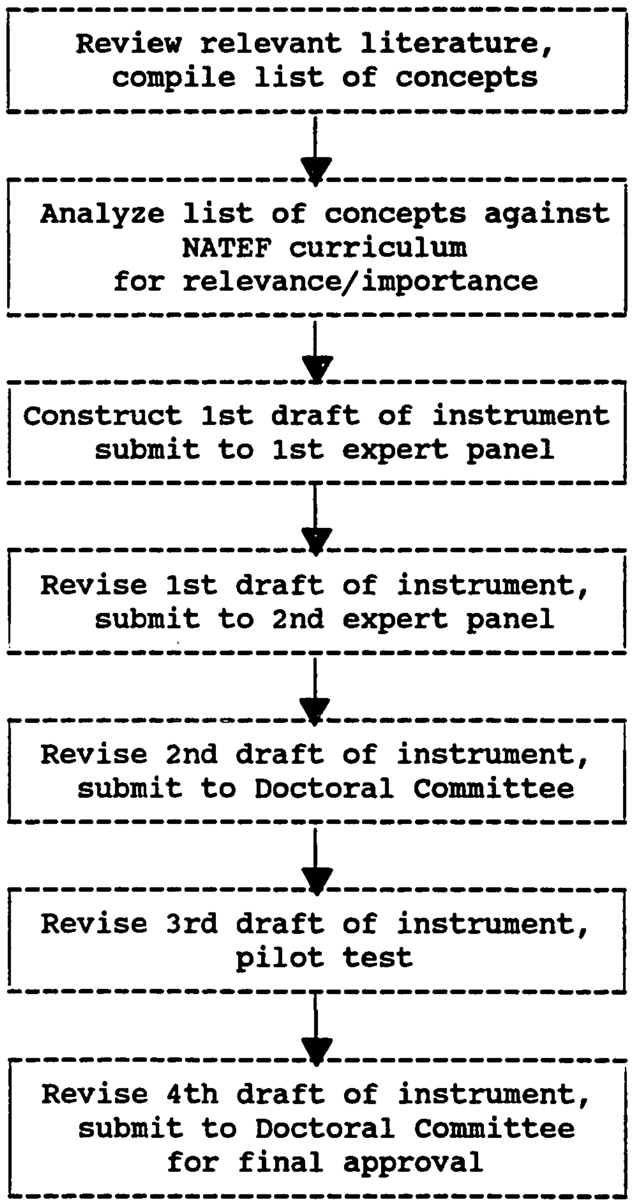

Figure 4. Survey Questionnaire Development Flow Chart

possession of special knowledge of the content areas represented in the questionnaire. Names, addresses, and credentials of individuals comprising this panel are set out as Appendix B.

4. Employing comments and suggestions of the first panel of expert reviewers, the first draft of the questionnaire was revised and submitted to a second panel of experts (Appendix C) having credentials similar to those of the first expert panel.

5. Employing comments and suggestions of the second panel of experts the second draft of the questionnaire was revised and submitted to this researcher's Doctoral Advisory Committee for additions, deletions, and/or comments.

6. After making revisions to the satisfaction of the Doctoral Advisory Committee, the third draft of the survey instrument was pilot tested on a group of automotive technology instructors who were a part of the survey population. Names and institution addresses of this questionnaire pilot test panel are set out as Appendix D.

7. The pilot testing process revealed no need for revision of the survey instrument.

8. The final version of the survey instrument was then submitted to this researcher's Doctoral Advisory Committee for final approval.

Validity of the Instrument

In the broad sense, validity is defined by Lang and Heiss (1984) as "the degree to which a procedure or device does what it claims to do" (p. 187). Best (1981) states that the only measure of validity available to survey instrument to be administered only once is content validity. Content validity, he further states, is established by submitting the instrument to the scrutiny and considered judgement of subject matter specialists. Considering this, the process enumerated above under the heading "Design and dDvelopment of the Survey Instrument" provided the survey questionnaire used in this study with ample content validity.

Reliability of the Instrument

"Reliability," as broadly defined by Best (1981), "is the quality of consistency that the instrument or procedure demonstrates over a period of time" (pp. 154-155). He adds that in the special case of a survey instrument to be administered only once, the only measures of reliability available are those of internal consistency. It must be noted, however, that the instrument employed in this study contained 77 concept statements which stood alone without relationship to one another. Considering this, the sole measure of reliability claimed for the instrument used in this study resulted from the considered judgement of the expert reviewers and this researcher's Doctoral Advisory Committee.

Data Collection

The data for this study was collected through the use of a mailed questionnaire. The procedures and timeline employed in this process are illustrated graphically on Figure 5 and listed below:

1. The frame of this study was selected in accordance with the procedures listed in the section above entitled "Sample Selection Procedure".

2. As an incentive to response the parent organization of the Automotive Service Councils of California was asked to lend its support to this study. Given this support, all correspondence with respondents bore their letterhead.

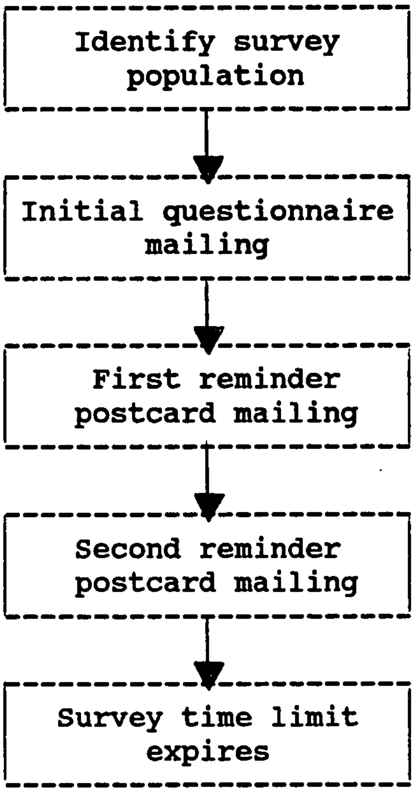

Figure 5. Data Collection Procedures Flow Chart

3. The time limit for the collection of survey data was 35 days from the initial mailing date.

4. Survey instruments were encoded with respondent identities in order to ensure respondent anonymity.

5. At a post time corresponding to an arrival time of Tuesday or Wednesday, individual copies of the survey questionnaire, a stamped self-addressed envelope, and a

cover letter (Appendix E) explaining the purposes of the study were mailed to each of the subjects.

6. A log of returned questionnaires indicating encoded questionnaire numbers and return dates was maintained.

7. After 7 calendar days from the first mailing, a postcard (Appendix F) was mailed to nonrespondents urging them to do so. Post time was calculated to coincide with a Tuesday or Wednesday delivery.

8. After 28 calendar days from the first mailing, a second reminder postcard (Appendix G) was mailed to subjects not responding.

9. Responses bearing a postmark beyond the 35 day data collection period were not included in this study.

Analysis of the Data

The data collected in this study were used to answer the research questions. These data were subjected to statistical analyses and procedures as indicated below. For each of the 77 questionnaire items:

1. Response frequencies were listed for each of the four categories: (0) "not important," (1) "low importance," (2) "important," and (3) "critical importance."

2. Percentage values derive from summing the total number of responses to the response categories (2) "important" and (3) "critical importance" divided by the total number of responses (n) were calculated (i.e., $\% = [f2 + f3] / n$).

3. Mean response values were calculated.

4. Standard deviations were calculated.

In addition,

5. Within each of the five concept groups, concept statements were rank-ordered by percentage value described above.

6. All 77 items appearing on the survey instrument were rank-ordered by percentage value described above.

7. A Chi square value at the .01 level of significance having one degree of freedom was calculated for the entire data set. (See Appendix H).

Research Question #1:

This question was: What do automotive technology instructors perceive to be the importance of selected mechanical concepts as prerequisites to training in automotive technology? In order to answer this question, the subjects of this study responded to concept statements giving to their perceptions of the value of each as a prerequisite to said training. For each question a response frequency distribution, percentage value (described above), mean response value, and standard deviation was calculated. Using the percentage value associated with the Chi square value calculated for the final data set, all concept statements having a percentage value equal to or greater than this cut-off percentage value were considered "important as prerequisites to training in automotive technology". Concept statements having having more than half of the total responses recorded in the "critical importance" category were considered as having "critical importance to training in automotive technology".

Mechanical concept statements are displayed in rank-order by perrcentage value (described above) in Chapter 4 as Table 3. Each is also accompanied by its respective response frequencies, mean response value, and standard deviation. A written description accompanies these data.

Research Questions #2 through #5:

Research questions #2 through #5 were identical to research question #1 except for the change in applied physics subset. Accordingly, questions #2 through #5 were answered using each question's corresponding section of the survey instrument. Statistical analyses and the manner of data presentation are identical to that employed in research question #1. Displayed in Chapter 4, Tables 4 through 7 present tabular data concerning fluidal, electrical/electronic, thermal, and chemical concept statements. Each is accompanied by a written description.

Research Question #6

This question was: For those concepts identified in research questions #1 through #5, what is the rank order of each concept within each category on the variable "importance as a prerequisite to training in automotive technology"?

Hopkins (1980) states that rank-ordering allows differentiation within groups when observation takes place on a continuum having a limited range and permits the quantitative handling of data which cannot be more precisely discriminated.

In order to answer question #6, the concepts identified in Tables 3 through 7 were rank-ordered from highest to lowest percentage value (see description above under heading "Analysis of Data") within each of the five applied physics subsets. Where two or more concepts were found to have the same percentage value, rank-order was determined using the higher mean value. Where two or more concepts were found to also have the same mean value, rank-order was assigned using the smaller standard deviation.

Research Question #7

This question was: For those concepts identified in research questions #1 through #5, what is the overall rank-order of each concept without regard to category on the variable "importance as a prerequisite to training in automotive technology"? In order to answer this question, all concept statements contained on the survey instrument were rank-ordered from highest to lowest percentage value (see description above under heading "Analysis of Data") without regard to subset. Where two or more concepts were found to have the same percentage value, rank-order was determined using the higher mean value. Where two or more concepts were found to also have the same mean value, rank-order was assigned using the smaller standard deviation.

Entitled "Applied Physics Concepts", this overall rank-ordering of concepts is displayed in Chapter 4 as

Table 8. This table is also accompanied by a written description.

Summary

This chapter has provided precise descriptions of the research design, methods employed to select the survey population, procedures used in the design and development of the survey instrument, methods used to insure validity and reliability, the data collection plan, and methods to be used to analyze and display the data.

CHAPTER 4

ANALYSIS AND PRESENTATION OF DATA

Return Rate

The frame of this study consisted of all 197 full-time automotive technology instructors employed by California's community colleges during the spring 1989 semester. Institution names and respective numbers of instructors are displayed as Table 1. One member of this population declined to take part in the study. This reduced the total number to 196. The number of responses returned bearing a postmark within the data collection period totaled 130 (66.33%). All were complete and usable. Six additional questionnaires were returned with a postmark beyond the data collection cut-off date and, consequently, were not included in this study.

Respondent Characteristics

Demographic data concerning respondents in this study were collected in order to support this study's assumption that its survey population possessed the best available

TABLE 1

Population of the Study

Colleges	Instructors	Colleges	Instructors
Allan Hancock College	2	Long Beach City College	3
American River College	6	Los Angeles Harbor College	2
Antelope Valley College	2	Los Angeles Pierce College	3
Bakersfield College	5	Los Angeles Trade-Tech	12
Barstow College	1	Marin--Indian Valley Campus	2
Butte College	3	Mendocino College	1
Cerritos College	6	Merced College	3
Cerro Coso College	2	Mira Costa College	1
Chabot College	2	Modesto Junior College	3
Chaffey College	2	Monterey Peninsula College	1
Citrus College	3	Mount San Jacinto College	1
College of Alameda	5	Oxnard College	2
College of the Desert	2	Palomar Community College	2
College of the Redwoods	2	Palo Verde College	0
College of the Sequoias	2	Pasadena City College	3
College of the Siskiyous	1	Porterville College	2
Columbia College	1	Rancho Santiago College	5
Compton College	1	Rio Hondo College	2
Contra Costa College	2	Riverside City College	1
Cosumnes River College	5	Saddleback College	2
Cuesta College	3	San Bernardino Valley Coll.	4
Cuyamaca College	3	San Diego City College	5
Cypress College	4	San Joaquin Delta College	2
De Anza College	5	Santa Barbara City College	3
East Los Angeles College	1	Santa Monica City College	4
El Camino College	3	Santa Rosa Junior College	2
Evergreen Valley College	4	Shasta College	5
Fresno City College	3	Sierra College	3
Fullerton College	4	Skyline College	4
Gavilan College	1	Solano College	1
Glendale College	0	Southwestern College	4
Golden West College	4	Taft College	1
Hartnell College	1	Ventura College	2
Imperial Valley College	2	Victor Valley College	2
Kings River College	3	West Hills College	2
Lassen College	2	Yuba Community College	3

Colleges = 72 Instructors = 197

Table 2

Respondent Characteristics

Characteristic	n	Percent
Age: (Mean = 48.16)		
20-30	1	0.77
31-40	17	13.08
41-50	53	40.77
51-60	35	26.92
61 and older	12	9.23
Did not indicate	12	9.23
Technical Experience (Years): (Mean = 12.34)		
0-5	13	10.00
6-10	47	36.15
11-15	26	20.00
16-20	13	10.00
21 and more	24	18.46
Did not indicate	7	5.39
Teaching Experience (Years): (Mean = 16.70)		
0-5	7	5.39
6-10	15	11.54
11-15	25	19.23
16-20	44	33.84
21 and more	36	27.69
Did not indicate	3	2.31
Education (Years): (Mean = 16.50)		
12-13	7	5.39
14-15	28	21.54
16-17	54	41.54
18-19	29	22.31
20 and more	11	8.46
Did not indicate	1	0.76

Table 2 (continued)

Characteristic	n	Percent
Educational Attainment:		
High School Diploma	13	10.00
A.A or A.S.	24	18.46
B.A., B.S., B.V.E.	44	33.85
M.A. or M.S.	45	34.62
Ed.D or Ph.D.	4	3.07
Credentials Held:		
Basic	58	N/A
Special Limited Services	48	N/A
Other	55	N/A
Possess Two or More Credentials	36	N/A

qualified knowledge of the prerequisites to training in automotive technologly. These data are reported on Table 2 and described as follows:

The mean age was 48.16, mean number of years of experience as a professional automotive technician was 12.34, mean number of years teaching experience was 16.69, and the mean number of years of education was 16.53. Thirteen of the respondents listed a high school diploma as the highest educational degree, 25 listed having earned an Associate's Degree, 45 have Bachelor's Degrees, 45 have

Master's Degrees, and 4 have Doctorates. Fifty-nine instructors indicated possession of California's "Basic" Community College Vocational Credential, 49 listed the Special Limited Services Credential, and 55 indicated that their credential belonged to the "Other" category. Six respondents did not indicate a credential type. Thirty-six indicated posession of two or more credentials.

Treatment of Data

Dr. H. E. Erickson (personal communications July 22, 1988, June 28, 1989) suggested that the most appropriate statistical treatments for the date collected in this study were response frequency distributions, percentages, mean values, standard deviations, rank-orders, and Chi square tests of significance. Accordingly, for each of the 77 questionnaire items:

1. The response frequencies were listed for each of the four response categories, (0) "not important," (1) "low importance," (2) "important," and (3) "critical importance."

2. The sum of the responses to each of the four response categories equaled 130 (n = 130).

3. A percentage value was calculated by summing the total responses recorded in the categories (2) "important" and (3) "critical importance" divided by the total number of responses (n) recorded in all four categories (i.e., % = [f2 + f3] / n).

4. Mean response values were calculated.

5. Standard deviations were calculated.

In addition;

6. Within each of the five concept groups, concept statements were rank-ordered from high to low by calculated percentage values (as noted in #3 above).

7. All 77 items appearing on the survey instrument were rank-ordered from high to low by calculated percentage values (as noted in #3 above) without regard to category.

8. A percentage value cut-point corresponding to a Chi square value at the .01 level of significance was calculated. (See Appendix H). All concept statments having a calculated percentage value (as noted) equal to or greater than this cut-point value were considered "important" as prerequisites to training in automotive technology.

9. Concept statements that were rated by more than half of the respondents as "critical" were considered as

having "critical importance" to training in automotive technology.

Research Question #1

This question was: What do automotive technology instructors perceive to be the importance of selected mechanical concepts as prerequisites to training in automotive technology? In order to answer this question items 1 through 15 of the survey questionnaire were analyzed. These are listed on Table 3 rank-ordered from highest to lowest percentage value. Each is accompanied by a frequency distribution of responses, percentage value (calculated as noted), mean response value, and standard deviation.

The percentage value cut-point for the final data set corresponding to a Chi square value at the .01 level of significance (see Appendix H) was calculated at 61.54. All 15 items in this category have percentage values greater than this value. This provides substantial support for a claim that all 15 concepts in the mechanical area are "important" prerequisites to automotive training.

Three of the 15 items in this group, "understands and uses mechanical test equipment," "mechanical-electrical

Table 3

Mechanical Concepts

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
01.	UNDERSTANDS AND USES MECHANICAL TEST EQUIPMENT	2	3	23	102	96.15	2.73	0.58
02.	TRANSMISSION OF MECHANICAL POWER	1	5	59	65	95.38	2.45	0.61
03.	MECHANICAL-ELECTRICAL TRANSDUCERS	1	7	44	78	93.85	2.53	0.64
04.	MECHANICAL-ELECTRICAL ENERGY CONVERSIONS	1	7	53	69	93.85	2.46	0.64
05.	SOURCES OF MECHANICAL FORCE	2	9	55	64	91.54	2.39	0.69
06.	MECHANICAL RESISTANCE	1	12	81	36	90.00	2.17	0.61
07.	MECHANICAL-FLUIDAL ENERGY CONVERSIONS	1	14	67	48	88.46	2.25	0.67
08.	MECHANICAL-THERMAL ENERGY CONVERSIONS	4	15	60	51	85.38	2.22	0.77
09.	MECHANICAL POWER CONCEPTS	1	19	70	40	84.62	2.14	0.68
10.	TYPES OF MECHANICAL FORCE	1	23	76	30	81.54	2.03	0.66
11.	MECHANICAL FORCE TRANSFORMERS	1	28	66	35	77.69	2.04	0.72
12.	MECHANICAL-PNEUMATIC ENERGY CONVERSIONS	4	32	66	28	72.31	1.91	0.76

Table 3 (continued)

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
13.	MECHANICAL ENERGY ACCUMULATORS	1	37	73	19	70.77	1.85	0.66
14.	VIBRATIONS/WAVES IN MECHANICAL SYSTEMS	7	32	73	18	70.00	1.78	0.75
15.	MECHANICAL LAWS & THEOREMS	3	47	66	14	61.54	1.70	0.69

transducers," and "mechanical-electrical energy conversions" were rated by the respondents as having "critical importance" as prerequisites to training in automotive technology.

Research Question #2

This question was: What do automotive technology instructors perceive to be the importance of selected fluidal concepts as prerequisites to training in automotive technology? In order to answer this question items 16 through 28 of the survey questionnaire were analyzed. These are listed on Table 4 rank-ordered from highest to lowest percentage value. Each is accompanied by a

Table 4

Fluidal Concepts:

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
01.	UNDERSTANDS AND USES FLUIDAL/ PNEUMATIC TEST EQUIPMENT	4	11	42	73	88.46	2.42	0.78
02.	PHYSICAL PROPERTIES OF FLUIDS	3	24	68	35	79.23	2.04	0.74
03.	FLUIDAL FORCE	4	27	61	38	76.15	2.02	0.79
04.	FLUIDAL FORCE TRANSFORMERS	4	27	67	32	76.15	1.98	0.76
05.	FLUIDAL TANKS, SEALS, AND FILTERS	7	27	70	26	73.85	1.88	0.78
06.	FLUIDAL RESISTANCE	4	31	72	23	73.08	1.88	0.73
07.	FLUIDAL TRANSDUCERS	7	29	53	41	72.31	1.98	0.87
08.	FLUIDAL CONTROL DEVICES	5	31	67	27	72.31	1.89	0.77
09.	FLUIDAL CONDUCTORS	6	37	66	21	66.92	1.78	0.77
10.	FLUIDAL-MECHANICAL ENERGY CONVERSIONS	4	48	56	22	60.00	1.74	0.77
11.	FLUIDAL ENERGY ACCUMULATORS	8	44	61	17	60.00	1.67	0.78
12.	VIBRATIONS AND WAVES IN FLUIDAL SYSTEMS	11	42	58	19	59.23	1.65	0.83
13.	FLUIDAL/PNEUMATIC LAWS AND THEOREMS	10	45	58	17	57.69	1.63	0.81

frequency distribution of responses, percentage value (calculated as noted), mean response value, and standard deviation.

The percentage value cut-point for the final data set corresponding to a Chi square value at the .01 level of significance (see Appendix H) was calculated at 61.54. Nine of the 15 concepts in the fluidal category had percentage values greater than this value. This provides substantial support for a claim that 9 concepts in the fluidal area are "important as prerequisites to training in automotive technology". One of these items, "understands and uses fluidal/pneumatic test equipment" was also rated by the respondens as having "critical importance" as a prerequisite to training in automotive technology.

Research Question #3

This question was: What do automotive technology instructors perceive to be the importance of selected electrical/electronic concepts as prerequisites to training in automotive technology? In order to answer this question items 29 through 62 of the survey questionnaire were analyzed. These are listed on Table 5 rank-ordered from highest to lowest percentage value. Each is accompanied by a frequency distribution of responses, percentage value (calculated as noted), mean response value, and standard deviation.

The percentage value cut-point for the final data set corresponding to a Chi square value at the .01 level of significance (see Appendix H) was calculated at 61.54. All 34 concept statements have a percentage value greater than this value. This provides substantial support for a claim that all 34 concepts in the electrical/electronic area are "important" prerequisites to training in automotive technology. Seventeen of these 34 items, furthermore, were rated by the respondents as having "critical importance" as prerequisites to training in automotive technology".

Table 5

Electrical/Electronic Concepts

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
01.	UNDERSTANDS AND USES VOLTAGE METERS	2	3	9	116	96.15	2.84	0.53
02.	UNDERSTANDS AND USES AMMETERS	3	2	15	110	96.15	2.78	0.59
03.	SOURCES OF ELECTRICITY	1	4	40	85	96.15	2.61	0.59

Table 5 (continued)

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
04.	UNDERSTANDS AND USES OHMMETERS	4	2	11	113	95.38	2.79	0.62
05.	UNDERSTANDS ELECTRICAL SYMBOLS AND SCHEMATICS	3	3	24	100	95.38	2.70	0.63
06.	ELECTROMOTIVE FORCE (VOLTAGE)	2	4	35	89	95.38	2.62	0.63
07.	VOLTAGE IN SERIES, PARALLEL, SERIES/PARALLEL CIRCUITS	3	5	28	94	93.85	2.64	0.67
08.	ELECTRICAL RESISTANCE	3	5	29	93	93.85	2.63	0.67
09.	ELECTRICAL TRANSDUCERS AND CONTROL CIRCUITS	2	6	48	74	93.85	2.50	0.66
10.	ELECTRICAL CURRENT (AMPERAGE)	3	5	49	73	93.85	2.48	0.68
11.	ELECTRICAL-MECHANICAL ENERGY CONVERSIONS	2	6	59	63	93.85	2.41	0.66
12.	UNDERSTANDS AND USES AUTOMOTIVE COMPUTER TEST EQUIPMENT	5	3	23	98	93.08	2.66	0.71
13.	ELECTRICAL SEMICONDUCTORS AND SEMICONDUCTOR DEVICES	2	8	50	70	92.31	2.45	0.68
14.	ELECTRONIC VOLTAGE REGULATORS	5	5	59	61	92.31	2.35	0.74
15.	UNDERSTANDS AND USES ELECTRONIC TEST EQUIPMENT	4	7	24	95	91.54	2.62	0.63

Table 5 (continued)

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
16.	AMPERAGE IN SERIES, PARALLEL, SERIES/PARALLEL CIRCUITS	3	10	34	83	90.00	2.52	0.74
17.	OHM'S LAW	3	11	48	68	89.23	2.39	0.74
18.	ELECTRICAL CONDUCTORS	3	11	50	66	81.54	2.38	0.74
19.	RESISTANCE IN SERIES, PARALLEL, SERIES/PARALLEL CIRCUITS	3	13	35	79	87.69	2.46	0.77
20.	ELECTRICAL POWER CONCEPTS	4	12	50	64	87.69	2.34	0.77
21.	BASIC COMPUTER/ MICROPROCESSOR INTERFACING	5	11	50	64	87.69	2.33	0.79
22.	ELECTRICAL FORCE TRANSFORMERS	3	16	60	51	85.38	2.22	0.79
23.	ELECTRICAL ENERGY ACCUMULATORS	4	15	60	51	85.38	2.22	0.77
24.	ELECTROMECHANICAL VOLTAGE/CURRENT REGULATORS	3	18	57	52	83.85	2.21	0.76
25.	READS AND UNDERSTANDS AC AND DC OSCILLOSCOPE WAVEFORMS	6	17	37	70	82.31	2.32	0.87
26.	AC/DC RECTIFIERS	3	20	58	49	82.31	2.18	0.77
27.	TIME CONSTANTS IN ELECTRONIC CIRCUITS	7	18	67	38	80.77	2.05	0.81
28.	BASIC COMPUTER/ MICROPROCESSOR ARCHITECTURE	6	20	60	44	80.00	2.09	0.82

Table 5 (continued)

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
29.	TRANSISTOR AMPLIFIER CONCEPTS/CIRCUITS	6	20	61	43	80.00	2.08	0.82
30.	PROPERTIES OF ELECTRICAL INSULATORS	3	25	61	41	78.46	2.08	0.77
31.	ELECTRICAL-THERMAL ENERGY CONVERSIONS	4	26	56	44	76.92	2.08	0.82
32.	HAS COMPUTER USER SKILLS	5	29	66	30	73.85	1.93	0.78
33.	UNDERSTANDS HIGH IMPEDENCE ISOLATION TESTING	8	31	57	34	70.00	1.90	0.86
34.	KIRCHOFF'S LAW	11	31	43	45	67.69	1.94	0.96

Research Question #4

This question was: What do automotive technology instructors perceive to be the importance of selected thermal concepts as prerequisites to training in automotive technology? In order to answer this question items 63 through 72 of the survey questionnaire were analyzed. These are listed on Table 6 rank-ordered from highest to lowest percentage value. Each is accompanied by a frequency distribution of responses, percentage value (calculated as

Table 6

Thermal Concepts

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
01.	THERMAL TRANSDUCERS	6	19	77	28	80.77	1.98	0.74
02.	SOURCES OF THERMAL ENERGY	3	23	75	29	80.00	2.00	0.70
03.	UNDERSTANDS AND USES THERMAL TEST EQUIPMENT	4	24	64	38	78.46	2.05	0.78
04.	THERMAL-MECHANICAL ENERGY CONVERSIONS	6	28	76	20	73.85	1.85	0.73
05.	THERMAL-ELECTRIC ENERGY CONVERSIONS	7	40	67	16	63.85	1.71	0.75
06.	THERMAL CONDUCTION PROPERTIES OF MATERIALS	7	42	62	19	62.31	1.71	0.77
07.	THERMAL LAWS AND THEOREMS	12	41	57	20	59.23	1.65	0.85
08.	THERMAL RESISTANCE PROPERTIES OF MATERIALS	10	47	59	14	56.15	1.59	0.78
09.	THERMAL ENERGY ACCUMULATORS	12	56	52	10	47.69	1.46	0.77
10.	TIME CONSTANTS IN THERMAL SYSTEMS	13	56	54	7	46.92	1.42	0.75

noted in Chapter 3), mean response value, and standard deviation.

The percentage value cut-point for the final data set corresponding to a Chi square value at the .01 level of significance (see Appendix H) was calculated at 61.54. Six of the 10 questionnaire items had percentage values greater than this value. This provides substantial support for a claim that 6 concepts in the thermal area are "important" as prerequisites to training in automotive technology. It is also significant that none of the 10 items in this category can be claimed as having "critical importance" as prerequisites to training in automotive technology.

Research Question #5

This question was: What do automotive technology instructors perceive to be the importance of selected chemical concepts as prerequisites to training in automotive technology? In order to answer this question items 73 through 77 of the survey questionnaire were analyzed. These are listed on Table 8 rank-ordered from highest to lowest percentage value. Each is accompanied by a frequency distribution of responses, percentage value (calculated as noted), mean response value, and standard deviation.

Table 7

Chemical Concepts

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
01.	CATALYTIC CONVERSION OF EXHAUST GASES	6	15	60	49	83.85	2.17	0.81
02.	COMBUSTION OF HYDROCARBONS IN AIR	6	16	56	52	83.01	2.18	0.82
03.	BASIC CHEMICAL/PHYSICAL PROPERTIES OF MATERIALS	8	40	61	20	62.31	1.72	0.80
04.	THERMOPLASTIC TRANSFORMATIONS	12	42	59	17	58.46	1.62	0.83
05.	ELECTROCHEMISTRY	10	52	54	14	52.31	1.55	0.79

The percentage value cut-point for the final data set corresponding to a Chi square value at the .01 level of significance (see Appendix H) was calculated at 61.54. Three of the 5 concept statements in this category had percentage values greater than this value. This provides substantial support for a claim that 3 concepts in the chemical area are "important" as prerequisites to training in automotive technology. It is also significant that none of the concept statements in the this group can be claimed as having "critical importance" as prerequisites to training in automotive technology.

Research Question #6

This question was: For those concepts identified in research questions #1 through #5, what is the rank order of each concept within each category on the variable "importance as a prerequisite to training in automotive technology"? In order to answer this question, concepts identified in Tables 3 through 7 were rank-ordered from highest to lowest percentage value within each of the five applied physics subsets. Where two or more concepts were found to have the same percentage value, rank-order was determined using the higher mean value. Where two or more concepts were found to also have the same mean value, rank-order was assigned using the smaller standard deviation.

When one looks critically at the concepts and concept areas definite prepotencies are evident. Concept statements dealing with applied topics such as "understands and uses. . .test equipment" are almost uniformly rated as having "critical importance" as prerequisites to training in automotive technology". Concept statements dealing with theoretical things such as ". . .laws and theorems", on the other hand, are rated nearer the bottom. Three of these concept statements, "mechanical laws and theorems", "fluidal laws and theorems", and "thermal laws and theorems" account for 3 of the 10 lowest rated items. At the same time, however, it is very significant that theoretical concepts dealing with the behavior of electricity in electrical/electronic circuits were all rated as having "critical importance" to training in automotive technology.

A grand mean was also calculated for each concept area. The area having the highest grand mean value was electrical/electronic (2.38) followed by mechanical (2.18), fluidal (1.89), chemical (1.85), and thermal (1.74). These values agree with the rank-order amongst the five concept areas. Accounting for 34 of the 67 concepts rated as "important" or better and 17 of the 21 items found to be "critical", the electrical/electronic concept group is clearly the highest ranking area. In second place with all 15 of its concept statements rated as "important" or better and three items placed in the "critical" category is the mechanical area. With 9 of its 13 items rated as "important" and one item in the "critical" category, the fluidal category occupies the third position. The chemical and thermal categories are tied at the bottom. Each had 60 percent of its items rated as "important" while neither had a single concept placed in the "critical" group. Using their respective grand mean values as a tie-breaker, chemical concepts are rank-ordered fourth and thermal concepts fifth.

Research Question #7

This question was: For those concepts identified in Research Questions #1 through #5, what is the overall rank-order of each concept without regard to category on the variable "importance as a prerequisite to training in automotive technology"? In order to answer this question all concept statements appearing on the survey instrument were rank-ordered from high to low by percentage value and displayed as Table 8. Where two or more concept statements were found to have the same percentage value, rank-order was determined using the highest mean value. Where two or more concept statements are also found to have the same mean value, rank-order was assigned using the smaller standard deviation.

When one looks critically at the rank-ordered concept statements, the dominance of electrical/electronic items becomes immediately apparent. It is significant, too, that as the importance rating increases, the standard deviation of response values become more tightly grouped about the mean. This is significant evidence of higher levels of agreement as regards the higher rated items.

A grand mean response value and standard deviation were also calculated for the combined 77 questionnaire items. These were 2.14 and 0.82 respectively.

Table 8

Applied Physics Concepts:

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
01.	UNDERSTANDS AND USES VOLTAGE METERS	2	3	9	116	96.15	2.84	0.53
02.	UNDERSTANDS AND USES AMMETERS	3	2	15	110	96.15	2.78	0.59
03.	UNDERSTANDS AND USES MECHANICAL TEST EQUIPMENT	2	3	23	102	96.15	2.73	0.58
04.	SOURCES OF ELECTRICITY	1	4	40	85	96.15	2.61	0.59
05.	UNDERSTANDS AND USES OHMMETERS	4	2	11	113	95.38	2.79	0.62

Table 8 (continued)

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
06.	UNDERSTANDS ELECTRICAL SYMBOLS AND SCHEMATICS	3	3	24	100	95.38	2.70	0.63
07.	ELECTROMOTIVE FORCE (VOLTAGE)	2	4	35	89	95.38	2.62	0.63
08.	TRANSMISSION OF MECHANICAL POWER	1	5	59	65	95.38	2.45	0.61
09.	VOLTAGE IN SERIES, PARALLEL, SERIES/PARALLEL CIRCUITS	3	5	28	94	93.85	2.64	0.67
10.	ELECTRICAL RESISTANCE	3	5	29	93	93.85	2.63	0.67
11.	MECHANICAL-ELECTRICAL TRANSDUCERS	1	7	44	78	93.85	2.53	0.64
12.	ELECTRICAL TRANSDUCERS AND CONTROL CIRCUITS	2	6	48	74	93.85	2.50	0.66
13.	ELECTRICAL CURRENT (AMPERAGE)	3	5	49	73	93.85	2.48	0.68
14.	MECHANICAL-ELECTRICAL ENERGY CONVERSIONS	1	7	53	69	93.85	2.46	0.64
15.	ELECTRICAL-MECHANICAL ENERGY CONVERSIONS	2	6	59	63	93.85	2.41	0.66
16.	UNDERSTANDS AND USES AUTOMOTIVE COMPUTER TEST EQUIPMENT	5	3	23	98	93.08	2.66	0.71
17.	ELECTRICAL SEMICONDUCTORS AND SEMICONDUCTOR DEVICES	2	8	50	70	92.31	2.45	0.68

Table 8 (continued)

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
18.	ELECTRONIC VOLTAGE REGULATORS	5	5	59	61	92.31	2.35	0.74
19.	UNDERSTANDS AND USES ELECTRONIC TEST EQUIPMENT	4	7	24	95	91.54	2.62	0.63
20.	SOURCES OF MECHANICAL FORCE	2	9	55	64	91.54	2.39	0.69
21.	AMPERAGE IN SERIES, PARALLEL, SERIES/PARALLEL CIRCUITS	3	10	34	83	90.00	2.52	0.74
22.	MECHANICAL RESISTANCE	1	12	81	36	90.00	2.17	0.61
23.	OHM'S LAW	3	11	48	68	89.23	2.39	0.74
24.	ELECTRICAL CONDUCTORS	3	11	50	66	89.23	2.38	0.74
25.	UNDERSTANDS AND USES FLUIDAL/PNEUMATIC TEST EQUIPMENT	4	11	42	73	88.46	2.42	0.78
26.	MECHANICAL-FLUIDAL ENERGY CONVERSIONS	1	14	67	48	88.46	2.25	0.67
27.	RESISTANCE IN SERIES, PARALLEL, SERIES/PARALLEL CIRCUITS	3	13	35	79	87.69	2.46	0.77
28.	ELECTRICAL POWER CONCEPTS	4	12	50	64	87.69	2.34	0.77
29.	BASIC COMPUTER/ MICROPROCESSOR INTERFACING	5	11	50	64	87.69	2.33	0.79
30.	ELECTRICAL FORCE TRANSFORMERS	3	16	60	51	85.38	2.22	0.79

Table 8 (continued)

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
31.	ELECTRICAL ENERGY ACCUMULATORS	4	15	60	51	85.38	2.22	0.77
32.	MECHANICAL-THERMAL ENERGY CONVERSIONS	4	15	60	51	85.38	2.22	0.77
33.	MECHANICAL POWER CONCEPTS	1	19	70	40	84.62	2.14	0.68
34.	ELECTROMECHANICAL VOLTAGE/CURRENT REGULATORS	3	18	57	52	83.85	2.21	0.76
35.	CATALYTIC CONVERSION EXHAUST GASES	6	15	60	49	83.85	2.17	0.81
36.	COMBUSTION OF HYDROCARBONS IN AIR	6	16	56	52	83.01	2.18	0.82
37.	READS AND UNDERSTANDS AC AND DC OSCILLOSCOPE WAVEFORMS	6	17	37	70	82.31	2.32	0.87
38.	AC/DC RECTIFIERS	3	20	58	49	82.31	2.18	0.77
39.	TYPES OF MECHANICAL FORCE	1	23	76	30	81.54	2.03	0.66
40.	TIME CONSTANTS IN ELECTRONIC CIRCUITS	7	18	67	38	80.77	2.05	0.81
41.	THERMAL TRANSDUCERS	6	19	77	28	80.77	1.98	0.74
42.	BASIC COMPUTER/ MICROPROCESSOR ARCHITECTURE	6	20	60	44	80.00	2.09	0.82
43.	TRANSISTOR AMPLIFIER CONCEPTS/CIRCUITS	6	20	61	43	80.00	2.08	0.82

Table 8 (continued)

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
44.	SOURCES OF THERMAL ENERGY	3	23	75	29	80.00	2.00	0.70
45.	PHYSICAL PROPERTIES OF FLUIDS	3	24	68	35	79.23	2.04	0.74
46.	PROPERTIES OF ELECTRICAL INSULATORS	3	25	61	41	78.46	2.08	0.77
47.	UNDERSTANDS AND USES THERMAL TEST EQUIPMENT	4	24	64	38	78.46	2.05	0.78
48.	MECHANICAL FORCE TRANSFORMERS	1	28	66	35	77.69	2.04	0.72
49.	ELECTRICAL-THERMAL ENERGY CONVERSIONS	4	26	56	44	76.92	2.08	0.82
50.	FLUIDAL FORCE	4	27	61	38	76.15	2.02	0.79
51.	FLUIDAL FORCE TRANSFORMERS	4	27	67	32	76.15	1.98	0.76
52.	HAS COMPUTER USER SKILLS	5	29	66	30	73.85	1.93	0.78
53.	FLUIDAL TANKS, SEALS, AND FILTERS	7	27	70	26	73.85	1.88	0.78
54.	THERMAL-MECHANICAL ENERGY CONVERSIONS	6	28	76	20	73.85	1.85	0.73
55.	FLUIDAL RESISTANCE	4	31	72	23	73.08	1.88	0.73
56.	FLUIDAL TRANSDUCERS	7	29	53	41	72.31	1.98	0.87
57.	FLUIDAL CONTROL DEVICES	5	31	67	27	72.31	1.89	0.77
58.	MECHANICAL-PNEUMATIC ENERGY CONVERSIONS	4	32	66	28	72.31	1.91	0.76

Table 8 (continued)

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
59.	MECHANICAL ENERGY ACCUMULATORS	1	37	73	19	70.77	1.85	0.66
60.	UNDERSTANDS HIGH IMPEDENCE ISOLATION TESTING	8	31	57	34	70.00	1.90	0.86
61.	VIBRATIONS/WAVES IN MECHANICAL SYSTEMS	7	32	73	18	70.00	1.78	0.75
62.	KIRCHOFF'S LAW	11	31	43	45	67.69	1.94	0.96
63.	FLUIDAL CONDUCTORS	6	37	66	21	66.92	1.78	0.77
64.	THERMAL-ELECTRIC ENERGY CONVERSIONS	7	40	67	16	63.85	1.71	0.75
65.	BASIC CHEMICAL/PHYSICAL PROPERTIES OF MATERIALS	8	40	61	20	62.31	1.72	0.80
66.	THERMAL CONDUCTION PROPERTIES OF MATERIALS	7	42	62	19	62.31	1.71	0.77
67.	MECHANICAL LAWS AND THEOREMS	3	47	66	14	61.54	1.70	0.69
68.	FLUIDAL-MECHANICAL ENERGY CONVERSIONS	4	48	56	22	60.00	1.74	0.77
69.	FLUIDAL ENERGY ACCUMULATORS	8	44	61	17	60.00	1.67	0.78
70.	THERMAL LAWS AND THEOREMS	12	41	57	20	59.23	1.65	0.85
71.	VIBRATIONS AND WAVES IN FLUIDAL SYSTEMS	11	42	58	19	59.23	1.65	0.83

Table 8 (continued)

Rank-Order	Concept	0	1	2	3	2+3/n	Mean	S.D.
72.	THERMOPLASTIC TRANSFORMATIONS	12	42	59	17	58.46	1.62	0.83
73.	FLUIDAL/PNEUMATIC LAWS AND THEOREMS	10	45	58	17	57.69	1.63	0.81
74.	THERMAL RESISTANCE PROPERTIES OF MATERIALS	10	47	59	14	56.15	1.59	0.78
75.	ELECTROCHEMISTRY	10	52	54	14	52.31	1.55	0.79
76.	THERMAL ENERGY ACCUMULATORS	12	56	52	10	47.69	1.46	0.77
77.	TIME CONSTANTS IN THERMAL SYSTEMS	13	56	54	7	46.92	1.42	0.75

Summary

The purpose of this chapter has been to present and analyze data pertinent to this study. Table 1 has presented the population of the study. Table 2 sets out the characteristics of the population. Following these, data pertinent to the research questions are set out and analyzed in Tables 3 through 8. Findings, conclusions, and recommendations that follow from these analyses are set forth in Chapter 5.

CHAPTER 5

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Study

This study was undertaken as a direct response to Brooking and Reindeau's (1980) recommendation that studies be undertaken in curriculum and program development for new and changing technologies, particularly in the area of:

> how to teach under-prepared students (academically) [parenthesis in original]. . .for successful entry into quality rigorous programs. . .[especially those students] who have little preparation in the mathematics and science base required by modern technology programs. (p.89)

Specifically, its purposes have been to:

1. Develop information that may be useful to guidance counselors, administrators, and curriculum specialists regarding the importance of selected applied physics concepts as prerequisites to training in automotive technology.

2. Develop information that may be useful in the preparation of curriculums and materials dedicated specifically to the remediation of applied physics knowledge

and skill deficits demonstrated by entering automotive technology students.

In order to accomplish these purposes the following procedure was followed:

An extensive review of the literature was undertaken in order to identify specific applied physics concepts that this researcher viewed as having potential value as prerequisites to training in automotive technology. A list of these concepts was developed and then analyzed against the 437 standard tasks of the National Automotive Technicians Education Foundation (NATEF) Curriculum. Via this screening process the original list was both expanded and refined. The remaining list of concept statements was then combined into the first draft of the survey instrument which was subsequently reviewed by an expert panel, revised, reviewed by a second expert panel, pilot tested, and approved by this researcher's Doctoral Advisory Committee. Thusly validated, the final instrument included 77 items grouped within five concept areas: mechanical, fluidal, electrical/ electronic, thermal, and chemical.

The survey questionnaire was then administered by mailed correspondence to 197 automotive technology instructors who were teaching full-time in California's community colleges during the spring 1989 semester. One hundred and thirty (66.33%) usable questionnaires were returned. For each questionnaire item a frequency distribution of responses, percentage value, mean response value, and standard deviation was calculated. A percentage value cut-point corresponding to a Chi square goodness-of-fit test at the .01 level of significance was also calculated for the entire data set.

The collected data was used to answer the following research questions:

1. What do automotive technology instructors perceive to be the importance of selected mechanical concepts as prerequisites to training in automotive technology?

2. What do automotive technology instructors perceive to be the importance of selected fluidal concepts as prerequisites to training in automotive technology?

3. What do automotive technology instructors perceive to be the importance of selected electrical/electronic concepts as prerequisites to training in automotive technology?

4. What do automotive technology instructors perceive to be the importance of selected thermal concepts as prerequisites to training in automotive technology?

5. What do automotive technology instructors perceive to be the importance of selected chemical concepts as prerequisites to training in automotive technology?

6. For those concepts identified in research questions #1 through #5 above, what is the rank-order of each concept within each category on the variable "importance as a prerequisited to training in automotive technology"?

7. For those concepts identified in research questions #1 through #5 above, what is the rank-order of each concept without regard for to category on the variable "importance as a prerequisite to training in automotive technology"?

In order to answer research questions #1 through #5 concept statements were listed in rank-order by percentage value on five separate tables by concept area along with respective response frequency distributions, percentage values, mean response values, and standard deviations. All concepts having a percentage value greater than or equal to the calculated percentage cut-point were considered "important" as prerequisites to training in automotive technology. Concept statements rated by more than half of the respondents as "critical" were considered as having "critical importance" as prerequisites to training in automotive technology.

In order to answer research question #6 the relationship of the rank-ordered concept statements within each of the five concept areas were analyzed. Rank-order amongst the five concept groups was also established using the grand mean value for each category.

In order to answer research question #7, all 77 concept statements were rank-ordered from high to low by percentage value without regard to category. Grand mean response values and standard deviations were calculated for each of the five concept areas and for the entire data set.

Findings

This study was designed to analyze the importance of selected applied physics concepts as prerequisites to training in automotive technology. The findings, based on the analyses and presentation of data, are as follows:

1. Three mechanical concepts were demonstrated as having "critical importance". The remaining 12 mechanical concepts were found to be "important". Amongst the five concept areas, the mechanical category ranked second highest in importance.

2. One fluidal concept was demonstrated as having "critical importance". Of the remaining 12 concepts, 8 were found to be "important". Amongst the five concept areas, the fluidal category ranked third in importance.

3. Seventeen electrical/electronic concepts were demonstrated as having "critical importance". The remaining 17 were found to be "important". Amongst the five concept areas, the electrical/ electronic category ranked first in importance.

4. Six of 10 thermal concepts were found to be "important". No thermal concepts qualified as having "critical importance". Amongst the five concept areas, the thermal category ranked fifth (lowest) in importance.

5. Three of 5 chemical concepts were found to be "important". No chemical concepts qualified as having "critical importance". Amongst the five concept areas, the chemical category ranked fourth in importance.

6. The over-all rank-ordering of all 77 survey items shows 67 of survey items (87.01%) rated as "important" or higher. Of these, 21 (22.27% of all 77 survey items) were rated as having "critical importance".

7. Within all concept categories except electrical/electronic, "applied" concepts such as

"understands and uses __________" were rated as having greater importance while "theoretical" concepts such as "__________ laws and theorems" were rated as being much less important.

8. Within the electrical/electronic category, unlike the other four, theoretical concepts dealing with the behavior of electricity were all rated as having "critical importance".

9. A stronger level of agreement (smaller standard deviation) was demonstrated by the more highly ranked concepts.

Conclusions

This study was undertaken in order to provide descriptive information concerning the importance of selected applied physics concepts as prerequisites to training in automotive technology. Four conclusions have been reached. Each carries clear implications for automotive curriculum developers and trainers. These conclusions are:

1. The findings of this study suggest that applied physics is foundational to training in automotive technology. Sixty-seven of the 77 concepts investigated in

this study have been demonstrated to be important prerequisites to learning automotive subject matter. Of these, 21 have been found to have critical importance. (A list of these concepts is set out as Appendix I). This implies that the learning success of the automotive technology trainee is related to pre-course knowledges and skills in applied physics.

2. As prerequisites to training in automotive technology, this study has demonstrated a definite rank-order amongst the five categories of applied physics concepts. Electricity/electronics ranks as the most important, followed closely by mechanical, at a distance by fluidal, and at a further distance yet by chemical and thermal. This finding implies a rank-order of curricular emphasis relative to each concept area.

3. With the notable exception of the electrical/ electronic category, this study demonstrates the existence of a large divergence in the rank-order of <u>applied</u> versus <u>theoretical</u> concepts. Within the mechanical, fluidal, thermal, and chemical groups, <u>applied</u> concepts and skills were found to be either important or critical as prerequisites to training in automotive technology. Concepts and skills having a more <u>theoretical</u> nature, on

the other hand, were ranked near the bottom. This suggests that theoretical knowledge in the mechanical, fluidal, thermal, and chemical areas are considered by the respondents of this study to have little or no importance as prerequisites to training in automotive technology. Applied knowledges and skills in these areas, by comparison, are considered very important. It follows, then, that a student entering vocational automotive training should possess fundamental applied knowledges and skills in these areas.

4. Within the electrical/electronic domain, the respondents of this study considered all concepts and skills, both theoretical and applied, as either important or critical as prerequisites to training in automotive technology. This suggests that a student entering vocational automotive training should be well prepared in both the applied and theoretical fundamentals of electricity/electronics.

Recommendations

Based on the findings and conclusions of this study, the following recommendations are offered:

1. Satisfactory completion of coursework in applied physics should be a prerequisite to entry in vocational automotive programs. The Principles of Technology, developed by the Center for Occupational Research and Development (CORD) of Waco, Texas, would be ideal.

2. Coursework in applied physics as it relates to all phases of vocational automotive technology should be a part of the vocational automotive curriculum and required for students who have a deficiency in these knowledges and/or skills.

3. High school counselors and administrators need to acknowledge the dramatic increase in amount and kind of education required for successful entry and continued success in today's automotive maintenance and repair industry. They need to direct a higher caliber of student into vocational automotive training programs, ones who possess the knowledges and skills that they must have in order to learn state-of-the-art automotive technology.

4. Given the rapidly increasing complexity of the automobile and the constraints of a two-year curriculum, automotive technician training programs might be better placed as a concentration within four-year engineering or industrial technology programs.

Recommendations for Further Study

A number of recommendations for further study follow from the findings and conclusions of this study. Some of the more prominent of these are:

1. The method used to identify and validate the applied physics concepts investigated in this study should be expanded and refined.

2. A study should be conducted to determine the applied science knowledges and skills actually possessed by the typical student entering vocational automotive programs.

3. Within the domain of vocational automotive training, a study should be conducted to demonstrate the effects of pre-course knowledges and skills in applied science on post-course outcomes.

4. A study should be conducted to determine the depth of knowledge required of each selected applied physics concept and/or skill relative to training in state-of-the-art automotive technology.

5. An investigation should be undertaken to determine the mathematical concepts that are fundamental to training in each of the eight recognized automotive specializations.

6. A study should be made of the relationship of electronic computer knowledges and skills to training in automotive technology.

7. The survey questionnaire used in this study should be administered to a random sample of competent journeymen automotive technicians to determine the level of agreement with the findings of this study.

8. A study should be conducted to determine the relationship of selected applied science knowledges and skills to in-service training of journeymen technicians in state-of-the-art automotive technology.

Summary

This study was designed, executed, and consummated in order to develop information that may be useful in the preparation of curriculums and materials dedicated specifically to the remediation of applied physics knowledge and skill deficits demonstrated by entering automotive technology students. It has involved the identification of a qualified population, the development of a survey instrument, the collection and analyses of specific data, and the setting forth of findings, conclusions, and recommendations. A clear implication of this study is the necessity that secondary and postsecondary administrators, counselors, curriculum developers, and instructors recognize the fundamental relationship of applied physics to automotive technology.

CITED REFERENCES

Abramson, T. (1978). Instructional Support System--Occupational Education II. ISSOE Automotive Mechanics Content Validation. (Report No. CASE-31-78). Albany, NY: City University of New York Center for Advanced Study in Education. (ERIC Document Reproduction Services No. ED 170 506)

Allen, R. (1984). The impact of technology on Hawaii's automotive mechanics: An analysis with recommendations. Honolulu, HW: Hawaii State Commission on Manpower and Full Employment. (ERIC Document Reproduction Service No. ED 260 209)

American National Standards Institute (1979). American national standard for training of automotive mechanics for passenger cars, recreational vehicles, and light trucks (ANSI D18.1-1980). New York: Author.

Barnhart, R. K. (Ed.). (1986). Hammond Barnhart Dictionary of Science. Maplewood, NJ: Hammond, Inc.

Bedell, E. L., & Carpenter, F. (1930). Cooperative training in automotive maintenance. Industrial Arts and Vocational Education, 19(9), 327-329.

Bennett, C. A. (1937). History of manual and industrial education 1870 to 1917. Peoria: Author.

Best, J. W. (1981). Research in education. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Boord, J. O. (1984). High tech and automotive service training. Industrial Education, 73(4), 10.

Borcher, S. D., & Leiter, P. B. (1973). Automotive Mechanics Occupational Performance Survey. (Report No. RD-Ser-86). Columbus, OH: Ohio State University Center for Vocational and Technical Education. (ERIC Document Reproduction Services No. ED 078 126)

Brewer, C. H. (1983). Entry level automobile mechanics tasks. Dissertation Abstracts International, 44, 1768A.

Brock, W. E. (1987). Future shock: The American workforce in the year 2000. American Association of Community/Junior College Journal, 57(4), 25-26.

Brooking, W., & Reindeau, A. (1980). In C. P. Coty (Ed.) Review and synthesis of research and development in technical education. Columbus, OH: ERIC Clearinghouse on Adult, Career, and Vocational Education. (ERIC Document Reproduction Service No. ED 193 526)

Carter, S. R. (1977). An analysis of selected variables and student achievement in beginning automechanics at the college level. Dissertations Abstracts International, 41, 3337A.

Castle, D. W. (1935). Auto mechanics. Industrial Arts and Vocational Education, 24(4), 108-110.

Center for Occupational Research and Development. (1984). Unified technical concepts--physics for technicians (2nd ed.). Waco, TX: Author.

Central Michigan University (1973). Automotive and power service: Cluster guide. Lansing, MI: Author. (ERIC Document Reproduction Service No. ED 091 526)

Chambers dictionary of science and technology. (1974). Edinburgh: W & R Chambers, Ltd..

Choulochas, J., & McKenney, J. (1986). Partnership building. American Association of Community/Junior College Journal, 56(5), 62-64.

Claude, J. (1935). Teaching auto mechanics. Industrial Arts and Vocational Education, 24(8), 331.

Clover, V. T., & Balsley, H. L. (1984). Business Research Methods (3rd ed.). New York: John Wiley & Sons.

Coleman, R. V. (1985). Motor vehicles. United States Industrial Outlook--1985. Washington, DC: U.S. Government Printing Office.

College Blue Book--Occupational Education (21st Edition) (1987). New York: MacMillan Publishing.

Connor, M., & Thoman, L. (1975). An analysis of the auto mechanics occupation. Columbus, OH: Ohio State University Trade and Industrial Education Instructional Materials Laboratory. (ERIC Document Reproduction Service No. ED 107 949)

Co-op training for service technicians: Dealerships sponsor students for automotive training (1985). Industrial Education, 74(8), 28.

Dillenbeck, K. J. (1980, March). Articulation with secondary schools--vocational/technical education. Paper presented at the Annual Convention of the American Association of Community and Junior Colleges. San Francisco, CA. (ERIC Document Reproduction Service No. ED 187 358)

Drost, J. L. (1970). Job characteristics of automotive mechanics in selected Iowa dealerships and garages. Ames, IA: Iowa State University of Science and Technology. (ERIC Document Reproduction Service No. ED 051 382)

Drucker, M. (1934). A course in auto mechanics. Industrial Arts and Vocational Education, 23(4), 142-144.

Ellinger, H. E. (1969). The automotive technology curriculum. Industrial Arts and Vocational Education, 58(9), 18-22.

Emerson, A. L. (1950). Vocational and technical education in the United States. American Vocational Journal, 25(7), 20.

Ferguson, G. A. (1981). Statistical analysis in psychology and education. New York: McGraw-Hill.

Fierer, J. (1979). Auto mechanics in the 80's. Industrial Education, 68(8), 2.

Fierer, J. (1981). Fierer's stand. Industrial Education, 70(4), 4.

Flax, A. (1987, October 5). Servicing the 88's: Its goodbye shadetree, hello computer. Automotive News, p. E-16.

Fleischman, B. (1985). GM teams up with a technical college. Journal of Vocational Education, 60(3), 53.

Flink, J. J. (1970). America adapts to the automobile: 1895-1910. Cambridge MA: MIT Press.

Flink, J. J. (1984). Henry Ford and the triumph of the automobile. In C. W. Pursell, Jr. (Ed.), Technology in America: A history of individuals and ideas (pp. 163-175). Cambridge, MA: MIT Press.

Foster, M. S. (1980). The automobile and the city. In D. F. Lewis (Ed.), The Automobile and American Culture. Ann Arbor, MI: University of Michigan Press.

GM dealers participate in new training program. (1970). American Vocational Journal, 45(8), 106.

Garcia, J. R. (1988). Fundamental concepts required for electromechanical technology graduates for entry-level employment in related industry. Unpublished doctoral dissertation, University of Northern Iowa, Cedar Falls, IA.

Gay, L. R. (1981). Educational Research. Columbus, OH: Merrill publishing.

Goodrich, A. C. (1937). Automechanics vs automotive service. Industrial Arts and Vocational Education, 26(2), 35-42.

Grosse, B. E. (1983). Automotive mechanatronics. Journal of Vocational Education, 58(3), 61-62.

Hawkins, L. S., Prosser, C. A., & Wright, J. C. (1951). Development of Vocational Education. Chicago: American Technical Society.

Helzer, S. C. (1986). Current practices and future trends in pre-employment skill requirements for welding technologists. Dissertation Abstracts International, 47, 4364A.

Henninger, G. R. (1959). The technical institute in America. New York: McGraw-Hill.

Heyler, J. (1988, August). Training still means people in 1999. Paper presented at the Society of Automotive Engineers Conference and Exposition on Future Transportation Technology, San Francisco, CA.

Hopkins, C. D. (1980). Understanding Educational Research. Columbus, OH: Bell and Howell Company.

Horning, S. D. (1928). Auto mechanics in the junior high school. Industrial Arts Magazine, 17(5), 157-159.

Jacobs, L. (1987, December). Who is going to repair tomorrow's complex cars? Brake & Front End, pp. 28-32.

Kahler, A., & Hamburger, E. (1948). Education for an industrial age. New York: Cornell University Press.

Kahn, H. (1982). Technology and auto shop education--an interview. School Shop, 41(3), 24-26.

Kennedy, H. D. (1941). The automobile industry. Clifton, NJ: Augustus M. Kelly Publishers.

Knox, R. J., & Lorenzo, A. L. (1987). Service wars: The race to be the best in product service. Paper presented at the Annual National Convention of the American Association of Community and Junior Colleges. Dallas, TX: (ERIC Document Reproduction Service No. ED 282 603)

Lamb, L. H. (1945). Industrial arts and vocational education in the postwar period. Industrial Arts and Vocational Education, 34(6), 347-48.

Lang, G., & Heiss, G. D. (1894). A practical guide to research methods. New York: University Press of America.

Losh, C. (1981). Automobile mechanic training evaluation project (AMTEP): final report. Atlanta, GA: Southern Association of Colleges and Schools, Commission on Occupational Education Institutions. (ERIC Document No. ED 223 783)

Mager, R. F., & Beach, K. M. (1967). Developing vocational instruction. Belmont, CA: Fearon Publishers.

McCarthy, J. A. (1951). Vocational education: America's greatest resource. Chicago: American Technical Society.

Minnesota State Department of Education - Division of Vocational and Technical Education. (1976). Automotive mechanic: Task list and competency record. St. Paul, MN: Author. (ERIC Document Reproduction Reproduction Service No. ED 128 625)

Mitchell, L. A. (1954). GM's new automotive training program opens in Detroit. American Vocational Journal, 29(4), 28.

Mitchell Automechanics. (1986). Englewood Cliffs, NJ: Prentice-Hall.

Morical, E. O. (1966). Automotive mechanics: Watered-down or worthwhile. Industrial Arts and Vocational Education, 55(4), 38-39.

Motor Vehicles Manufacturers Association (1974). Automobiles of America. Detroit: Wayne State University Press.

Motor Vehicles Manufacturers Association. (1985). Guidelines for automotive service instruction. Detroit: Author.

Motor Vehicles Manufacturers Association (1988, November). Newsletter of the Motor Vehicles Manufacturers Association. Available from the Motor Vehicles Manufacturers Association, Detroit, MI.

National Automotive Technicians Education Foundation (1988, October). National NATEF Certification Statistics. Available from the National Automotive Technicians Foundation, Reston, VA.

North Carolina State Department of Community Colleges. (1977). State articulated instructional objectives guide for occupational education programs. State guide for automechanics. Raleigh, NC: Author. (ERIC Document Reproduction Service No. ED 164 891)

Olsen, M. S. (1939). Industrial education in senior and vocational high schools. Industrial Arts and Vocational Education, 28(6), 233-234.

Phelps, L., & Lutz, R. (1977). Career exploration and preparation for the special needs learner. Boston: Allyn & Bacon.

Prosser, C. A. (1949). Vocational education in a democracy. Chicago: American Technical Society.

Puchinski, R. C. (1971, October). A congressman views technical education. Science Education News, p. 2.

Rae, J. B. (1980). Why Michigan? In D. L. Lewis (Ed.), The automobile and American culture. Ann Arbor, MI: University of Michigan Press.

Real-world training for automotive technicians. (1988). Industrial Education, 77(4), 14-17.

Renzelman, J. H. (1982). Automobile service requirements 1982-1992: implications for automotive educators. Dissertation Abstracts International, 43, 1860A.

Roberts, R. (1965). Vocational and practical arts education. New York: Harper and Row.

Selvidge, R. W. (1931). A cooperative study fostered by the AVA committee on standard. Industrial-Arts Magazine, 20(9), 342-343.

Sinclair, B. (1984). Thomas P. Jones and the evolution of technical education. In C. Pursell (Ed.), Technology in America (pp. 62-71). Cambridge, MA: MIT Press.

Smith, L. F., & Beckley, D. K. (1948). The technical institute of American education. Industrial Arts and Vocational Education, 37 (9), 303-306.

Steigers, J. P. (1988, November 15). Availability and quality of automotive training programs. (Available from Motor Vehicle Manufacturers Association, 7430 Second Avenue, Suite 300, Detroit, MI 48202).

Turner, M. (1966). Wanted: 50,000 auto mechanics. Industrial Arts and Vocational Education, 55(4), 36.

The American repairman--a vanishing breed (1965). U.S. News and World Report, 59(11), 88-90.

U.S. Department of Labor: Employment and Training Administration (1977). Dictionary of occupational titles. Washington, DC: U.S. Government Printing Office.

U.S. Department of Labor Statistics (1987). Occupational outlook handbook. (Bulletin 2250). Washington, DC: U.S. Government Printing Office.

Vance, A. H. (1934). The modern auto shop. Industrial Arts and Vocational Education, 23(6), 209-211.

Wards Automotive Yearbook. (1958). Detroit, MI: Author.

Weinberg G. H., & Schumaker, J. A. (1974). Statistics: An Intuitive Approach (3rd ed.). Monterey, CA: Brooks/Cole Publishing.

Williams, H. A. (1961). The future of automobile service instruction. American Vocational Journal, 36(5), 12-13, 30.

Womack, J., & Jones, D. (1984). The fourth transformation in autos. Technology Review, 87(7), 28-37.

Yu, J. H. (1987). Technical competencies for the electromechanical technician. Dissertation Abstracts International, 48, 909A.

Zion, K. R. (1985). The entry level skills and knowledge required in the automotive collision repair industry of California with implications for curriculum development and management. Dissertation Abstracts International, 47, 447A.

A P P E N D I C I E S

APPENDIX A

SURVEY INSTRUMENT

AN ANALYSIS OF THE IMPORTANCE OF SELECTED APPLIED PHYSICS CONCEPTS AS PREREQUISITES TO TRAINING IN AUTOMOTIVE TECHNOLOGY

- Q U E S T I O N N A I R E -

•• RESPONDENT INFORMATION ••
(circle or fill-in all that apply)

• YOUR AGE: _____ #___________

• AUTOMOTIVE EXPERIENCE:

As a Technician _____ years _____ months As an Instructor _____ years _____ months

• HIGHEST GRADE COMPLETED: 12 13 14 15 16 17 18 19 20

• ACADEMIC DEGREES HELD: AA/AS BA/BS MA/MS EdD/PHD

• CREDENTIAL TYPE: BASIC _____ SPECIAL LIMITED SERVICES _____ OTHER _____

DIRECTIONS: Using the scale and key below, rate each concept on the following pages according to your perception of it's **IMPORTANCE** as a prerequisite to training in state-of-the-art automotive subject matter.

Ø	1	2	3
Not Important	Low Importance	Important	Critical Importance

Ø **Not Important** means the concept or skill is unimportant to learning state-of-the-art automotive subject matter.

1 **Low Importance** means the concept or skill has limited importance to learning state-of-the-art automotive subject matter.

2 **Important** means the concept or skill is helpful to learning state-of-the-art automotive subject matter.

3 **Critical Importance** means the concept or skill is essential to learning state-of-the-art automotive subject matter.

EXAMPLES

IMPORTANCE TO LEARNING --- AUTOMOTIVE SUBJECT MATTER --->	NOT	LOW	IMPORTANT	CRITICAL
00. Has knowledge of advanced calculus	(Ø)	1	2	3
00. Reads and understands written instructions	Ø	1	2	(3)

--- TURN TO THE NEXT PAGE --->

MECHANICAL CONCEPTS — IMPORTANCE TO LEARNING --- AUTOMOTIVE SUBJECT MATTER --->	NOT	LOW	IMPORTANT	CRITICAL
01. SOURCES OF MECHANICAL FORCE (combustion engines, electric motors, solenoids, vacuum motors, etc.)	0	1	2	3
02. TYPES OF MECHANICAL FORCE (linear, rotational)	0	1	2	3
03. MECHANICAL RESISTANCE (sliding friction: ie, clutches, braking systems, rubber compounds, etc.)	0	1	2	3
04. MECHANICAL POWER CONCEPTS (torque, horsepower, etc.)	0	1	2	3
05. TRANSMISSION OF MECHANICAL POWER (shafts, rods, cranks, cams, screws, chains, belts, gears, etc.)	0	1	2	3
06. MECHANICAL LAWS & THEOREMS (ie, Newton's Laws of Motion leverage, torque losses, etc.)	0	1	2	3
07. MECHANICAL ENERGY ACCUMULATORS (springs, gravity, flywheels, etc.)	0	1	2	3
08. MECHANICAL FORCE TRANSFORMERS (simple machines: gear sets, screws, pulleys, levers, cams, etc.)	0	1	2	3
09. MECHANICAL-ELECTRICAL ENERGY CONVERSIONS (alternators, generators)	0	1	2	3
10. MECHANICAL-FLUIDAL ENERGY CONVERSIONS (pumps, shock absorbers, master cylinders, etc.)	0	1	2	3
11. MECHANICAL-PNEUMATIC ENERGY CONVERSIONS (compressors, fans, etc.)	0	1	2	3
12. MECHANICAL-THERMAL ENERGY CONVERSIONS (braking systems, air conditioning systems, etc.)	0	1	2	3
13. MECHANICAL-ELECTRICAL TRANSDUCERS (sensors, sending units, etc.)	0	1	2	3
14. VIBRATIONS AND WAVES IN MECHANICAL SYSTEMS (metal fatigue, knocking, sound diagnostics, etc.)	0	1	2	3
15. UNDERSTANDS AND USES MECHANICAL TEST EQUIPMENT (torque wrenches, spring guages, calipers, micrometers etc.)	0	1	2	3
FLUIDAL/PNEUMATIC CONCEPTS				
16. PHYSICAL PROPERTIES OF FLUIDS (liquids, gases, density, viscosity, compressibility, specific gravity, etc.)	0	1	2	3
17. FLUIDAL FORCE (relationship of pressure and displacement in a fluidal system)	0	1	2	3
18. FLUIDAL CONDUCTORS (pipes, hoses, etc.)	0	1	2	3
19. FLUIDAL CONTROL DEVICES (valves, capillary tubes, etc.)	0	1	2	3
20. FLUIDAL RESISTANCE (filters, restrictions, air flow)	0	1	2	3
21. FLUIDAL/PNEUMATIC LAWS AND THEOREMS (ideal gas laws, Bernoulli's principle, force in liquids, etc.)	0	1	2	3
22. FLUIDAL TANKS, SEALS, AND FILTERS (physical characteristics, maintenance procedures, etc.)	0	1	2	3
23. FLUIDAL ENERGY ACCUMULATORS (pneumatic/mechanical over fluidal devices)	0	1	2	3
24. FLUIDAL FORCE TRANSFORMERS (hydraulic lifts and jacks, pneumatic tools, torque converters, etc.)	0	1	2	3
25. FLUIDAL-MECHANICAL ENERGY CONVERSIONS (turbines, compressors, fluid motors, actuators, lifts, etc.)	0	1	2	3
26. FLUIDAL TRANSDUCERS (flowmeters, Bourdon tube, aneroid bellows, MAP sensor, etc.)	0	1	2	3

FLUIDAL CONCEPTS

27. VIBRATIONS AND WAVE
intake/exhaust man
28. UNDERSTANDS AND USE
(flowmeters, vacuu

ELECTRICAL/ELECTRONI

29. SOURCES OF ELECTRI
alternators, frict
30. ELECTROMOTIVE FORC
potential between
31. VOLTAGE IN SERIES,
(voltage drops, et
32. UNDERSTANDS AND US
33. ELECTRICAL CURRENT
unit of time)
34. AMPERAGE IN SERIES
(current branching
35. UNDERSTANDS AND US
[inductive], digit
36. ELECTRICAL RESISTA
circuit loads, eff
37. RESISTANCE IN SERI
CIRCUITS (computat
38. UNDERSTANDS AND US
39. ELECTRICAL POWER (
40. OHM'S LAW (voltage
41. KIRCHOFF'S LAW (cur
exiting a point)
42. UNDERSTANDS ELECTR
(S.A.E. - industry
43. ELECTRICAL CONDUCT
44. ELECTRICAL SEMICON
(diodes, transisto
45. PROPERTIES OF ELEC
46. ELECTRICAL TRANSDU
sending units, sen
47. ELECTRICAL ENERGY
batteries, etc.)
48. ELECTRICAL FORCE T
coils, inverters,
49. ELECTRICAL-MECHANI
solenoids, relays,
50. ELECTRICAL-THERMAL
light, thermocoupl
51. AC/DC RECTIFIERS (
52. ELECTROMECHANICAL

PLEASE

FLUIDAL CONCEPTS — IMPORTANCE TO LEARNING --- AUTOMOTIVE SUBJECT MATTER --->	NOT	LOW	IMPORTANT	CRITICAL
27. VIBRATIONS AND WAVES IN FLUIDAL SYSTEMS (streamlining, intake/exhaust management, turbocharging, etc.)	0	1	2	3
28. UNDERSTANDS AND USES FLUIDAL/PNEUMATIC TEST EQUIPMENT (flowmeters, vacuum guages, pressure guages, etc.)	0	1	2	3
ELECTRICAL/ELECTRONIC CONCEPTS				
29. SOURCES OF ELECTRICITY (batteries, generators/alternators, friction, pressure, heat, light)	0	1	2	3
30. ELECTROMOTIVE FORCE (VOLTAGE) (difference in electrical potential between two points, AC vs DC, etc.)	0	1	2	3
31. VOLTAGE IN SERIES, PARALLEL, SERIES/PARALLEL CIRCUITS (voltage drops, etc.)	0	1	2	3
32. UNDERSTANDS AND USES VOLTAGE METERS (analog & digital)	0	1	2	3
33. ELECTRICAL CURRENT (AMPERAGE) (charge transferred per unit of time)	0	1	2	3
34. AMPERAGE IN SERIES, PARALLEL, SERIES/PARALLEL CIRCUITS (current branching, etc.)	0	1	2	3
35. UNDERSTANDS AND USES AMMETERS (VAT 29 [series], VAT 40 [inductive], digital V.O.M.)	0	1	2	3
36. ELECTRICAL RESISTANCE (opposition to current flow: circuit loads, effects of corrosion, etc.)	0	1	2	3
37. RESISTANCE IN SERIES, PARALLEL, SERIES/PARALLEL CIRCUITS (computation of, effects of, etc.)	0	1	2	3
38. UNDERSTANDS AND USES OHMMETERS (analog & digital)	0	1	2	3
39. ELECTRICAL POWER (voltage X amperage)	0	1	2	3
40. OHM'S LAW (voltage = amperage X resistance)	0	1	2	3
41. KIRCHOFF'S LAW (currents entering a point = currents exiting a point)	0	1	2	3
42. UNDERSTANDS ELECTRICAL SYMBOLS AND SCHEMATICS (S.A.E. - industry standards)	0	1	2	3
43. ELECTRICAL CONDUCTORS (metals/liquids, wire sizes, etc)	0	1	2	3
44. ELECTRICAL SEMICONDUCTORS AND SEMICONDUCTOR DEVICES (diodes, transistors, op amps, SCR's, etc.)	0	1	2	3
45. PROPERTIES OF ELECTRICAL INSULATORS	0	1	2	3
46. ELECTRICAL TRANSDUCERS AND CONTROL CIRCUITS (meters, sending units, sensors, fuses, etc.)	0	1	2	3
47. ELECTRICAL ENERGY ACCUMULATORS (capacitors, secondary batteries, etc.)	0	1	2	3
48. ELECTRICAL FORCE TRANSFORMERS (inductors, transformers, coils, inverters, etc.)	0	1	2	3
49. ELECTRICAL-MECHANICAL ENERGY CONVERSIONS (motors, solenoids, relays, etc.)	0	1	2	3
50. ELECTRICAL-THERMAL ENERGY CONVERSIONS (resistive heat, light, thermocouples, etc.)	0	1	2	3
51. AC/DC RECTIFIERS (bridge circuits, commutators, etc.)	0	1	2	3
52. ELECTROMECHANICAL VOLTAGE/CURRENT REGULATORS	0	1	2	3

PLEASE RESPOND TO ALL ITEMS IN ALL SECTIONS

ING .TTER --->	NOT	LOW	IMPORTANT	CRITICAL
imlining,)	0	1	2	3
IUIPMENT :tc.)	0	1	2	3
	0	1	2	3
·lectrical	0	1	2	3
IRCUITS	0	1	2	3
digital)	0	1	2	3
red per	0	1	2	3
CIRCUITS	0	1	2	3
, VAT 40	0	1	2	3
low:	0	1	2	3
L	0	1	2	3
al)	0	1	2	3
	0	1	2	3
	0	1	2	3
rrents	0	1	2	3
	0	1	2	3
zes, etc)	0	1	2	3
JICES	0	1	2	3
	0	1	2	3
sters,	0	1	2	3
:ondary	0	1	2	3
sformers,	0	1	2	3
·s,	0	1	2	3
re heat,	0	1	2	3
etc.)	0	1	2	3
	0	1	2	3

.L SECTIONS

ELECTRONIC CONCEPTS --- IMPORTANCE TO LEARNING AUTOMOTIVE SUBJECT MATTER --->	NOT	LOW	IMPORTANT	CRITICAL
53. ELECTRONIC VOLTAGE REGULATORS	0	1	2	3
54. TRANSISTOR AMPLIFIER CONCEPTS/CIRCUITS	0	1	2	3
55. TIME CONSTANTS IN ELECTRONIC CIRCUITS (TBI pulse timing, capacitor charge/discharge rates, etc.)	0	1	2	3
56. BASIC COMPUTER/MICROPROCESSOR ARCHITECTURE (CPU, RAM, ROM, EPROM, busses, drivers, etc.)	0	1	2	3
57. BASIC COMPUTER/MICROPROCESSOR INTERFACING (ECM, sensors, drivers, electromechanical relays, etc.)	0	1	2	3
58. READS AND UNDERSTANDS AC AND DC OSCILLOSCOPE WAVEFORMS	0	1	2	3
59. UNDERSTANDS HIGH IMPEDENCE ISOLATION TESTING (rationale for and procedures)	0	1	2	3
60. UNDERSTANDS AND USES ELECTRONIC TEST EQUIPMENT (analog/digital V.O.M., logic probes/pulsers, wave generators, etc.)	0	1	2	3
61. UNDERSTANDS AND USES AUTOMOTIVE COMPUTER TEST EQUIPMENT (scanners, brainmaster, etc.)	0	1	2	3
62. HAS COMPUTER USER SKILLS (ability to load/use software packages, keyboarding skills, computer literacy, etc.)	0	1	2	3
THERMAL CONCEPTS				
63. SOURCES OF THERMAL ENERGY (combustion, friction, etc.)	0	1	2	3
64. THERMAL CONDUCTION PROPERTIES OF MATERIALS (heat flow in metals, gases, liquids, etc.)	0	1	2	3
65. THERMAL RESISTANCE PROPERTIES OF MATERIALS (asbestos, ceram-metallics, thermal expansion, etc.)	0	1	2	3
66. THERMAL LAWS AND THEOREMS (convection, latent heat, specific heat, adiabatic processes, etc.)	0	1	2	3
67. THERMAL ENERGY ACCUMULATORS (relative abilities of metals, liquids, gases, composites, etc.)	0	1	2	3
68. THERMAL-MECHANICAL ENERGY CONVERSIONS (heat engines, bi-metallic strips, thermostats, etc.)	0	1	2	3
69. THERMAL-ELECTRIC ENERGY CONVERSIONS (thermocouples)	0	1	2	3
70. THERMAL TRANSDUCERS (thermometers, thermistors, thermocouples, bi-metallic strips, etc.)	0	1	2	3
71. TIME CONSTANTS IN THERMAL SYSTEMS (heating and cooling rates for materials/mediums, etc.)	0	1	2	3
72. UNDERSTANDS AND USES THERMAL TEST EQUIPMENT (thermometers, etc.)	0	1	2	3
CHEMICAL CONCEPTS				
73. BASIC CHEMICAL/PHYSICAL PROPERTIES OF MATERIALS (metals, composites, plastics, greases, oils, etc.)	0	1	2	3
74. COMBUSTION OF HYDROCARBONS IN AIR (basic transformations and resultant compounds, etc.)	0	1	2	3
75. CATALYTIC CONVERSION OF EXHAUST GASES (basic transformations and resultant compounds, etc.)	0	1	2	3
76. THERMOPLASTIC TRANSFORMATIONS (reaction of: antifreeze/petrochemicals, galvanic cells/silicone esters, etc.)	0	1	2	3
77. ELECTROCHEMISTRY (energy transfer between chemical /electrical mediums, electroplating, electrolysis, etc.)	0	1	2	3

COMMENTS

APPENDIX B

SURVEY INSTRUMENT

FIRST EXPERT REVIEW PANEL

FIRST EXPERT REVIEW PANEL

Mr. Bob Barkhouse

Founder and Past President of California Automotive Teachers Assn
Automotive Technology Textbook Author
Automotive Technology Instructor (Retired)
Yuba College
Marysville, CA 95901

Mr. Ray Fausel

Professor of Energy, Power, and Automotive Technology
California State University
Los Angeles, CA

Dr. Lynn S. Mosher

Past President of California Automotive Teachers Association
Automotive Technology Textbook Author
Professor of Energy, Power, and Automotive Technology
California Polytechnic State University
San Luis Obispo, CA 93406

Dr. A. Tolu-Honory

Associate Professor of Energy and Power
University of Northern Iowa
Cedar Falls, IA 50614

Mr. Stan Thompson

Industry-Education Coordinator
Automotive Service Councils of California
Automotive Technology Instructor
Cuesta Community College
San Luis Obispo, CA 93403

Mr. Jere Wheatley

Assistant Professor of Energy and Power
University of Northern Iowa
Cedar Falls, IA 50613

APPENDIX C

SURVEY INSTRUMENT

SECOND EXPERT REVIEW PANEL

SECOND EXPERT REVIEW PANEL

Dr. Robert W. Donoho

Professor of Energy, Power, and Transportation Technology
California State University
Chico, CA 95929

Dr. Melvin Edwards

Automotive Technology Instructor
Chabot College
Hayward, CA 93545

Dr. William D. Guentzler

Professor and Director of Power Technology
San Diego State University
San Diego, CA 92182

Mr. Angus MacDonald

Professor of Energy and Power
California State University
San Jose, CA 95001

Dr. Wayne R. Olson

Past President
California Automotive Teachers Association
Associate Dean of Occupational Education
El Camino Community College
Torrance, CA 90506

Dr. Kenneth Zion

Automotive Instructor
El Camino College
Torrance, CA 90506

APPENDIX D

SURVEY INSTRUMENT

PILOT TEST PANEL

PILOT TEST PANEL

Mr. Kenneth Chew

Automotive Instructor
Cuesta College
San Luis Obispo, CA 93403

Mr. Bill Richmond

Automotive Instructor
Cuesta College
San Luis Obispo, CA 93403

Mr. Stan Thompson

Automotive Instructor
Cuesta College
San Luis Obispo, CA 93403

APPENDIX E

COVER LETTER FOR FIRST MAILING OF QUESTIONNAIRE

CALIFORNIA ASC
AUTOMOTIVE SERVICE COUNCILS
PROFESSIONALS - AUTOMOTIVE SERVICE

Automotive Service Councils of California

415 Tanner Lane
Arroyo Grande, CA 93420
(805) 489-3052

15 April 1989

SUBJECT: SURVEY QUESTIONNAIRE

Dear Fellow Automotive Teacher:

What is the relationship of applied science knowledge to the learning of state-of-the-art vocational automotive subject matter? How much does the student need to know? How much is "critical to know?" How much is "unimportant to know?" or in between the two? These questions are worth answering and, as automotive teachers,

THESE ANSWERS ARE IMPORTANT TO US ALL

The attached questionnaire is designed to help answer these questions. Please note that only you guys -- California's full-time community college automotive teachers -- are being asked to respond.

I WANT TO KNOW WHAT YOU THINK

So, if you have 15 or 20 minutes right now, please fill out the questionnaire right now and return it in the provided stamped, self-addressed envelope. If you don't have time right now, be sure to do it soon.

We're shooting for 100% response.

Thanks a lot.

Sincerely,

P. M. McCleskey
Automotive Instructor
ASC Industry-Education Coordinator

ASA

Affiliate of AUTOMOTIVE SERVICE ASSOCIATION • We support ASE

BACKGROUND INFORMATION

Throughout the history of the automobile there has always been far more vehicles in need of repair than qualified technicians capable of repairing them. For as long as there has been automobiles experts have urged that students coming into automotive training be well prepared in math and the applied sciences. In recent times, knowledge of computers has been added to the list.

A hundred or more task analyses have been done that describe just what a student who has completed an automotive training program ought to know. Only a few have flirted with what students need to know when they come to the training program.

The attached questionnaire is designed to identify and rank-order the importance of selected applied physics concepts and skills as prerequisites to learning state-of-the-art vocational automotives. It is composed of 77 items that have been gleaned from numerous studies of the curricular content of automotive technicians trades cross-tabulated with the Unified Technical Concepts - Physics curriculum.

If technicians who work with or on today's and tomorrow's highly technical vehicles and machines need to understand the entire system with which they work, what is the importance of each fundamental concept and/or skill listed on the questionnaire in bringing about this level of learning?

APPENDIX F

FIRST REMINDER POSTCARD

FIRST REMINDER POSTCARD

Dear Automotive Instructor:

Just a friendly reminder about the questionnaire (the yellow one) that you should have received about a week or so ago. We really do want to know your thoughts about the importance of selected applied physics concepts as prerequisites to to training in automotive technology but

WE HAVEN'T RECEIVED YOURS YET.

This info will be used to support curriculum and to develop journal articles dedicated to upgrading the educational preparation of your students. So, if you haven't found time to fill-out and return yours yet, please do it soon.

Thanks again,

Mike McCleskey

MIKE McCLESKEY
ASC Industry-Education Coordinator
415 Tanner Lane
Arroyo Grande, CA 93420

Courtesy/First Name/Surname
Title
Department
Institution
Street Address
City, State ZIP

APPENDIX G

SECOND REMINDER POSTCARD

SECOND REMINDER POSTCARD

Just a second friendly reminder about the questionnaire (the yellow one) that you should have received about three weeks ago. We're still interested in what you think.

So far, 118 of the 196 full-time instructors who teach in California's community college programs have responded. Thats right at 60% of you. We're elated! But we're still shooting for 100%.

May 19 is the cut-off date for data collection for this study. If you'd like to have your input be a part of the outcome, you'll have to have your questionnaire in the mail on/before this date.

Again, Thanks.

Mike McCleskey

MIKE McCLESKEY
ASC Industry-Education Coordinator
415 Tanner Lane
Arroyo Grande, CA 93420

Courtesy/First Name/Surname
Title
Department
Institution
Street Address
City, State ZIP

APPENDIX H

CHI SQUARE VALUE COMPUTATION

CHI SQUARE VALUE COMPUTATION

The survey instrument used in this study required the respondent to rate a concept statement as either (0) "not important", having (1) "low importance", (2) "important", or (3) "critical" as a prerequisite to training in automotive technology. In order to analyze this data the number of respondents rating a concept as either "important" or "critical" were summed and divided by the total number of responses to the concept statement and expressed as a percentage (i.e., $\% = f_1 + f_2 / n$). This value was calculated for each of the 77 survey items. In order to establish the cut-point on these percentage values above which a concept may be claimed statistically "important" the following Chi square goodness-of-fit calculation at the .01 level of significance with 1 degree of freedom was performed:

n=130

	0+1	2+3	
observed (O)	50	80	130
expected (E)	65	65	130

$$X^2 = \sum \frac{(O-E)^2 + (O-E)^2}{E} = \sum \frac{(50-65)^2 + (80-65)^2}{65} = 6.92$$

Using a table of critical values of Chi square (Weinberg & Schumaker, 1974) the value corresponding to the 0.01 level of significance having 1 degree of freedom is 6.64. The above calculation corresponds with a percentage value of 61.54 (80/130). All concept statements having a computed percentage value equal to or above 61.54, then, may be claimed as "important" as prerequisites to learning automotive technology.

APPENDIX I

PREREQUISITES TO TRAINING IN AUTOMOTIVE TECHNOLOGY

Applied Physics Concepts Demonstrated as Having Critical Importance as Prerequisites to Training in Automotive Technology

Rank-Order	Concept
01.	Understands and uses voltage meters.
02.	Understands and uses ammeters.
05.	Understands and uses Ohmmeters.
03.	Understands and uses mechanical test equipment.
06.	Understands electrical sysbols and schematics.
16.	Understands and uses automotive computer test equipment.
19.	Understands and uses electronic test equipment.
09.	Voltage in series, parallel, series/parallel circuits.
10.	Electrical resistance.
07.	Electromotive force (voltage).
04.	Sources of electricity.
21.	Amperage in series, parallel, series/parallel circuits.
27.	Resistance in series, parallel, series/parallel circuits.
11.	Mechanical-electrical transducers.
12.	Electrical transducers and control circuits.
13.	Electrical current (amperage)
25.	Understands and uses fluidal/pneumatic test equipment.

Rank-Order	Concept
17.	Electrical semiconductors and semiconductor devices.
37.	Reads and understands AC and DC oscilloscope waveforms
14.	Mechanical-electrical energy conversions.
23.	Ohm's Law.

Applied Physics Concepts Demonstrated as Being Important Prerequisites to Training in Automotive Technology

Rank-Order	Concept
08.	Transmission of mechanical power.
15.	Electrical-mechanical energly conversions.
18.	Electronic voltage regulators.
20.	Sources of mechanical force.
22.	Mechanical resistance
24.	Electrical conductors.
26.	Mechanical-fluidal energy conversions.
28.	Electrical power concepts.
29.	Basic computer/microrpocessor interfacing.

Rank-Order	Concept
30.	Electrical force transformers.
31.	Electrical energy accumulators.
32.	Mechanical-thermal energy conversions.
33.	Mechanical power concepts.
34.	Electromechanical voltage/current regulators.
35.	Catalytic conversion of exhaust gases.
36.	Combustion of hydrocarbons in air.
38.	AC/DC rectifiers.
39.	Types of mechanical force.
40.	Time constants in electronic circuits.
41.	Thermal transducers.
42.	Basic computer/microprocessor architecture.
43.	Transistor amplifier concepts/circuits.
44.	Sources of thermal energy.
45.	Physical properties of fluids.
46.	Properties of electrical insulators.
47.	Understands and uses thermal test equipment.
48.	Mechanical force transformers.
49.	Electrical-thermal energy conversions.
50.	Fluidal force.

Rank-Order	Concept
51.	Fluidal force transformers.
52.	Computer user skills.
53.	Fluidal tanks, seals, and filters.
54.	Thermal-mechanical energy conversions.
55.	Fluidal resistance.
56.	Fluidal transducers.
57.	Fluidal control devices.
58.	Mechanical-pneumatic energy conversions.
59.	Mechanical energy accumulators.
60.	Understands high impedence isolation testing.
61.	Vibrations/waves in mechanical systems.
62.	Kirchoff's Law.
63.	Fluidal conductors.
64.	Thermal-electric energy conversions.
65.	Basic chemical/physical properties of materials.
66.	Thermal conduction properties of materials.
67.	Mechanical laws and theorems.