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EVALUATING THE EFFICIENCY AND EFFECTIVENESS OF SELF-INSTRUCTIONAL METHODS FOR SELECTED AREAS OF VOCATIONAL EDUCATION. FINAL REPORT.

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DESCRIPTORS- *TRADE AND INDUSTRIAL EDUCATION, SKILL ANALYSIS, *AUTOINSTRUCTIONAL AIDS, *EVALUATION, *MATERIAL DEVELOPMENT, *JOB SKILLS, UNITS OF STUDY (SUBJECT FIELDS), MATHEMATICS, TASK PERFORMANCE, TASK ANAYSIS, PROBLEM SOLVING, VISUAL DISCRIMINATION, ORAL COMMUNICATION, HAND TOOLS, AUDITORY DISCRIMINATION, PROGRAMED MATERIALS, PROGRAMED UNITS, AUTO MECHANICS (OCCUPATION), SHEET METAL WORKERS, COSMETOLOGISTS, DRAFTSMEN, ELECTRICIANS, WELDERS, MACHINISTS,

THE TWO MAJOR PHASES OF THIS RESEARCH WERE (1) ANALYZING TRADE AND INDUSTRIAL EDUCATION TO IDENTIFY AND DESCRIBE PRIMARY VOCATIONAL SKILLS, AND (2) DEVELOPING AND EVALUATING NINE SELF-INSTRUCTIONAL UNITS. THREE INSTRUMENTS WERE USED IN ANALYZING VOCATIONAL CONTENT SOURCES TO IDENTIFY AND DESCRIBE GENERAL BEHAVIORS AS WELL AS TRADE-SPECIFIC EXAMPLES OF HOW THE BEHAVIORS ARE DEMONSTRATED WITHIN AUTOMOTIVE MECHANICS, COSMETOLOGY, DRAFTING, ELECTRICAL-ELECTRONICS, MACHINE TRADES, SHEET METAL, AND WELDING. THE MAJOR RESULT OF THE ANALYSIS PHASE WAS THE DEVELOPMENT OF A BEHAVIORAL CATALOG CONTAINING THE GENERAL BEHAVIORS INVOLVED IN TRADE AND INDUSTRIAL EDUCATION AND SPECIFIC EXAMPLES OF HOW THESE BEHAVIORS ARE DEMONSTRATED. SELF-INSTRUCTIONAL UNITS DEVELOPED TO TEACH EIGHT SELECTED SKILLS WERE--(1) OPERATING HACKSAWS AND OPERATING SCREWDRIVERS TO TEACH HAND TOOL OPERATION, (2) COMMUNICATING COURTEOUSLY IN COSMETOLOGY TO TEACH ORAL COMMUNICATION, (3) VISUALIZING STATIONARY THREE DIMENSIONAL OBJECTS FROM TWO-DIMENSIONAL DRAWINGS TO TEACH VISUALIZATION, (4) DETERMINING THE CAUSES OF TIRE WEAR TO TEACH VISUAL DIAGNOSIS, (5) IDENTIFYING METALS TO TEACH SENSORY DISCRIMINATION, (6) DOING A GOOD JOB AT WORK TO TEACH PERFORMANCE EVALUATION, (7) GIVING A BASIC HAIRCUT TO TEACH TASK PERFORMANCE, AND (8) LETTERING TO TEACH TWO-DIMENSIONAL FORM CONSTRUCTION. STUDIES OF THE SKILLS OF AUDITORY DIAGNOSIS AND MATHEMATICAL WORD-PROBLEM SOLVING DID NOT RESULT IN UNITS THAT COULD BE EVALUATED. EVALUATIONS OF FIVE UNITS SUPPORTED THE CONTENTION THAT SELF-INSTRUCTION IS EFFICIENT AND EFFECTIVE. A PROGRESS REPORT OF THE PROJECT IS ED 010 403. (PS)

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EVALUATING THE EFFICIENCY AND EFFECTIVENESS OF SELF-INSTRUCTIONAL METHODS FOR SELECTED AREAS OF VOCATIONAL EDUCATION

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realization of the centrality of instructional methods in the behavioral-change process that has been largely responsible for the extensive efforts underlying the currently evolving educational technology.

Although problems associated with the efficiency and effectiveness of instructional methods have plagued the whole of American education, they have been especially troublesome within vocational education. "Breakthroughs" in instructional methods, while so far having only limited effects on education in general, are even less apparent in vocational education. Consequently, a problem of considerable concern is improving the efficiency and effectiveness of instructional methods specifically within vocational education.

Background

Because of the central position of instructional methods in the educational process, it is not surprising that instructional-method research historically has consumed the efforts of many educational researchers. For a significant period of this century, the major thrust of much research was directed toward what might be called "changing the nature of the aversive control of student behavior". It has only been within the past 15 years or so that serious efforts toward the application of behavioral technology to education as a whole have made discernible progress. The major impact of behavioral technology upon vocational education has been even more recent.

During the 1960's, research in vocational education has been increasing at an extremely rapid rate. A major factor contributing to this increase has been the Vocational Education Act of 1963. Additionally, renewed interest in vocational education at virtually every level of government has in no small way pointed up the need for improved vocational education systems. Consequently, a considerable proportion of current work has been directly concerned with improving vocational instructional methods.

The work reported here falls clearly within the instructional-methods area. However, it also has more general applications than a very narrow view of "instructional methods" might indicate. That is, the emerging educational technology is making compartmentalization of education extremely difficult. This technology incorporates a "systems-science flavor"; in a very real sense, the technology is based upon an approach that is systems oriented. A systems approach to education, however, can be interpreted simply as another way of saying that education today is being influenced significantly by the "systems" characteristics that are inherent in an effective behavioral technology.

Objective and Scope

The major objective of the work reported here was to evaluate the efficiency and effectiveness of self-instructional methods for selected areas of vocational education. The scope of the work was limited to trade and industrial education--that is, to the specific vocational areas of automotive mechanics, cosmetology, drafting, electrical-electronics, machine trades, sheet metal, and welding.

Rationale

The specific tasks conducted during the course of this effort fall within the framework of an overall rationale. It is of value, therefore, to make the rationale explicit. By doing this, relationships among the various tasks, as well as how they relate to the major objective of the work, will be more evident.

Self-instruction, as a specific case of general behavioral technology, is a predominating characteristic of recent and current research on instructional methods. Roughly speaking, the justification for the self-instructional trend can be traced to two kinds of considerations: (1) the practical requirements of education and (2) the necessary conditions for behavioral change to occur. Fortunately for education, these two kinds of considerations appear to be, for the most part, in harmony. Further, research on self-instructional methods has demonstrated convincingly their potential for meeting these two central considerations.

The rationale for this work, therefore, provided for conducting many tasks in accordance with the requirements of self-instructional methodology. For example, one methodological requirement of self-instruction is behavioral specification of the desired outcomes of instruction. Considerable work was directed toward this end. Similarly, self-instructional methodology requires empirical try-outs of instructional materials. Again, efforts were devoted to this activity. To summarize this point, a considerable number of the tasks were conducted in accordance with the general methodology that has been derived for the development of self-instructional materials such as programmed instruction.

A second important consideration was included in the overall rationale: the nature of the subject matter that would be investigated within a self-instructional context. This consideration can be illustrated by the following.

When an effort is being directed toward investigating the efficiency and effectiveness of self-instructional methods within a particular area such as vocational education, a major question arises as to what specific instructional objectives (i.e., behavioral outcomes of instruction) should be employed as the bases of the investigations. At one extreme, the selection of behaviors can be essentially random; at another extreme, the selection problem can prompt fairly extensive revision of the instructional area. Somewhere between is the technique of analyzing current instruction for the purpose of identifying behaviors that are considered significant. An important criterion of "significance" is the frequency with which the behaviors appear as the desired instructional outcomes of different instructional sequences within the instructional area.

Analyses for this purpose yield behaviors (i.e., skills) that have somewhat wide applicability within the instructional area being considered. Although some behaviors have wider applicability than others, greater value from the work (in terms of wider generality of the findings within the instructional area) results from basing the investigation of self-instructional methods upon skills that have applicability to a reasonable number of specific instructional objectives. Therefore, the activities of this work included the conduct of such analyses for trade and industrial education.

In summary, the work reported here was conducted within the framework of a rationale that provided for two broad types of activities. One type lead to skill identification along with the selection of those skills having somewhat broad applicability as the desired outcomes of instruction within trade and industrial education. The second type of activity was the investigation of self-instructional methods for teaching the selected skills.

METHOD

Consistent with the preceding discussion, the activities constituting the major work reported here are grouped into two categories. The first category, which can be labelled "analysis and selection of skills", is made up of the tasks conducted in connection with the first two specific activities listed on page 8 of the proposal (i.e., "analyzing selected areas of vocational education to identify primary vocational skills", and "from the primary skills identified, selecting those to which self-instructional methods will be applied"). The second category, labelled below as "evaluation of self-instructional methods", groups together those tasks that were conducted in connection with the remaining four specific activities listed on page 8 of the proposal (i.e., "selecting or generating strategies for teaching each selected primary skill", "selecting or generating self-instructional methods for teaching each selected primary skill", "empirically developing self-instructional materials to teach each selected primary skill", and "evaluating the efficiency and effectiveness of the self-instructional materials for each selected skill").

In addition to the above, certain tasks were conducted in connection with the activities listed on page 9 of the proposal. Brief descriptions of these tasks also are included in this section of the report.

Analysis and Selection of Skills

The tasks directed toward the analysis of vocational education and the selection of skills were conducted between July 1, 1966, and approximately June 30, 1967. Although the details of most of this work have been described in the First and Second Technical Progress Reports, a more condensed review of it also is included here.

Skill Definition and Scope

An initial task was arriving at a skill definition that would meet the practical requirements of the work. Several such requirements were foreseen. One was the large amount of information that would have to be analyzed in each trade area in order to identify skills. Because of this, the way in which a skill was defined, it was judged, would have to yield a procedure that was workable, efficient, and reliable. A second very practical requirement was the necessity for incorporating a scope limitation within the definition. Without such a limitation, a skill easily could become an unmanageably large behavioral unit. A third requirement was communicating with vocational educators who probably would not be familiar with many of the technical terms and procedures embodied in behavioral technology. Because their assistance would be required, a definition that would yield meaningful skills in relation to the trade areas was an important consideration.

To meet such requirements, an initial, general skill definition was formulated. A skill was defined as a comprehensive, meaningful behavioral unit consisting of a starting point, developmental stages, and an end point and composed of behavioral components encompassing cognitive, verbal, and motor processes.

The skill definition itself provided some general scope limitations. That is, it provided for a skill being a comprehensive behavioral unit bounded by a starting point and an end point. Further the behavioral unit had to be meaningful; in the context of vocational education, there appeared to be a self-limiting factor in the presence of many somewhat discrete, identifiable behavioral units. Finally, at a minimum, a skill had to consist of behavioral components encompassing cognitive, verbal, and motor processes. This part of the definition tended to preclude such behaviors as a simple discrimination or the memorization of a fact from being defined as skills.

During this work, it was realized that any consideration of equating skill "size" in an absolute sense would be meaningless. On the other hand, the need for guidelines that would preclude the identification of unmanageably large behavioral units as skills was a very practical requirement. Consequently, it was tentatively decided that vocational content material would be employed as the primary determinant of skill size. (It was subsequently found that given the skill definition and a vocational content source, the identification of behavioral units compatible with the definition and appearing to be roughly comparable with respect to scope was possible.)

Development of Skill-Identification Methods

Another early task was developing methods whereby skills consistent with the definition could be identified and described from various types of vocational content sources (e.g., textbooks, manuals, educators). As part of this task, a rather extensive literature search was conducted for the purpose of determining the extent to which existing methodology might assist in the skill identification and description task. The literature search, although helpful in further orienting the project staff to many of the problems that might be expected, did not yield much in terms of practical, applicable methodology.

Consequently, an analytical method was developed. This method (described in detail in the First Technical Progress Report) consisted of three major tools that greatly assisted the project staff in analyzing vocational content sources for the purpose of identifying and describing vocational skills.

One tool was a standardized format and terminology to be used for describing each identified vocational skill. This included provisions for a meaningful skill name (e.g., "hand tool operation", "mathematical problem solving"). The format also provided for a general behavioral description of the skill as well as a listing of component behaviors constituting the skill.

The second tool was a standardized form for use in recording vocational content information relevant to each component behavior for each skill.

The third tool was an operational procedure that provided for the following: (1) identifying vocational skills from vocational content sources (e.g., textbooks, manuals), (2) describing the identified skills according to the standardized format and terminology, (3) checking the skills against other identified skills to eliminate overlap or redundancy among skills, (4) sequencing the component behaviors for each skill, and (5) recording vocational content information relevant to each component behavior using the standardized form. This procedure was formalized by means of two flow charts--one for conducting a "one-skill-at-a-time" analysis and the other for a "multiple-skill-at-a-time" analysis.

Analyses of Vocational Trade Areas

The methodology that had been developed was designed to yield three kinds of information: (1) identification of skills, (2) description of skills in terms of a general behavioral unit and in terms of sequenced behavioral components, and (3) trade-specific information concerning how each component behavior was demonstrated within trade tasks. To test the methodology, two analyses were conducted. One dealt with selected tasks in automotive mechanics, cosmetology, drafting, electrical-electronics, sheetmetal, and welding. The other dealt in detail with machine trades. The usual unit analyzed was a specific, meaningful trade-specific task. For example, "machining an adjustable boring head" was one of 47 tasks included in the analysis of machine trades. During these analyses, some methodological refinements were made. For the most part, however, the analytical methodology proved to be workable and efficient.

Three major outputs resulted from the two initial analyses: (1) the refined methodology, (2) a set of 25 identified skills described in terms of a general behavioral unit and sequenced component behaviors, and (3) trade-specific information concerning how the component behaviors were demonstrated within the tasks.

Utilizing the refined methodology and the set of 25 skills, the next major undertaking was detailed analyses of the remaining six trades within trade and industrial education (i.e., automotive mechanics, cosmetology, drafting, electrical-electronics, sheetmetal, and welding*). These analyses, as the previous ones, were selected to obtain trade-specific information concerning how each component behavior of each skill was demonstrated in the tasks analyzed, and to identify, describe, and secure trade-specific information for additional skills that might be encountered.

The additional analyses yielded surprisingly few changes in the number and nature of the skills that already had been identified and described. Specifically, two skills were added, two were deleted, and one was significantly modified. Consequently, in summary, all analyses of trade and industrial education yielded a total of 24 skills. Each skill consisted of a meaningful name, a general description of the behavioral unit encompassed by the skill, and a listing of the sequenced component behaviors making up the behavioral unit. Additionally, for each behavioral component, there existed a description of how it was demonstrated in each of the analyzed tasks for the seven trades.

Organization of Analytical Results

Inasmuch as one major purpose of the analyses was to identify and describe skills so that primary vocational skills (i.e., skills having wide applicability across trades) could be identified, a procedure for making across-trade comparisons was necessary. A detailed description of this work made up part of the Second Technical Progress Report; however a brief review of it is included below.

As pointed out earlier, the usual unit analyzed was a trade task. Following the analysis of a trade area, from the information that existed it was possible to examine any one task that had been analyzed and determine which skills were involved, which component behaviors of each skill were involved, and how these component behaviors were demonstrated in the conduct of the task. These kinds of information were used in organizing the results of the analyses.

From the standpoint of identifying widely applicable skills for instructional purposes, the ideal situation would be the one where each task analyzed in each trade area involved exactly the same skills, including exactly the same component behaviors. If this were the case, within a trade an across-task comparison would reveal that all skills involved (and, consequently, the component behaviors involved) are equally applicable. Further, comparisons across trades would reveal exactly the same finding. In this ideal case, one could choose at random from among the identified skills with the assurance that any choice would result in a skill that is as widely applicable as any other.

*Because of the overlap in tasks making up electrical-electronics, these two areas were considered as one area during the analyses.

Of course, the ideal situation does not exist; however, the same rationale can be used to determine the extent to which differences in the applicability of skills across trade areas does exist. After this is known, across-trade applicability can enter into the selection of skills to be employed in investigations of the efficiency and effectiveness of self-instructional methods.

The approach, then, that was taken provided for determining the differential extent to which the identified skills were applicable to the trades constituting trade and industrial education. To accomplish this, a procedure of grouping tasks that were identical with respect to the skills involved, as well as their component behaviors, and then comparing these groups, or classes, of tasks across trades was employed. For example, within machine trades, 47 trade-specific tasks were analyzed. The total number of skills involved in these 47 tasks was nine. By grouping the 47 tasks according to identical component behaviors of the involved skills, three classes of tasks emerged. Consequently, it was possible to say that at the component-behavior level, the 47 tasks, although different in trade-specific details, constituted three groups, each group being the same with respect to the nature of the behaviors involved in them.

The same procedure was employed for developing task classes in the other trade areas that were analyzed. A summary of the task-class formulation for all trade areas within trade and industrial education is presented as Table 1.

TABLE 1. SUMMARY OF TASK CLASS FORMULATION

Trade Area	Number of Tasks Analyzed	Number of Task Classes Formed	Number of Skills Involved in Trade Area
Machine Trades	47	3	9
Automotive Mechanics	105	13	14
Electrical-Electronics	89	12	11
Drafting	15	5	7
Sheetmetal	42	5	10
Cosmetology	42	7	7
Welding	24	3	6

To determine the extent to which groups of skills (each group being made up of those skills involved in a single class of tasks) were applicable across trades, each task class within a trade was compared with all other task classes in the other trades. These comparisons yielded no identical task classes across trades. This, in turn, meant that there were no groups of skills common across trades. Consequently, the largest unit of behavior that initially could be considered across trades was that unit represented by a skill--not the unit represented by a task class.

The results of the work described immediately above were checked in detail by having vocational educators for each trade review the task class structure and assist with improving the structure's validity. Additionally, these educators assisted in providing instructional priorities for the identified skills. (The specific tasks completed by the vocational educators were pointed out in some detail in the Second Technical Progress Report.)

The results of the work with the vocational educators were fed back into the task-class structure. Although the revised structure had the same characteristics as the original one, the validity was greatly improved. However, a re-examination of the structure for discovering identical task classes across trades revealed that none existed. That is, even with improved validity, no groups of skills (as represented by task classes) were common across the trades making up trade and industrial education. Again, therefore, individual skills represented the largest behavioral unit having across-trade applicability.

Final Skill Formulation

Following the conclusion of the work designed to identify common groups of primary vocational skills, an initial attempt was made to select individual primary skills (i.e., single skills having applicability across trades) for the purpose of employing them as the bases for investigations of the efficiency and effectiveness of self-instructional methods. In the selection process, a major problem was encountered. This problem had to do with what can be characterized as a differential applicability of the component behaviors constituting a skill as a function of certain dimensions required for teaching the skill. Specifically, the dimensions of concern were subject matter, sequence of behaviors, and student proficiency required.

A typical finding illustrates the problem encountered. As described previously, each skill was made up of a name, a general description of the behavioral unit, and a set of sequenced, component behaviors that specifically defined the behavioral unit. Often, a skill was found to be common to several trade areas--for example machine trades, automotive mechanics, and sheetmetal. This meant that for at least one (usually more than one) analyzed task in each trade area, all component behaviors of the skill were required for conduct of the tasks in the three trade areas. However, when the trade-specific information (generated during the analyses) was examined, it might be found that considerable differences existed in the way in which the component behavior was demonstrated. Consequently, the subject matter that could be employed to teach the component behavior would vary across the three trades. This type of problem was considered as a subject-matter restriction--a restriction that in a very real way limited the teaching of the component behavior across trades at any practical, workable level.

A second dimension along which applicability was specifically limited was one of sequence within a component behavior. This means that if one were to develop a practical instructional sequence for teaching the component behavior for one trade, significant changes would have to be made in order to develop an equally practical instructional sequence for another trade. This type of restriction was viewed as a sequence limitation restricting the applicability of the component behaviors across trades.

Differences in required student proficiency represented a third dimension that tended to restrict applicability of a component behavior across trades. This problem refers to the requirement for extremely high student proficiency in one trade compared with the acceptability of variably lower proficiency in other trades. Although these differences could be accommodated in instructional sequences, the result is a considerable lowering of instructional efficiency. This problem was viewed as a proficiency restriction on applicability.

Because of the differential nature of the degree of applicability of the component behaviors, a decision was made to drop the skill names and the general behavioral description and to deal exclusively with the component behaviors. Although this decision represented a change in the way a skill could be viewed, operationally it was consistent with the work that had been accomplished because this work had dealt primarily with component behaviors.

A primary purpose for the skill name and general description, in the first place, had been to provide a useful way to establish manageable behavioral boundaries and to represent groups or clusters of behaviors (i.e., the component behaviors). This grouping was particularly useful for examining the extent of skill applicability through the task-class comparisons.

On the other hand, the skill name and general description tended to lock together behavioral components. Because of the differential restrictions on the components, this was highly undesirable.

Consequently, a pooling of all component behaviors into a "behavioral catalog" that would represent the behaviors involved in trade and industrial education appeared to be an ideal solution. This course of action was taken and great, subsequent flexibility was realized. For example, with the behavioral catalog one component behavior could be treated as a skill. On the other hand, a skill could be formulated from a number of behaviors. In fact, nothing precluded the reformulation of an originally described skill if this were required.

Originally, the behavioral catalog contained the trade-specific information generated during the analyses of the trade areas. This information served two purposes: (1) it indicated those trades in which component behaviors were required, and (2) it provided examples of precisely how they were demonstrated. The catalog was made more current and complete by having the vocational educators add current trade-specific information. Further, the project staff made minor modifications to some component behaviors in order to make the catalog even more valid with respect to trade and industrial education.

The result of this work is the revised behavioral catalog included as Appendix A to this report. The catalog is organized according to logical groupings into which the behaviors appeared to fall--the first five pages of the catalog presents the overall organization. Other than organization, no additional meaning is intended by the group headings.

Skill Selection

Concurrent with, and subsequent to, the formulation of the behavioral catalog, skills were selected to serve as the bases for investigating the efficiency and effectiveness of self-instructional methods. Several factors entered into the selection process.

One factor was the extent of applicability of the skill across trades. From the outset of the work, two general types of applicability had been foreseen as potentially possible. One type was a sort of "ideal" applicability--applicability not restricted along any of the instructional dimensions such as those cited earlier. The other type was applicability restricted along one or more instructional dimensions.

The results of the completed analyses when examined using the task-class structure strongly indicated that beyond certain basic skills, most likely already within the behavioral repertoire of students at the vocational education level, there are few if any skills that closely approximate ideal, across-trade applicability from a practical, instructional point of view. This finding had been suspected by the project staff during the analyses; it was confirmed by examining the analytical results. In fact, as late as May 31, 1967, it was believed that certain ideally applicable skills had been identified. It was found, however, in subsequent work that this was not the case. For now, it is sufficient to say that most restrictions appear to be along the subject-matter dimension. The overall extent of skill applicability is treated in more detail in a subsequent section of this report.

Because of this finding, all but two skills selected were restricted along some instructional dimension, usually subject matter. In spite of these restrictions, however, efforts were made to select skills that had reasonable across-trade applicability.

A second factor entering into skill selection was the extent to which self-instruction had been investigated in connection with the skill. Certain skills, particularly those dealing primarily with verbal knowledge of trade-related information, were not selected because of the existence of many programmed-instruction materials covering these topics.

To assist in evaluating this factor, a rather large body of information describing available instructional materials in vocational education was formulated. Of particular interest were materials such as textbooks, booklets, films, film strips, audio tapes, and programs. To accomplish this, a total of 206 publishers, industries, and film companies were contacted by letter. The letter requested descriptive literature concerning available instructional materials. About 83 percent of the organizations contacted responded with appropriate literature. A workable system for retrieving information desired by the project staff was set up. By using this information, it was possible to obtain a realistic estimate of the extent to which skills of interest had received self-instructional treatment.

Instructional priorities was a third factor considered in skill selection. Inputs on this factor were obtained from the vocational educators; particular attention was given to difficult instructional areas and to areas for which acceptable instructional materials are lacking.

A fourth factor considered was the relative importance of the trades in terms of size of student enrollment. Where practical, attention was given to selecting skills that were applicable to large-enrollment trades.

The adaptability of instructional materials resulting from the self-instructional investigations was a fifth factor entering into skill selection. That is, if the development of self-instructional materials for a skill would likely require hardware not normally existing within a school system, the probability of the skill being selected was decreased.

Within the framework of these factors, the following ten skills were selected.

(1) Hand tool operation

(2) Oral communication

(3) Auditory diagnosis

(4) Mathematical word-problem solving

(5) Visualization

(6) Visual diagnosis

(7) Sensory discrimination

(8) Performance evaluation

(9) Task performance

(10) Two-dimensional form construction

In general, these skills were typical, central ones involved in trade and industrial education. Further, the behaviors constituting them had considerable applicability across trades. Additionally, this applicability included, in most cases, major trades in relation to student enrollment. All, however, except "mathematical word-problem solving" and "performance evaluation" were restricted, principally along the subject-matter dimension. From an instructional-priority standpoint, each skill represented a troublesome area either because of difficulty in instructing students or lack of effective materials or a combination of these two problems. Finally, it was judged that self-instructional investigations of the skills would not require exceptional hardware requirements and that the materials developed would be readily adaptable to school systems.

Skill Descriptions

Presented below is a brief description of each selected skill.

Hand Tool Operation. The skill labelled "hand tool operation" is concerned with precisely what the name implies: the operation of hand tools required in the practice of trades comprising trade and industrial education. This skill is applicable at the component-behavioral level to each trade studied--in this sense it has maximum applicability. It is, however, highly restricted along the instructional dimension of subject matter. That is, in the absence of particular hand tools (e.g., a screwdriver, a hacksaw) as a subject-matter vehicle for teaching the skill, very little remains upon which to base practical instruction. In fact, it appears that the proper operation of any hand tool is directly dependent upon very precise instruction designed to bring about similarly precise behaviors.

However, the nature of hand tool operation is such that it appears to be well suited to common instructional strategies and methods. This means that the sequence of behaviors involved, how they are taught, and how the instruction is implemented through instructional media might be relatively independent of particular hand tools. In other words, if an effective and efficient self-instructional unit could be designed to teach, for example, the operation of screwdrivers, it is plausible that the instructional technology constituting the unit could serve as a model for developing similar instruction for operation of other hand tools. It was this approach that was taken for the subsequent work on evaluating the efficiency and effectiveness of self-instructional methods for the skill of hand tool operation. Further, this type of consideration entered into the investigation of many of the other selected skills.

Oral Communication. "Oral communication" also is a skill that is concerned precisely with what the name implies: interpersonal vocal communication within the trades studied. Oral communication also has maximum applicability at the component-behavior level; yet it is severely restricted along the subject-matter dimension of instruction. This means that at the vocational-education level, general instruction in oral communication is not meaningful unless a specific type of communication is incorporated into the terminal behaviors of instruction.

On the other hand, the wide applicability of this skill makes it an attractive one from the standpoint of developing strategies and methods for self-instruction. It follows, then, that if this could be done for a specific case of oral communication, the instructional unit reasonably could serve as a model for subsequent extension of the instructional methodology to other, specific cases of oral communication.

Auditory Diagnosis. The "auditory diagnosis" skill refers to those behaviors required for problem identification based upon auditory inputs to the identifier. Except for drafting, auditory diagnosis was found to be applicable to all trades comprising trade and industrial education. The skill, from an instructional standpoint, had perhaps less severe subject-matter restrictions than hand tool operation and oral communication. That is, although specific subject matter was required as a vehicle for instruction, there appeared to be more subject-matter commonality than in the two previous skills. Consequently, the attractiveness of this skill for a self-instructional investigation was increased because of the transfer-of-training effects that potentially could be realized.

Mathematical Word-Problem Solving. The "mathematical word-problem solving" skill included those behaviors required for converting verbal statements of mathematical problems into mathematical notation and those behaviors required to arrive at an equation or numerical answer. This skill had applicability to all trades studied. It also had very few, if any, restrictions along the subject-matter dimension of instruction. These features made the skill particularly attractive for investigation.

Visualization. "Visualization" was the name given to the behaviors involved in making cognitive translations of inputed information. Typical of these behaviors is visualizing three-dimensional objects from two-dimensional representations. This skill was found to be applicable to all trades studied. Although a subject-matter restriction existed, it was less severe than that for the hand tool operation and oral communication skills. In this respect, visualization was more similar to auditory diagnosis because of notable subject-matter commonality across the trades studied.

Visual Diagnosis. The behaviors constituting "visual diagnosis" were quite similar to those constituting auditory diagnosis except for the difference in sense modality. Visual diagnosis grouped together behaviors required for problem identification based upon visual inputs to the identifier. This skill had applicability to all trades studied. It was somewhat restricted along the instructional dimension of subject matter, yet some subject-matter commonality did exist.

Sensory Discrimination. The behaviors grouped by the "sensory discrimination" skill were those central to the process of reducing reasonable alternatives until the correct alternative is reached through the use of sensory information. Sensory discrimination was applicable to all trades yet was quite restricted along the subject-matter dimension of instruction. In this respect, sensory discrimination was similar to both the hand tool operation and oral communication skills.

Performance Evaluation. The "performance evaluation" skill had to do with the behaviors involved in a person's evaluation of his own performance in the working world. Of course, this skill also was applicable to all trades studied; it was not particularly restricted with regard to subject matter or other instructional dimensions. In this respect, performance evaluation was like mathematical word-problem solving.

Task Performance. "Task performance" as a skill groups together those behaviors required for the performance of a trade-specific task. At a conceptual level, this skill has total applicability to every trade studied. However, at a practical, instructional level, it probably is more restricted along all instructional dimensions than any other skill that was selected. However, the question of employing self-instructional methods for the purpose of establishing task behaviors is an important and interesting one. For this reason, task performance was included as an area of investigation.

Two-Dimensional Form Construction. The final skill selected was "two-dimensional form construction". The behaviors comprising this skill are those normally associated with the generation of such materials as sketches, drawings, etc., in two dimensions. This skill had applicability to all trades studied. It was, for all practical purposes, totally restricted along the subject-matter dimension of instruction. That is, from an instructional standpoint, any practical teaching of two-dimensional form construction within a trade is dependent upon the subject matter of the trade.

Evaluation of Self-Instructional Methods

The tasks directed toward the evaluation of self-instructional methods in connection with the selected skills were conducted between approximately April 1, 1967, and February 29, 1968. This part of the work was completed as ten more or less independent studies, each study being principally concerned with one of the selected skills. This section of the report deals with the procedures employed for the ten studies.

Although the studies can be viewed more or less independently, the same procedure tasks, with minor modifications, were employed for each one. Consequently, this section of the report contains descriptions of the procedural tasks common to the studies as a group. Separate, more detailed descriptions of each study are contained in appendices to the report. Specific references to each appendix are included subsequently.

Objective Specification

For each selected skill, an initial task was describing the terminal behaviors (i.e., the objectives) for the self-instructional unit. It was at this point that subject-matter restrictions operated most directly upon the skills. That is, a very real requirement was determining the specific context in which the skill would be investigated. The practical requirements of this work dictated that this context would have to be trade-specific instances of the behaviors because of the following reasons.

First, the extent of applicability of each skill at the component-behavior level was known. For example, it was known that visual diagnosis was a skill required for all trades. Second, it was believed that an attempt to teach visual diagnosis without employing subject matter from the trades would result in an extremely abstract instructional program if, indeed, teaching in the absence of subject matter was possible at all. Consequently, the only meaningful approach appeared to be the use of a trade-specific case of visual diagnosis (e.g., determining the causes of tire wear). Third, it appeared reasonable that if visual diagnosis could be taught for one specific case, the strategies and methods of instruction that were employed would be more likely applicable for teaching visual diagnosis in almost any specific instance.

Therefore, the approach that was taken for each skill (except mathematical word-problem solving and performance evaluation) was to employ trade-specific instances of the skill as the terminal behaviors of the self-instructional units. The trade-specific behaviors selected for each skill are given below.

(1) Hand tool operation - operation of screwdrivers and the hacksaw

(2) Oral communication - communicating courteously in cosmetology

(3) Auditory diagnosis - the use of sound as a diagnostic tool for auto engine malfunction

(4) Mathematical word-problem solving - (behaviors not trade specific)

(5) Visualization - visualizing stationary three-dimensional objects from two-dimensional drawings

(6) Visual diagnosis - determining causes of tire wear

(7) Sensory discrimination - the identification of metals

(8) Performance evaluation - (how to do a good job in any trade)

(9) Task performance - giving a basic haircut

(10) Two-dimensional form construction - lettering

Subject-Matter Study

A second task conducted in connection with each skill was a more detailed study of potential subject matter that could be employed for instruction. This task usually involved careful examination of available subject-matter sources and discussions with vocational educators. As part of this task, current and relevant subject matter for teaching each skill was selected.

Strategy Development

Another procedural task was developing an instructional strategy that appeared to be efficient and effective for achieving criterion performance levels on the terminal behaviors. Of course, this activity varied depending upon the terminal behaviors involved. However, strategy development usually was concerned with such matters as determining appropriate and reasonable intermediate behaviors, sequencing intermediate behaviors, determining instructional techniques (e.g., discrimination training versus shaping), determining mode of presentation, etc. The usual output of this task was a plan for the instructional unit in the form of an instructional outline.

Method Application

This procedural task was concerned with implementation of the instructional plan through the application of self-instructional methods.

The major activity of this task, then, was constructing instructional materials such as programmed-instruction sequences, student instructions, visual materials, and audio materials as well as incorporating these materials into an integrated, self-instructional unit or "package". At the conclusion of this task for each skill, an initial self-instructional unit was ready for initial try-outs.

Criterion Test Development

The generation of criterion instruments based upon the terminal behaviors that had been described was the major purpose of this task. This included developing paper-and-pencil tests as well as performance tasks. These instruments were designed for use as pre- and post-tests in the subsequent evaluations.

Empirical Try-Out

Another procedural task associated with each skill was one or more empirical try-outs of the self-instructional units and criterion instruments with a small sample of students characteristic of the target population for whom the units were designed. This try-out usually included administration of a pre-test, administration of the program under observation of a project team member, administration of a post-test, and discussions with the students. The purpose of this task was to improve the instructional unit based upon student feedback.

Instructional-Unit Revision

The purpose of this procedural task was to revise, where necessary, the self-instructional units based upon the information gained from the initial empirical try-outs. In most cases, revisions were necessary and were completed.

Final Evaluation

The purpose of this task was to conduct a final evaluation of the self-instructional units with larger samples of students than those employed for the empirical try-outs. Original expectations had included the possibility of comparative evaluations between current instruction on the skills and the instruction contained in the self-instructional units. However, as the work progressed, it became increasingly clear that necessary conditions for comparative evaluations would be extremely difficult, and in some cases impossible, to achieve. Three identifiable conditions accounted for this.

One condition was simply the absence of existing instruction on the skill within the educational institutions to which Battelle had access. For example, although visualization is considered to be a highly desirable skill by vocational educators, no specific instruction on this skill is provided to students.

A second condition was the absence of a wholly integrated unit of instruction on the skill of interest. For example, instruction on courteous communication by cosmetologists is treated in connection with a number of other topics spread throughout the curriculum. To achieve an experimental comparison of existing instruction and the self-instructional units would have been too disruptive for the educational institution.

The unavailability of the self-instructional unit at a time when comparable instruction was presented was a third condition that existed. That is, in some cases time limitations within which Battelle had to work precluded comparative evaluations. For several skills, instruction on them by the educational institutions would not occur again until the 1968-1969 school year. It was not possible for Battelle to have had these units ready for evaluation by the time instruction occurred during the 1967-1968 school year.

Because of the conditions pointed out above, it was necessary to evaluate the self-instructional units in terms of pre- and post-test gains in proficiency. These kinds of comparisons were the only reasonable ones that could be conducted. Consequently, the primary data generated by the evaluations were these gains. Additionally, attitudinal data concerning student preferences for instructional methods were obtained.

Individual Study Reports

As pointed out earlier, the preceding descriptions were of tasks common to the individual studies of the ten selected skills. A more detailed account of the work accomplished for each study is contained in a series of appendices to this report as indicated below.

(1) Operation of screwdrivers - Appendix B

(2) Operation of the hacksaw - Appendix C

(3) Communicating courteously - Appendix D

(4) The use of sound as a diagnostic tool - Appendix E

(5) Mathematical word-problem solving - Appendix F

(6) Visualization - Appendix G

(7) Determining causes of tire wear - Appendix H

(8) The identification of metals - Appendix I

(9) How to do a good job - Appendix J

(10) Giving a basic haircut - Appendix K

(11) Lettering - Appendix L

Other Activities

Several other activities were conducted in relation to the specific activities listed on page 9 of the proposal. A brief description of these is included below.

Manual Development

The evaluations of the skills revealed some that appear to be of particular value for vocational education. For each of these a manual usable by vocational educators was developed. These manuals, except for processing to a final printed form, are available at Battelle. The specific activity on page 9 of the proposal to which this work was related is "submitting manuals for use by personnel who prepare vocational-education materials to assist them in preparing self-instructional materials".

A list of skills for which manuals exist is included below.

(1) Operation of screwdrivers

(2) Operation of the hacksaw

(3) Determining causes of tire wear

(4) The identification of metals

(5) Giving a basic haircut

Automated Instruction

The unanticipated problems encountered in the work (and described in the First and Second Technical Progress Reports) precluded the project team from doing much in the area of automated instruction. Some work, however, was accomplished: flow-charting a general automated-instructional system. This will be of value should Battelle proceed in the directions described by its pending proposal to the Bureau of Research.*

The specific activity on page 9 of the proposal to which this work was related is "submitting validated automated-instruction courses which provide instruction for selected vocational-education subsystems".

Publication of Articles

It is likely that at least one of the reports of the individual studies (included as appendices) will be submitted for publication to a professional journal. This submission as well as the formulation of the reports are related to two specific activities listed on page 9 of the proposal: (1) "submitting reports which describe experimental and developmental work accomplished in the program", and (2) "submitting periodic monographs or articles summarizing the state of the art of self-instruction in vocational education and pointing out where additional work should be done".

Conduct of Seminars

Another activity conducted was seminars and working sessions with vocational educators. A primary purpose of these seminars was to obtain information concerning the optimum use of self-instruction for accomplishing the objectives of vocational education. In this sense, these interactions with vocational educators were related to another specific activity listed on page 9 of the proposal: "conducting seminars for administrators and educators in vocational education for the purpose of exchanging information on self-instruction in vocational education and arriving at guidelines for optimum use of self-instruction in order to accomplish vocational-education objectives".

Responses to Specific Inquiries

Throughout the work, specific inquiries concerning it and related work were answered by the project staff. Responding to these inquiries was related to the final specific activity listed on page 9 of the proposal: "answering specific inquiries concerning self-instruction in vocational education".

*The Evaluation of Self-Instruction in Vocational Education, dated October 13, 1967, Proposal Number 8-0244.

RESULTS

The results of this work fall into two general categories. One category includes information generated from the analysis phase as well as instructional materials. The second category includes information generated from the evaluations. Each is presented separately below.

Informational Results

A principal result from the work was the body of information generated concerning trade and industrial education. These informational results have been cited previously. The major one is the behavioral catalog for trade and industrial education (included as Appendix A to this report). Another is the manuals that have been developed in connection with the skills that were most promising from an instructional standpoint. These manuals are available at Battelle. A final type of informational result is the self-instructional units that through evaluation proved to be effective. Although these units are included as part of the manuals, they are worth mentioning separately.

Evaluation Results

A second kind of results was that obtained from the evaluations of the self-instructional units. In most cases, the data obtained from these evaluations were pre- and post-test scores. In some cases, because of the nature of the behaviors taught, judgments by qualified persons regarding pre- and post-instructional performance were the data analyzed. Analyses of pre- and post-instructional performance data gave results relative to the effectiveness of the self-instructional units.

Questions concerning the efficiency of the self-instructional units as compared with existing instruction could not be answered because of the problems cited earlier (i.e., lack of comparative instruction, etc.). Consequently, statements concerning efficiency have to be limited to intra-instructional-unit findings. Where this is possible, such statements are included in the discussion of results section of the report.

Two types of analyses were conducted. One was a t-test of the differences between pre- and post-test means. The purpose of these tests was to determine whether or not it could be safely concluded that learning, as measured by the tests used, occurred.

The second type of analysis was computation of the G statistic.* The G statistic is an index of amount learned, consequently it bears

*McGuigan, F. J. "The G Statistic", Journal of the National Society for Programmed Instruction, V1, 9, 1967, pp 14-16.

directly upon the question of instructional effectiveness. A G value is the ratio of actual gain over possible gain. Actual gain is determined by subtracting the mean pre-test score from the mean post-test score; possible gain results from subtraction of the mean pre-test score from the total possible score. A G value of 0.70 or greater is regarded as a indication of superior learning.

Immediately below a brief description of the results of each evaluation is presented. Following these descriptions, a summary of the evaluation results is given.

Operation of Screwdrivers

The principal instruments used for the final evaluation of the self-instructional unit on operation of screwdrivers were a 28-item written test and a 4-item performance test. Both instruments were used for pre- and post-testing. A total of 19 students (11 pre-vocational and 8 in sheetmetal) participated in the evaluation.

The mean pre-test score for the written test was 12.8 as compared with a mean post-test score of 24.8. The mean pre-test score on the performance test was 2.0 compared with a mean post-test score of 3.21. A t-test for correlated means indicated that the pre-test/post-test differences for both tests were significant at the 0.001 level. The G value for the written tests was 0.79; for the performance tests it was 0.61. The average time required for completion of the self-instructional unit was 20.9 minutes.

Operation of the Hacksaw

For the final evaluation of the self-instructional unit on the operation of the hacksaw, the same 30-item written test was used both as the pre- and post-test. The evaluation involved a total of 15 students drawn from the machine trades and automotive mechanics trade areas.

The mean pre-test score was 5.7 and the mean post-test score was 24.3. A t-test for correlated means revealed that the pre-test/post-test difference was significant at the 0.001 level. The G value was 0.92. The average time required for completion of the self-instructional unit was 35 minutes.

Communicating Courteously

The pre-test for evaluation of the self-instructional unit on courteous communication was made up of ten discourteous dialogues. The students were required to convert the discourteous dialogues to courteous dialogues by writing a courteous dialogue to replace each discourteous one. The post-test consisted of the same task for the same ten discourteous dialogues. Six female cosmetology students participated in the evaluation.

At the conclusion of the evaluation, three professional cosmetologists were given typewritten copies of the ten pairs of pre- and post-instructional dialogues prepared by each student. The dialogues in each pair were randomly arranged so that the judges did not know whether they were reading a pre-instructional or post-instructional dialogue. The judges' task was to read each pair of dialogues for each student and to judge which was more courteous.

Of the total post-test dialogues, 62.6 percent were judged to be more courteous than their pre-test counterparts. Since one would expect 50 percent of the dialogues to be judged more courteous by chance, this finding was viewed as an indication that the self-instructional unit resulted in some learning, but not a convincing amount. The average time for the students to complete the unit was 100 minutes.

The Use of Sound as a Diagnostic Tool

Because of the inability to secure acceptable subject-matter materials for the self-instructional unit on the use of sound as a diagnostic tool for determining automobile engine malfunction, it was not possible to develop a self-instructional unit for evaluation. A number of tape recordings of the sounds of typical engine malfunctions were made. When these sounds were tested, however, even with expert diagnosticians, they were not able to identify them significantly better than chance.

The work that was accomplished in connection with this skill is described in more detail as Appendix E. Neither sufficient time nor funds were available for starting another effort on this skill after the initial effort proved unsuccessful.

Mathematical Word-Problem Solving

Difficulties that precluded meaningful data generation also were experienced with the mathematical word-problem solving skill. These difficulties, however, were quite different than those encountered in connection with the auditory-diagnosis skill. For mathematical word-problem solving a self-instructional unit was developed and subjected to three evaluations and two revisions.

The major problem appeared to be that by the time students reach the vocational-education level, they already have developed a strategy (be what it may) for solving word problems. Because of this, it was extremely difficult to effect any changes in their behavior. The result was that the unit was not a useful tool for them. A more detailed description of the work accomplished in connection with this skill is included as Appendix F.

Visualization

The pre-test for the self-instructional unit on visualization was made up of ten items. Each item consisted of one orthographic drawing and four isometric drawings, one of which corresponded to the orthographic drawing. The students' task for each item was to examine the orthographic drawing and then to select the correct, corresponding isometric drawing. The students were not permitted to flip back and forth between the orthographic and isometric drawings. The post-test was an alternate form of the pre-test also containing ten items. The students' task on the post-test was the same as for the pre-test.

The evaluation of the self-instructional unit was conducted with 30 drafting students--17 seniors and 13 juniors. For the evaluation, three groups of ten students each were formed: a first experimental group, a second experimental group, and a control group. The first experimental group received the pre-test, the self-instructional unit, and the post-test. The second experimental group was administered the self-instructional unit and the post-test with the pre-test being omitted. The control group was administered the pre-test and the post-test with the self-instructional unit being omitted.

An examination of the pre- and post-test data for the first experimental group indicated no difference in the mean scores (pre-test mean = 7.5; post-test mean = 7.4). Similarly, no appreciable difference in the mean scores for the control group were found (pre-test mean = 7.4; post-test mean = 7.6). The mean post-test score for the second experimental group (7.4) was the same as that for the first experimental group. Because of these findings, no G values were calculated (they would be very close to zero). The average time required to complete the self-instructional units was 49.1 minutes.

Determining Causes of Tire Wear

The evaluation of the self-instructional unit on tire wear employed two types of criterion instruments. One was a 17-item written test; the second was an 18-item test on which the students were shown photographs of various types of tire wear and were required to give the causes of the wear shown. The same two instruments were used both as the pre- and post-tests. Five students were involved in the evaluation.

For the written test, the mean pre-test score was 2.4 and the mean post-test score was 10.2. This difference was significant at the 0.01 level (t-test for correlated means). A G value of 0.53 for the written test characterized the effectiveness of the program. The pre-test mean for the photograph test was 1.5 and the post-test mean was 9.8. This difference was found to be significant at the 0.05 level using the same t-test. The G value for the photograph test was 0.50. The average time required for students to complete the program was 65 minutes.

<u>The Identification of Metals</u>

For the self-instructional unit on the identification of metals, two criterion instruments were used. One was an 18-item written test; the second was a 10-item performance test on metals identification. The same criterion instruments were used for pre- and post-testing. Eleven students in a machine-trades program participated in the evaluation.

On the written test, a mean pre-test score of 6.6 was obtained; the mean score for the post-test was 13.8. A t-test for correlated means indicated that the difference between those means was significant at the 0.01 level. The effectiveness of the self-instructional unit in relation to the written test was 0.63 as measured by the G statistic.

The mean pre-test score on the performance test was 3.6. The mean post-test score was 6.6. The difference between these means also was significant at the 0.01 level (t-test for correlated means). The effectiveness of the self-instructional unit in relation to the performance test was reflected by a G value of 0.47. The average time required for the students to complete the self-instructional unit was 45 minutes.

<u>How to do a Good Job</u>

The evaluation of the 12-minute, tape-recorded self-instructional unit on how to do a good job involved 41 students (12 students from electronics, 13 from automotive mechanics, and 16 from drafting). An 8-item written test was used to evaluate the self-instructional unit. (Of course, it was realized that the ultimate effectiveness of the unit would depend upon the work behavior of students on the job. Consequently, the written test was viewed as a clear case of a proximate criterion instrument.)

The 12 students from electronics (judged by school personnel as probably the best class in the school) were assigned to a first experimental group. The 13 students from automotive mechanics (judged as probably the worst class in the school) were assigned to a second experimental group. The 16 drafting students (judged as about average) were assigned to the control group. Each experimental group was given the tape recording followed by administration of the criterion test. The control group was given only the criterion test. The mean score for the control group was 4.44. The mean scores for the first and second experimental groups were 7.33 and 5.00 respectively. The mean score for the combined experimental groups was 6.12.

A t-test for correlated means revealed a significant difference between the first experimental group and the control group at the 0.001 level (the control group's mean score was used as a pre-test score). The difference between the second experimental group and the control group was not significant. Significance at the 0.01 level was found for the difference between the mean scores of the first and second experimental groups. The difference between the mean score for the combined experimental groups and the control group was significant at the 0.05 level.

The G value (using the control group's mean score as a pre-test score) for the first experimental group was 0.50; it was 0.10 for the second experimental group. For the combined experimental groups, the G value was 0.30.

Giving a Basic Haircut

A 36-item written test was used as both the pre- and post-test for the evaluation of the self-instructional unit on giving a basic haircut. The mean pre-test score was 22.5; 35.0 was the mean post-test score. The number of students participating in the evaluation was 26 juniors from the cosmetology trade area. The average time required to complete the program was 32 minutes.

The difference between the pre- and post-test means was significant at the 0.001 level. The G value associated with the self-instructional unit was 0.93.

Lettering

The self-instructional unit on lettering was evaluated using alternate forms of a test designed to measure (1) lettering ability and (2) ability to discriminate between "good" and "bad" lettering. The section of the test covering lettering ability required the students to produce lettering samples. The section designed to test discrimination consisted of a lettered sentence containing lettering errors (e.g., improperly formed letters, improper letter spacing). The students' task was to indicate these errors by circling them. Thirteen drafting students who were juniors participated in the evaluation. The average time required to complete the self-instructional unit was 119 minutes.

Each student as the result of the pre-test section on lettering ability generated two samples of lettering: all letters of the alphabet and the numerals 0 through 9 plus a lettered sentence. The post-test section on lettering also resulted in two samples of lettering: all letters of the alphabet and the numerals 0 through 9 plus a lettered sentence (the lettered sentence being different from the pre-test sentence). Consequently, each student, as a result of the pre- and post-test, generated two pairs of lettering samples (one pair being made up of pre-instructional letters and numerals and post-instructional letters and numerals with the other pair being made up of pre- and post-instructional lettered sentences).

Five experienced Battelle draftsmen judged each student's two pairs of lettering samples without knowing which member of a pair was pre- or post-instructional. The purpose of the judging was to determine which member of each pair was the superior lettering.

The results of judging were that 48 percent of the post-instructional lettering was judged to be superior to the pre-instructional lettering, 42 percent was judged to be inferior to the pre-instructional lettering, and 10 percent of the post-instructional lettering was judged to be equal to the pre-instructional lettering. Inasmuch as 50 percent of the post-instructional lettering would be judged superior by chance, these results were not significantly different from a chance finding.

The mean score on that section of the pre-test designed to test discrimination between good and bad lettering was 76 percent (percentages were used for this section because the number of discriminations on the pre- and post-test was different). The post-test mean score was 81 percent. This difference was not statistically significant. The G value for the program as measured by the discrimination section of the test was 0.22.

Summary of Results

A summary of the results described above is presented as Table 2.

TABLE 2. SUMMARY OF EVALUATION RESULTS

Self-Instructional Unit	Number of Students	Significant Pre/Post-Test Difference at 0.05 Level or Better?	G Value Greater Than 0.50?*	Average Time Required in Minutes
Operation of screwdrivers	19	Yes	Yes	20.9
Operation of hacksaw	15	Yes	Yes	35.0
Communicating courteously	6	No	No	100.0
Sound as a diagnostic tool	-	**	**	-
Mathematical word-problem solving	-	**	**	-
Visualization	30	No	No	49.1
Causes of tire wear	5	Yes	Yes	65.0
Identification of metals	11	Yes	Yes	45.0
How to do a good job	41	Yes	No	12.0
Giving a basic haircut	26	Yes	Yes	32.0
Lettering	13	No	No	119.0

*Although a G value of 0.70 is considered a measure of superior effectiveness, a value of 0.50 is generally regarded as a measure of acceptable effectiveness.

**Not possible to develop and/or evaluate a self-instructional unit.

DISCUSSION OF RESULTS

This section of the report separately discusses the informational results and the evaluation results of the work.

Discussion of Informational Results

The results incorporated in the behavioral catalog consist of two types of information. One is general behaviors involved in trade and industrial education; the other type is specific examples of the general behaviors. The former behaviors resulted from the analyses of the trade areas--for all practical purposes they are viewed as being exhaustive for trade and industrial education. A relatively complete listing of general behaviors was a necessary requirement for this work.

The specific examples of the general behaviors, however, should not be viewed as exhaustive. The requirements of this work called for determining whether or not each general behavior was involved in the specific trade areas, and, if so, obtaining typical examples of how it was demonstrated. Consequently, any attempts to arrive at a complete listing of how each general behavior (if applicable to a trade) was demonstrated within the trade would have gone far beyond practical requirements.

However, should such an effort be appropriate, it is believed that the behavioral catalog would greatly facilitate the work because it contains a relatively complete delineation of the general behaviors for which trade-specific behaviors should be sought. In fact, the catalog provides a considerable start in the direction of obtaining all trade-specific behaviors because it includes examples of them. Finally, the behavioral catalog indicates which trade areas do and do not involve the general behaviors. Consequently, it would give great assistance to any person concerned with a relatively complete listing of trade-specific behaviors. It is anticipated that any work concerned with trade and industrial education done in connection with the organic curriculum would greatly benefit from use of the behavioral catalog.

The five manuals are viewed as being of practical assistance to those persons concerned with the development of self-instructional materials for vocational education in the skills with which the manuals are associated. Further, the self-instructional units incorporated within the manuals appear to be sufficiently efficient and effective at this time for use by students within vocational education.

In an overall view, the informational results appear to have applicability to both additional research and to practical instructional requirements. The dual-dimensional applicability of these results is viewed as a substantial contribution to vocational education.

Discussion of Evaluation Results

The results from the evaluations of the self-instructional units must be viewed as a mixture of promising and not-so-promising ones. On the whole, nine self-instructional units were developed and evaluated (two studies did not result in units that could be evaluated). Of these nine, five appeared to support the contention that self-instruction offers an efficient and effective way to handle instructional requirements within vocational education. It is of some interest, then, to consider why the other four did not. There are reasons to believe that the lack of success of these units was not wholly attributable to self-instructional methodology. These reasons in connection with each of the four self-instructional units that failed to yield significant results are discussed below.

Communicating Courteously

The major problem, it is suspected, with the evaluation of the self-instructional unit on communicating courteously was the pre- and post-test rather than the instructional unit itself. It may have been that the ten discourteous dialogues were simpler to convert to courteous dialogues than was estimated during their preparation. That is, the features of the dialogues that made them discourteous could have been too obvious.

If this is true, the actual effectiveness of the self-instructional unit would have been masked. Consequently, it is apparent that the self-instructional unit in its present form should be re-evaluated employing a more valid pre- and post-test. A re-evaluation would reveal the extent to which the suspected problem with the pre- and post-test is true.

Visualization

In retrospect, the problems with the evaluation of the self-instructional unit on visualization appear to be quite different from the problem described above. Apparently, students were able to visualize (as defined for the study) prior to instruction (the mean pre-test score was approximately 75 percent). Consequently, the self-instructional unit should be evaluated with different students. Another possible problem could be that the instruction is not valid with respect to the objectives. This also could be determined from an evaluation employing students who are not able to visualize (as measured by the pre-test) prior to instruction. In summary, for a different group of students, the self-instructional unit might prove to be very effective.

How to do a Good Job

Because of the necessity to use a proximate criterion instrument for evaluating the self-instructional unit on how to do a good job, it is difficult to judge the ultimate effectiveness of the self-instructional unit. Consequently, before any changes in it are made, performance on the job should be assessed.

The evaluation results, however, suggest a possible reason for the relative ineffectiveness of the program. This is that it may be differentially effective as a function of student ability--possibly in the direction of being more effective for more capable students. To determine this, another evaluation of the unit would be necessary. If differential effectiveness was the case, the self-instructional unit would have to be viewed as being more effective than was demonstrated.

Lettering

Two possible problems could have affected the evaluation of the self-instructional unit on lettering. One is that students were able to do what the unit was designed to teach (because of timing problems, students had been in lettering instruction approximately three months before the unit was available for evaluation). The second problem could be that the instructional strategy incorporated in the program was not an effective one for achieving the terminal behaviors. This is not a method problem; it is a problem of instructional strategy. Both of these problems could be investigated with an additional evaluation of the unit.

Overall Considerations

From the evaluation results obtained, it is probable that those indicating the ineffectiveness of self-instructional methods most likely were not a function of the methods themselves. That is, for the self-instructional units that resulted in non-significant findings, relatively modest re-evaluations at the proper times and, in some cases, with improved criterion instruments, most likely would show effectiveness of the units. In hindsight, some problems that were not foreseen have become clear.

On the other hand, the majority of the self-instructional units evaluated yielded results that can be interpreted as very promising with respect to instructional effectiveness. Further, from the times required for students to complete them, the self-instructional units appear to be relatively efficient. Finally, from the attitudinal data (included in Appendix B through L), the students generally preferred self-instructional methods. Because of these findings and because of the non-methodological problems cited earlier, the results obtained are viewed as strongly supporting the contention that self-instruction is efficient and effective for vocational education.

CONCLUSIONS AND RECOMMENDATIONS

As a result of the work accomplished, a number of conclusions concerning vocational education can be drawn. Some of these are fairly general conclusions; others are more specific. Both are presented below, followed by recommendations.

General Conclusions

During the work of the analysis phase, the project staff often was concerned with fairly broad considerations in trade and industrial education. From these considerations, some observations of importance were made. Further, a number of problems were noted throughout the work. Primarily from these sources, several conclusions can be drawn.

One fairly broad conclusion is that the area of trade and industrial education is characterized by the absence of educational objectives that are specified in terms of observable, measurable student behaviors. The project staff also had occasion to examine other vocational education areas. It is quite probable that these areas, too, are characterized by this shortcoming.

This conclusion is of singular importance; the implications for an educational system of an absence of clearly stated, measurable objectives are problems of the first order throughout the system, eventually affecting every student within the system. The ultimate, certain effect of an educational endeavor characterized by an absence of objectives is a relationship with the real world that is random with respect to meeting real-world requirements.

Although trade and industrial education is not without objectives, their usefulness for describing precise instructional outcomes (and, consequently, for the measurement of these outcomes) is far below what could be obtained. There is little evidence that this situation is improving.

Another conclusion, related to the first, is that instructional materials designed for use within trade and industrial education lack the important characteristic of informing students as to what they should do. There is within these materials a surprising orientation toward only the subject matter of trades--not toward what students ultimately will do (i.e., their trade-specific activities) in the working world. Conceivably, in an extreme case, a student could exit from an automotive mechanics program knowing precisely how an automobile transmission operates, but not knowing the first step in the process of disassembling or adjusting a transmission. Normally, this aspect of education is left up to the instructor. There is questionable reliability among instructors regarding what they emphasize and how they instruct students.

A third general conclusion is that the gap between what students can do upon exiting from instruction and what is required of them in the real world is widening. In repeated cases, the project staff found that although vocational educators were quite familiar with significant trade changes, for one reason or another (often financial reasons), these changes are not reflected by significant changes in instructional content. An important effect of this trend is an increasing inappropriateness of the instruction that students are receiving.

Another fairly general conclusion from the work is that trade and industrial education, and, quite likely, other areas of vocational education are almost ideally suited for application of improved educational technology. This is particularly true with respect to applications of self-instructional methodologies and systems. The kinds of skills that were investigated during the course of this work represented a somewhat characteristic variety of those required in trade and industrial education. As preceding sections of this report have pointed out, these investigations, on the whole, support the contention that self-instructional applications can be efficient and effective for vocational education.

Related to the preceding conclusion is the extent to which current educational technology has affected vocational education. From the work that was conducted, it can be concluded that although a considerable amount of materials based upon this technology exist, the practical impact of them on vocational education has been quite limited.

A final general conclusion is that trade and industrial education is badly in need of greater flexibility of instructional programs both within trades and among trades. This means that considerable opportunities exist for effective, specific instructional units to be used in many different instances. The common case at present is for the design of instructional programs with insufficient attention given to using instructional units that exist. For example, one highly effective and relatively flexible instructional unit on the use of a fairly common hand tool would have application within many instructional programs. Existing practices seem to favor the development of instruction on the hand tool over and over again for the many instructional programs.

Specific Conclusions

A number of specific, yet important, conclusions can be drawn from the work. These are presented below.

One purpose of the work was to attempt to identify "primary" vocational skills that could be employed in connection with evaluating self-instructional methods. By "primary" was meant skills that have wide applicability across the specific trades in the sense that they were independent of such instructional restrictions as trade-specific subject matter, trade-specific proficiency requirements, etc.

From the work that was accomplished, an inescapable conclusion was reached: at the level of trade and industrial education, no such skills exist. For this conclusion, it appears justifiable to go beyond the data and hypothesize that within vocational education in general, the same finding is true.

From a theoretical standpoint, it unquestionably is efficient, attractive, and appropriate to speak in terms of general (i.e., widely applicable) capabilities or capability hierarchies. From the very practical standpoint of vocational instruction, however, such a position is impractical--even unrealistic.

There is good reason why such a position is impractical for vocational education. By the time students reach the vocational education level, most widely applicable skills already exist within their behavioral repertoires to varying degrees of proficiency. The task of vocational education (as well as many other educational programs) is to bring about quite specific skills regardless of whether they are viewed as cognitive, verbal, manipulative or any combination of these. That is, the task of vocational education is a specific one--bringing about specific behavioral change. This task, by its nature, is in opposition to the idea of generality, or wide applicability, of behaviors. For example, the task of vocational education is not to teach verbal behavior (a widely applicable skill); the task is to teach very specific cases of verbal behavior--cases that are trade specific. This requirement operates directly as a subject-matter restriction, and at this point the skill becomes trade specific.

A second specific conclusion concerns the nature of instructional materials for trade and industrial education; these materials should incorporate to the extent possible multiple media. A common practice in our educational establishment is to rely heavily upon verbal abilities of students--particularly the verbal ability of reading. Students within trade and industrial education generally do not perform well with textual materials. Consequently, at least for the present, as much of the instructional load as possible should be borne by non-textual, or simplified textual, materials. This conclusion is particularly important for those concerned with the development of self-instructional materials.

From this work it also can be concluded that students within trade and industrial education like to use self-instructional materials. Generally speaking, the attitudes of students toward these materials are quite favorable.

A final conclusion is that the nature of the instructional tasks of vocational education makes this educational area potentially capable of becoming perhaps the most sophisticated in terms of instructional systems. The justification for such an effort exists in view of the increasing requirements for vocationally trained persons within the society. The requirements are present and the instructional-system capability is present. Hopefully, the means will be present.

Recommendations

A number of recommendations are warranted and are presented below.

(1) Perhaps the most pressing requirement of vocational education is specification of educational objectives in terms of students behaviors that are observable and measurable. It is recommended that behavioral specification of objectives be given very high priority.

(2) The potential for self-instructional units and systems for vocational education is perhaps, at the present time, greater than for any other educational area. It is recommended that development, evaluation, and implementation of such systems be undertaken at an increased rate.

(3) A problem of increasing importance in vocational education is the widening discrepancy between what students can do upon exiting from the educational system and real-world performance requirements. It is recommended that efforts designed to establish and implement methodologies for reducing these discrepancies be given serious consideration.

(4) It appears that a practical approach to improving the efficiency and effectiveness of vocational education would be the development of instructional units (preferably employing self-instructional methods) plus the adaptation of existing instructional units for those instructional areas commonly found in many trade programs. For example, imaginative, multi-media instructional units on common hand tools or power tools would have wide applicability in vocational education. It is recommended that efforts directed toward making such units available and directed toward implementing them within vocational education be undertaken.

(5) Problems exist concerning how to formulate effective and efficient trade programs capitalizing upon existing instructional materials and methodologies. It is recommended that research and developmental efforts directed toward establishing flexible, general procedures for formulating such programs be undertaken.

(6) Vocational education appears to have some very special requirements such as improving certain fairly basic skills (e.g., reading). It is recommended that these special problems and their implications be investigated and resolved.

(7) Because of the very specific behaviors that are the instructional objectives of vocational education, it is recommended that high priority be given to specific efforts designed to improve specific methods required to bring about these behavioral changes.

(8) Finally, because so many of the instructional materials of vocational education are oriented toward subject matter rather than student behaviors, it is strongly recommended that future efforts toward instructional-material development be particularly concerned with making these materials at least partially oriented toward student behaviors.

SUMMARY

The objective of this work was to evaluate the efficiency and effectiveness of self-instructional methods for selected areas of vocational education. The scope of the work was trade and industrial education.

Two major work phases were conducted. The first was directed toward a very detailed analysis of trade and industrial education for the purpose of identifying and describing primary vocational skills to be used as the basis for subsequent development of self-instructional units. A "primary" skill was viewed as one having wide applicability across the specific trade area comprising trade and industrial education (i.e., automotive mechanics, cosmetology, drafting, electrical-electronics, machine trades, sheetmetal, and welding). This applicability was viewed as being restricted by certain instructional dimensions such as subject matter. During the analyses of the trade areas, general behaviors were identified and described as well as trade-specific examples of how the behaviors are demonstrated (if they are) within the specific trades.

The major result of the analysis phase was the development of a behavioral catalog containing the general behaviors involved in trade and industrial education and trade-specific examples of how these behaviors are demonstrated.

The final activity of the analysis phase was the selection of ten skills to serve as the basis for evaluations of self-instructional methods. The selections were made according to a set of selection criteria. The skills selected, as well as the trade-specific cases of them employed in the evaluations of self-instructional methods, are presented below.

(1) Hand tool operation - operation of screwdrivers and the hacksaw

(2) Oral communication - communicating courteously in cosmetology

(3) Auditory diagnosis - the use of sound as a diagnostic tool for auto engine malfunction

(4) Mathematical word-problem solving - (behaviors not trade specific)

(5) Visualization - visualizing stationary three-dimensional objects from two-dimensional drawings

(6) Visual diagnosis - determining causes of tire wear

(7) Sensory discrimination - the identification of metals

(8) Performance evaluation - (how to do a good job in any trade)

(9) Task performance - giving a basic haircut

(10) Two-dimensional form construction - lettering

Throughout the analysis phase, the project staff was assisted by vocational educators.

The second work phase was concerned with the development and evaluation of the self-instructional units. Because of various problems, self-instructional units could not be developed for two skills (auditory diagnosis and mathematical word-problem solving). However, a total of nine units (hand tool operation included two self-instructional units) were developed and evaluated. Five of the nine evaluations supported the contention that self-instruction is efficient and effective for vocational education. It is suspected that the failure of the other four units to do so is attributable to problems not associated with self-instructional methodology per se.

A set of conclusions and recommendations based upon the total work accomplished was formulated. Some of these were based upon central problems discovered within vocational education; the specific aspects of the work were the bases for others. Included in the conclusions was that self-instruction is a significant methodological way to improve the efficiency and effectiveness of vocational education. A second, important conclusion was that primary vocational skills, as originally conceived, simply do not exist at the vocational education level.

APPENDIX A

CATALOG OF BEHAVIORS FOR TRADE AND INDUSTRIAL EDUCATION

APPENDIX A

CATALOG OF BEHAVIORS FOR TRADE AND INDUSTRIAL EDUCATION

Overall Organization of Behaviors

I. Manipulative Behavior

A. Controls

1. Turns a crank or long-handled control
2. Turns a dial indicator knob
3. Turns a valve with dial indicator
4. Flips a switch
5. Pushes a button
6. Uses a handwheel
7. Changes gear system
8. Changes pulley system
9. Operates two-way lever

B. Operator Position

1. Assumes proper position of body and hands to use an instrument or tool
2. Holds tool at appropriate angle to work media
3. Holds tool at appropriate distance from work media
4. Applies sufficient force and pressure to use tool or instrument

C. Tool Motion

1. Applies tool to work media with a horizontal motion
2. Applies tool to work media with a vertical motion
3. Applies tool to work media with a sawing motion
4. Applies tool to work media with a circular motion
5. Applies tool to work media with a scissors motion

Overall Organization of Behaviors

6. Applies tool to work media at the appropriate rate of speed

D. Inserts, Positions, and Secures

1. Transport tools, equipment, and/or work media

2. Connects or disconnects tools, machines, and/or equipment from a power supply

3. Inserts or removes work media, equipment, or tools in a machine or fixture

4. Adjusts or positions tools, parts, equipment, or work media

5. Secures tools, equipment, and/or work media; removes securing device

6. Manually brings equipment, tools, and/or work media into contact

E. Cleaning and Coating

1. Fills lubricant and/or coolant supply

2. Manually coats work media, tools, or equipment with a substance

3. Cleans work station

II. Sensory

A. Auditory

1. Obtains auditory information

2. Uses auditory information

B. Kinesthetic

1. Obtains kinesthetic information

2. Uses kinesthetic information

C. Olfactory

1. Obtains olfactory information

2. Uses olfactory information

D. Visual

1. Obtains visual information

2. Uses visual information

III. Covert Behavior

A. Selection

1. Selects work media based on available information

2. Selects the tools, equipment, and material required to perform the operations

3. Selects the appropriate storage for tools and equipment

4. Selects the work operations to be performed

5. Selects the time, place, and sequence of operations

6. Selects the appropriate scale of measurement, unit of measurement, and level of precision

7. Selects the scale of dimensions for a drawing

8. Selects the view(s) to be presented in a drawing

9. Selects the appropriate product or service for the customer

B. Problem Solving

1. Trouble shooting the situation

2. Based on an analysis of the work media, determines which changes must be made to produce correct work media

3. Reads the measurement indicated on a multiple scale measuring instrument

4. Converts a statement of the problem to an equation or formula

Overall Organization of Behaviors

5. Resolves problems or complaints concerning the product or service

C. Visualization

1. Given a textual or vocal description, visualizes a stationary three-dimensional object

2. Given a textual or vocal description, visualizes a moving three-dimensional object

3. Given a two-dimensional drawing, visualizes a stationary three-dimensional object

4. Given a two-dimensional drawing, visualizes a moving three-dimensional object

5. Given a three-dimensional object, visualizes in two dimensions

6. Given a photograph or perspective drawing, visualizes in two dimensions

7. Given a textual or vocal description, visualizes in two dimensions

D. Application of Knowledge

1. Uses knowledge of engineering principles

2. Uses knowledge of the physics and chemistry of heat

3. Uses knowledge of specific machines

4. Uses knowledge of electrical and electronic principles

5. Uses knowledge of drawing principles

6. Uses knowledge of chemical reactions

7. Uses knowledge of current trends in the trade

8. Uses knowledge of mathematics

9. Uses knowledge of the principles of metallurgy

Overall Organization of Behaviors

10. Uses knowledge of physics

11. Uses knowledge of physiology

12. Uses knowledge of safety principles, equipment, and clothing

13. Uses knowledge of trade terminology

IV. Communicative Behavior

A. Oral

1. Orally communicates information

2. Uses courteous forms of oral expression

3. Speaks with a pleasant, modulated voice

4. Collects information by asking relevant questions

B. Written

1. Prepares forms and sales contracts

2. Uses reference materials

C. Non-verbal

1. Uses non-verbal communication

I. Manipulative Behavior

A. Controls

1. Turns a crank or long-handled control

Trades	Representative Functions of Turning Cranks or Long-Handled Control
Auto Mechanics	None
Cosmetology	None
Drafting	None
Electricity	Moves work inertia
Electronics	None
Machine Trades	Adjust or engage feeds
Sheet Metal	To advance metal through beading machine
Welding	To engage and adjust amperage

I. Manipulative Behavior

A. Controls

2. Turns a dial indicator knob

TRADES	Representative Functions of Turning a Dial Indicator Knob
Auto Mechanics	Adjust valve refacer
Cosmetology	Adjust timer on color machine
Drafting	None
Electricity	Adjust speed of rotation
Electronics	Adjust tuning of channel or station
Machine Trades	Determines movement of table, spindle, etc.
Sheet Metal	None
Welding	Adjust voltage and amperage

I. Manipulative Behavior

A. Controls

3. Turns a valve with dial indicator

TRADES	Representative Functions of Turning a Value With Dial Indicator
Auto Mechanics	Adjust hydraulic pressure
Cosmetology	None
Drafting	None
Electricity	Adjust hydraulic pressure
Electronics	None
Machine Trades	None
Sheet Metal	None
Welding	Adjust pressure

I. Manipulative Behavior

A. Controls

4. Flips a switch

TRADES	Representative Functions of Fliping a Switch
Auto Mechanics	On/off of grinder
Cosmetology	On/off of current
Drafting	On/off of blueprint machine
Electricity	Opens, closes, or prepares a circuit
Electronics	On/off of current
Machine Trades	Change spindle direction
Sheet Metal	On/off of electrical shears
Welding	On/off of current

I. Manipulative Behavior

A. Controls

5. Pushes a button

TRADES	Representative Functions of Pushing a Button
Auto Mechanics	Activate load test with carbon pile
Cosmetology	Reset heating cup for manicure
Drafting	None
Electricity	Open, closes, or prepares a circuit
Electronics	Test for momentary contact
Machine Trades	On/off of current
Sheet Metal	Activate cutting blade
Welding	On/off of current

I. Manipulative Behavior

A. Controls

6. Uses a handwheel

TRADES	Representative Functions of Using a Handwheel
Auto Mechanics	Adjust pin hone or valve refacer
Cosmetology	None
Drafting	Rotate drafting machine
Electricity	None
Electronics	None
Machine Trades	Adjust or engage feed
Sheet Metal	Adjust amperage and voltage
Welding	Adjust amperage and voltage

I. Manipulative Behavior

A. Controls

7. Changes gear system

TRADES	Representative Functions of Changing a Gear System
Auto Mechanics	None
Cosmetology	None
Drafting	Adjust speed on blue print machine
Electricity	None
Electronics	Adjust speed of drill press
Machine Trades	Adjust dividing head
Sheet Metal	Adjust speed of drill press
Welding	None

I. Manipulative Behavior

A. Controls

8. Changes pulley system

TRADES	Representative Functions of Changing a Pulley System
Auto Mechanics	Operating chain falls
Cosmetology	None
Drafting	None
Electricity	None
Electronics	Adjust the speed of drill press
Machine Trades	Driver lathe
Sheet Metal	Adjust speed of drill press
Welding	Drive power saws, drills, etc.

I. Manipulative Behavior

A. Controls

9. Operates two-way lever

TRADES	Representative Functions of Operating a Two-Way Lever
Auto Mechanics	Operate a hoist or jack
Cosmetology	None
Drafting	None
Electricity	None
Electronics	None
Machine Trades	Start and stop spindle
Sheet Metal	None
Welding	None

I. Manipulative Behavior

B. Operator Position

1. Assumes proper position of body and hands to use an instrument or tool

TRADE	Tool or Equipment	Body and Hand Position
Auto Mechanics	Micrometer	Curl little finger around frame of micrometer. Place thimble between forefinger and thumb.
	Valve Spring Compressor	Work should be on a bench about belt high. Stand slightly sideways. Place left hand firmly on frame of compressor.
	Piston Ring Compressor	Hold rim of compressors with forefinger and thumb or the left hand. Hold handle with fight hand and turn slightly clockwise.
	Cylinder Ridge Reamer	Shoulders should be above work at arms length. Left hand holds ream straight in cylinder. Right hand turns handle clockwise with open pull toward body.
	Torque Wrench	Body should be square with work. Left arm should be slightly bent while left hand on socket end of wrench. Right arm should be straight while right hand firmly around handle. Keep right wrist straight to avoid pivoting of handle on pin.

I. B. 1. (Continued)

TRADE	Tool and Equipment	Body and Hand Position
Cosmetology	Straight razor with guard	Stand in a relaxed erect position with both feet firmly implanted on floor. Adjust patron to chest level. Hold razor with guard facing cosmetologist. Place three fingers over the shank, the thumb in the groove of the shank and the little finger in the hollow part of the tang.
Drafting	Dividers	Sit or stand. Use a clamping hand position.
	Compass	Sit or stand. Use a pressing hand position.
	Ruling Pen	Sit or stand. Use a clamping hand position.
	Protractor	Sit or stand. Use a clamping and pressing hand position.
	Scale	Sit or stand. Use a clamping hand position.
	Lettering Pen	Sit or stand. Use an up and down or across motion.
	Erasing Shield	Sit or stand. Use a pressing ahdn position.
	Templates	Sit or stand. Use a pressing hand position.
	T squares	Sit or stand. Use a pressing hand position.
	Triangles	Sit or stand. Use a pressing hand position.

I. B. 1. (continued)

TRADE	Tool or Equipment	Body and Hand Position
	Lettering Instruments	Sit or stand. Use an up and down or across motion.
	Drafting Machine	Sit or stand. Use a pressing hand position.
	Irregular curve	Sit or stand. Use a pressing hand position.
	Pencils	Sit or stand. Use an up and down or across motion.
Electricity	Diagonal cutters	Normally seated. Held as a dinner knife.
	Needle Nose Pliers	Normally seated. Held as a dinner knife.
	Soldering gun	Pistol grip--seated or standing.
	Tube testers, voltmeters	Seated and operated like a tuning a radio or T.V.
	Files and punches	Held in vise and usually twisted or pushed back and forth.
	Drawing Equipment	Normally seated.
Electronics	Conduit Bender	Pressure is exerted through lever action by pulling on handle. Foot pressure is applied to the length of conduit to hold it in place on the floor.
	Crimping Tool	Pressure is exerted by hand grip
	Torch	Torch is hand held and controlled so as to direct heat to electrical connections. Where temperature is sufficient solder is applied with other hand.

I. B. 1 (continued)

TRADE	Tool and Equipment	Body and Hand Position
Machine Trades	Hammers	
	Files	
	Chisles	
	Screwdriver	Use a hand grip which allows turning
	Plier	Use a hand grip which allows grasping
	Wrench	
	Mike-Verniers	
	Calipers	Body position not important. Be able to hold mike (1", 2", 3") in one hand freeing other hand for job.
	Indicators	
	Gages	
	Lathe	Stand relative to controls; hand off machine when in operation.
	Drill Press	Operator stands. Right hand operates down feed. Keep left hand clear.
	Mills	On long jobs operator can sit. Hand feed machine requires left hand to operate longitudal feed while right hand operates cross feed.
	Saw Band	Both hands guide saw out. Standing position.

I. B. 1. (continued)

TRADE	Tool or Equipment	Body and Hand Position
	Shaper	Stand to side of machine while in operation. May sit or stand, but must be in a position where controls can be reached.
Sheet Metal	T squares	Hold firmly.
	Drawing Boards	Tilt to 30° angle.
	Triangles	Hold firm with left hand.
	Compasses	Hold at top and twist.
	Mallets	Hand firmly back on handle.
	Steel Rules	Hold firm.
	Screwdrivers	Use a hand grip which allows turning.
	Steel squares	
	Combination squares	
	Trammel Points	
	Hand Punch Set	Hold firmly with left hand.
	Hammer	Grip at handle position.
	Aviation Snips	Scissor grip position
	Rivet sets	Hold firmly 90° in left hand.
	Pipe groovers	Hold firmly 90° in left hand.
	Dividers	
	Center Punch	Hold firmly 90° in left hand.
	Vise grips	Scissor position
	Box Brake	Left hand on counter balance; right hand on lever.

I. B. 1. (continued)

TRADE	Tool or Equipment	Body and Hand Position
	Folder	Right hand on lever
	Cornice Brake	Left hand on counter balance; right on lever
	Preso Brake	Hold metal to gage and push foot pedal.
	Pittsburgh lock machine	Hold metal to gage and push foot pedal.
	Scratch Awls	Hold against rule at 60° and scribe.
Welding	Welder and Rod	Welder is held in right hand and rod in left, the angle at which they are held varies depending on the type of welding done; (the usual angle is 45°); the welder takes a stance which is comfortable and which avoids being hit by parts or more often metal.

I. Manipulative Behavior

B. Operator Position

2. Holds tool at appropriate angle to work media

TRADES	Tool or Equipment	Angle of Tool to Work Media
Auto Mechanics:	Hammer	180°
	Screw driver	180°
	Open end wrench	90°
	Box end wrench	90°
	Socket with speed handle	180°
	Socket with racket	90°
	Socket with flex handle	90°
	Socket with tee handle	90°
	Line wrench	90°
	Tap and die	180°
	Micrometer	90°
	Dial test	180°
Cosmetology:	Nail file	45°
	Scissors	90°
	Scissors for shingle	Parallel with comb

I. B 2. (continued)

TRADES	Tool or Equipment	Angle of Tool to Work Media
Drafting:	Compass	90^{o}
	Divider	90^{o}
	Ruling Pen	75^{o}
	Architects scale	180^{o}
	Drafting machine	180^{o}
	Triangle	180^{o}
	Pencil pointer	90^{o}
	Mechanical pencil	75^{o} (15^{o} from vertical)
	Erasure shield	180^{o}
	Protractor	180^{o}
	Template	180^{o}
	Irregular curve	180^{o}
	T square	180^{o}
	Lettering instrument	90^{o}
Electricity:	Needle nose pliers	varies
	Soldering	"

I. B. 2. (continued)

TRADES	Tool or Equipment	Angle of Tool to Work Media
Electronics:	Side cutting plier	90°
	Hack saw	90°
	Knife	0°-90°
	Conduit Dies	90°
	Crimping tool	90°
	Conduit bender	0°-90°
	Pipe wrench	90°
Machine Trades:	Hammer	75°-90°
	Hack saw	30°-180°
	Files	180°
	Chisel	45°-30°
	Gages	180°
	Tap and dies	90°
	Layout squares	90°
	Scriber	60°-80°
	Wrenches	180°
	Calipers	75°-90°
	Dividers; Trammel	75°-90°
	Screw Drivers	90°

I. B. 2. (continued)

TRADE	Tool or Equipment	Angle of Tool or Work Media
Sheet Metal:	Punch	90°
	Groover	90°
	Snips	90°
	Hammer	60°
Welding	Pedestal grind	Varies
	Side grinder	Varies
	Dividers	75°-90°
	Compass	90°
	Radio Graph	
	Squares	90° or 180°
	Protractors	180°
	Chisels	Varies
	Hack saw	Varies

I. Manipulative Behavior

B. Operator Position

3. Holds tool at appropriate distance from work media

TRADES	Tool or Equipment	Distance of Tool to Work Media
Auto Mechanics	Hammer	Contact
	Screw Driver	"
	Open end wrench	"
	Box end wrench	"
	Socket with speed handle	"
	Socket with flex handle	"
	Socket with tee handle	"
	Line wrench	"
	Tap and die	"
	Micrometer	"
	Dial test	"
Cosmetology	Nail file	Contact
	Scissors	"
	Scissors for shingle	"

I. B. 3. (continued)

TRADES	Tool or Equipment	Distance of Tool to Work Media
Drafting	Compass	Contact
	Divider	"
	Ruling pen	"
	Architects scale	"
	Drafting machine	"
	Triangle	"
	Pencil Pointer	"
	Mechanical pencil	"
	Erasure shield	"
	Protractor	"
	Template	"
	Irregular curve	"
	T square	"
	Lettering instrument	"
Electricity	Needle nose pliers	"
	Soldering	"

I. B. 3. (continued)

TRADES	Tool or Equipment	Distance of Tool to Work Media
Electronics	Side cutting plier	Contact
	Hack saw	"
	Knife	"
	Conduit dies	"
	Crimping tool	"
	Conduit bender	"
	Pipe wrench	"
Machine trades	Hammer	"
	Hack saw	"
	Files	"
	Chisel	"
	Gages	"
	Tap and dies	"
	Layout squares	"
	Scriber	"
	Wrenches	"
	Calipers	"
	Dividers; trammel	"
	Screw Drivers	"

I. B. 3. (continued)

TRADES	Tool or Equipment	Distance of Tool to Work Media
Sheet metal	Punch	Contact
	Groover	"
	Snips	"
	Hammer	N.A.
Welding	Pedestal grind	Contact
	Side grinder	"
	Dividers	"
	Compass	"
	Radio graph	Varies
	Squares	Contact
	Protractors	"
	Chisels	"
	Saw	"

I. Manipulative Behavior

B. Operator Position

4. Applies sufficient force and pressure to use tool or instrument

TRADE	Tool or Equipment	Force and Pressure on Work Media
Auto Mechanics	Hammer	Varies
	Screwdriver	Varies
	Open end wrench	Light
	Box end wrench	Medium to Firm
	Socket with speed handle	Light
	Socket with rachet	Light to Medium
	Socket with flex handle	Firm
	Socket with tee handle	Medium to Firm
	Line wrench	Firm
	Tap and Die	Light
	Micrometer	Light
	Dial Test	Light
Cosmetology	Nail File	Light to Medium
	Scissors	Medium
	Scissors for shingle	Medium
Drafting	Compass	Light
	Divider	Light
	Ruling Pen	Light
	Architects scale	Firm
	Drafting machine	Firm
	Triangle	Firm
	Pencil pointer	Medium
	Mechanical pencil	Medium
	Erasure shield	Firm
	Protractor	Firm

I. B. 4. (continued)

TRADE	Tool or Equipment	Force and Pressure on Work Media
	Template	Firm
	Irregular curve	Firm
	T Square	Firm
	Lettering instrument	Light
Electricity	Needle nose pliers	Firm
	Soldering	Light
Electronics	Side cutting plier	Firm
	Hack saw	Light
	Knife	Medium
	Conduit dies	Firm
	Crimping tool	Firm
	Conduit bender	Firm
	Pipe wrench	Firm
Machine Trades	Hammer	Varies by hammer weight
	Hack saw	Medium
	Files	Variable
	Chisel	Variable
	Gages	Light
	Tap and Dies	Light to Medium
	Layout Squares	Light
	Scriber	Light
	Wrenches	Variable
	Calipers	Light
	Dividers; trammel	Light
	Screwdrivers	Variable
Sheet Metal	Punch	Firm and Light
	Groover	Firm and Light
	Snips	Firm and Light
	Hammer	Firm and Light

I. B. 4. (continued)

TRADE	Tool or Equipment	Force and Pressure on Work Media
Welding	Pedestal Grind	Medium
	Size grinder	Medium
	Dividers	Medium
	Compass	Light
	Radio Graph	Not applicable
	Squares	Medium
	Protractors	Medium
	Chisels	Varies
	Saw	Medium
	Hammer	Varies

I. Manipulative Behavior

C. Tool Motion

1. Applies tool to work media with a horizontal motion

TRADE	Tool or Equipment
Auto Mechanics	Open end wrench Box end wrench Socket with rachet Socket with flex handle
Cosmetology	Straight razor Scissors Cuticle pusher
Drafting	Architects scale Drafting machine Triangle Erasure shield Protractor Template Irregular curve T square
Electricity	Not applicable
Electronics	Knife Fish tape Conduit bender Cutting torch Arc Welding Electrolode
Machine Trades	Pliers Hack saw Files Scriber Squares Wrenches Taps and Dies Rulers Calipers Trammel Parallel Bars

I. C. 1. (continued)

TRADE	Tool or Equipment
	V Blocks Angle plates Sine Bar Telescoping gage Thickness gage Screw Pitch gage Center gage Radius gage Micor-Finish gage Surface gage Planner gage Drill Point gage Plug gage Ring gage Tool Bit gage Vernier Height gage Vernier Depth gage Vernier Bever Protractor Gear tooth Veinier Dial Indicators Gage blocks Visual gages Outside Micrometer Inside Micrometer Depth Micrometer
Sheet Metal	T square Pittsburgh Lock Pan brake Cornice brake Rolls Folder

I. C. 1. (continued)

TRADE	Tool or Equipment
Welding	Pedestal grinder Side grinder Framing square Chisel Gouges Saw band Measuring tape T square

I. Manipulative Behavior

C. Tool Motion

2. Applies tool to work media with a vertical motion

TRADE	Tool or Equipment
Auto Mechanics	Hammer
Cosmetology	Straight razor Buffer Cuticle pusher
Drafting	Not Applicable
Electricity	Not Applicable
Electronics	Conduit Dies (Rachet type) Hydraulic Conduit Bender Cutting torch Arc Welding Electrode
Machine Trades	Hammer Pliers Chisels Screwdrivers Wrenches Tap and Dies Calipers Trammel Telescoping Gage Thickness Gage Plug Gage Ring Gage Dial Indicators Outside Micrometer Inside Micrometer

I. C. 2. (continued)

TRADE	Tool or Equipment
Sheet Metal	T square Triangles Compasses Hammers Hacksaws Scratch Awls Snips Punches Files Pipe grooners Rivet sets Trammel Points Press Brake
Welding	Side grinder Framing square Chisel Gouges Saw band Protractor Measuring tape T square

I. Manipulative Behavior

C. Tool Motion

3. Applies tool to work media with a sawing motion

TRADE	Tool or Equipment
Auto Mechanics	Hack saw File Sanding block
Cosmethology	Electric manicure
Drafting	Not applicable
Electricity	Hack saw
Electronics	Hack saw
Machine Trades	Hack saw
Sheet Metal	Hack saw
Welding	Hack saw

I. Manipulative Behavior

C. Tool Motion

4. Applies tool to work media with a circular motion

TRADE	Tool or Equipment
Auto Mechanics	Screwdriver Socket with speed handle Socket with tee handle Tap and dye
Cosmetology	Electric manicure
Drafting	Compass Divider Pencil pointer Lettering instrument
Electricity	Hole punch Meters
Electronics	Side cutting plier Fish tape Conduit bender Cutting torch Arc welding electrode Pipe wrench Meggar
Machine Trades	Pliers Wrenches Taps and dyes

I. C. 4. (continued)

TRADE	Tool or Equipment
	Dividers Trammel Dial indicators
Sheet Metal	Compasses Trammel points Circle cutter
Welding	Compass Protractor

I. Manipulative Behavior

C. Tool Motion

5. Applies tool to work media with a scissors motion

TRADE	Tool or Equipment
Auto Mechanics	Tap and dye
Cosmetology	Scissors
Drafting	Not applicable
Electricity	Wire cutters
Electronics	Side cutting plier Diagonal plier Long nose plier Crimping tool
Machine Trades	Pliers
Sheet Metal	Vise grips Snips
Welding	Tin snips

I. Manipulative Behavior

C. Tool Motion

6. Applies tool to work media at the appropriate rate of speed

TRADE	Tool or Equipment	Speed of Movement Across Work Media
Auto Mechanics	Hammer	60 strokes/min.
	Screwdriver	slow
	Open end wrench	medium to slow
	Box end wrench	slow
	Socket with speed handle	fast
	Socket with rachet	medium to fast
	Socket with flex handle	slow
	Socket with fee handle	medium to fast
	Line wrench	slow
	Tap and Dye	slow
	Micrometer	slow
	Dial test	slow to medium
Cosmetology	Nail file	two short quick and one long sweeping strokes
	Scissors	medium
	Scissors for shingle	fast, scissor movement
Drafting	Compass	medium
	Divider	slow
	Ruling pen	medium
	Architects scale	Not applicable
	Drafting machine	Not applicable
	Triangle	Not applicable
	Pencil pointer	Not applicable
	Mechanical pencil	medium
	Erasure shield	Not applicable

I. C. 6. (continued)

TRADE	Tool or Equipment	Speed of Movement Across Work Media
	Protractor	Not applicable
	Template	Not applicable
	Irregular curve	Not applicable
	T square	Not applicable
	Lettering instrument	slow
Electricity	Needle nose pliers	Not applicable
	Soldering	Not applicable
Electronics	Side cutting plier	fast
	Hack saw	40-60 strokes/min.
	Knife	medium to fast
	Conduit dyes	slow
	Crimping tool	fast
	Conduit bender	slow
	Pipe wrench	Not applicable
Machine Trades	Hammer	Not applicable
	Hack Saw	40-60 strokes/min.
	Files	medium
	Chisel	Not applicable
	Gages	slow
	Tap and Dyes	Not applicable
	Layout squares	Not applicable
	Scriber	medium
	Wrenches	Not applicable
	Calipers	Not applicable
	Dividers, Trammel	slow to medium
	Screwdrivers	Not applicable
Sheet Metal	Punch	slow
	Groover	slow
	Snips	slow
	Hammer	slow

I. C. 6. (continued)

TRADE	Tool or Equipment	Speed of Movement Across Work Media
Welding	Pedestal grinder	varies
	Side grinder	varies
	Dividers	slow to medium
	Compass	medium
	Radio graph	
	Squares	Not applicable
	Protractors	Not applicable
	Chisels	Not applicable
	Hack Saw	40-60 strokes/min.
	Hammer	60 strokes/min.

I. Manipulative Behavior

D. Inserts, Positions, and Secures

1. Transport tools, equipment, and/or work media

TRADES	Transporting Devices, Other Than Hands, That Are Used in Trade
Auto Mechanics	Hoists, jacks, dollies, creepers
Cosmetology	Hydraulic
Drafting	None
Electricity	Chain hoists, Reel buggies, Rope blocks, Line Trucks
Electronics	None
Machine Trades	Cranes, Hand trucks, Skids
Sheet Metal	Chain blocks, Scaffolds
Welding	Trucks for portable welders and compressed gases

I. Manipulative Behavior

D. Inserts, Positions, and Secures

2. Connects or disconnects tools, machines, and/or equipment from a power supply.

TRADES	Power Sources Used in Trade			
	Electricity	Gas	Compressed Gas	Other
Auto Mechanics	✓	✓	✓	
Cosmetology	✓	✓		
Drafting	✓			
Electricity	✓	✓	✓	
Electronics	✓			
Machine Trades	✓	✓	✓	
Sheet Metal	✓	✓	✓	
Welding	✓	✓	✓	Disel

I. Manipulative Behavior

D. Inserts, Positions, and Secures

3. Inserts or removes work media, equipment, or tools in a machine or fixture

TRADES	Representative Situations Where Work Media, Equipment, or Tool are Inserted into a Machine or Fixture
Auto Mechanics	Inserting valves into valve refacer
Cosmetology	Inserting electrode into wall outlet
Drafting	Inserting paper into blueprint machine, Inserting pencil into pencil pointer
Electricity	Inserting auger bit into boring machine
Electronics	Inserting components into equipment
Machine Trades	Inserting drills or cutters into spindles
Sheet Metal	Inserting drills into drill presses, Inserting metal into edging and crimping machines
Welding	Inserting tank wrenches, chipping hammers, wire brushes, tip cleaners, and filler metals into portable equipment

I. Manipulative Behavior

D. Inserts, Positions, and Secures

4. Adjusts or positions tools, parts, equipment, or work media

TRADES	Representative Situations Where Tools, Parts, Equipment, or Work Media are Adjusted or Positioned
Auto Mechanics	Adjusting valves, transmissions, and clutches
Cosmetology	Adjusting facial, shampoo, and styling chairs, positioning dryer hoods and permanent rods
Drafting	Adjusting drafting machine and adjustable triangles
Electricity	Zero adjusting an ohmmeter
Electronics	Adjusting television picture controls
Machine Trades	Adjusting vertical and cross feeds on lathes
Sheet Metal	Positioning drill press vice, adjusting folding and edging machines
Welding	Adjusting heat settings and polarity on welders

I. Manipulative Behavior

D. Inserts, Positions, and Secures

5. Secures tools, equipment, and/or work media; removes securing device

TRADES	Major Securing Devices Used in Trade
Auto Mechanics	Vices, C-clamps, Bench fixtures, Engine stands
Cosmetology	Clamps for holding manikin head blocks, Latches on facial chairs, Neck bands on capes
Drafting	Drafting tape, thumb tacks, staples
Electricity	Masonry anchors, Bolts, Screws, Nails, Staples, Rope and cable slings
Electronics	Solder, Heat sinks
Machine Trades	Vices, Clamps, Jigs
Sheet Metal	Clamps, Ropes, Hangers, Drivers and S hooks, Angles
Welding	C-clamps, Bench vices, Corner clamps

I. Manipulative Behavior

D. Inserts, Positions, and Secures

6. Manually brings equipment, tools, and/or work media into contact

TRADES	Representative Situations Where Equipment, Tools, and/or Work Media are Brought Into Contact Manually
Auto Mechanics	Body repair work
Cosemotology	Combing, Brushing, Manicuring
Drafting	Drawing, Placing triangles, protractors, etc., on paper
Electricity	Soldering, Placing wires under terminal screws
Electronics	Soldering
Machine Trades	Filing, Chiseling
Sheet Metal	Hammmering of locks and scams
Welding	Operating side grinders, slag suckers, and rotating brushes

I. Manipulative Behavior

E. Cleaning and Coating

1. Fills lubricant and/or coolant supply

TRADES	Necessary to Fill Lubricant and/or Coolant Supply?	
	Yes	No
Auto Mechanics	✓	
Cosmetology	✓	
Drafting		✓
Electricity	✓	
Electronics	✓	
Machine Trades	✓	
Sheet Metal	✓	
Welding	✓	

I. Manipulative Behavior

E. Cleaning and Coating

2. Manually coats work media, tools, or equipment with a substance

TRADES	Cleaning and Coating Substances Used			
	Layout Dye	Coating with a lubricant	Shellac	Other
Auto Mechanics		✓	✓	Adhesives
Cosmetology				Numerous liquids for coloring, setting, etc., Makeup Nail polish Hand crean
Drafting				Ground erasers
Electricity				Insulating varnish
Electronics				Silicone spray
Machine Trades	✓	✓		
Sheet Metal	✓			
Welding	✓			Fluxes, De-Spat, Granular metals

I. Manipulative Behavior

E. Cleaning and Coating

3. Cleans work station

All eight of the trades teach students to clean their work station.

II. Sensory

A. Auditory

1. Obtains auditory information

TRADES	Situations Where Auditory Information is Obtained
Auto Mechanics	Listens to a running engine
Cosmetology	Listens to running hair dryer and clippers
Drafting	None
Electricity	Listens to the operation of a circuit containing relays, motors, solenoids, and/or transformers
Electronics	Listens to operation of circuits, as above
Machine Trades	Listens to running machinery
Sheet Metal	Listens to running machinery
Welding	Listens to sound of arc and to running machinery

II. Sensory

A. Auditory

2. Uses auditory information

TRADES	Situations Where Auditory Information is Used
Auto Mechanics	Detects engine misfire, knocks, exhaust noise, backfire, air leaks, gear noise, etc.
Cosmetology	Detects hair dryer, clippers, high frequency electrodes, etc., malfunction
Drafting	None
Electricity	Detects relay clatter, motor and transformer noise
Electronics	Detects radio, T.V., relay, motor, transformer, etc., noise
Machine Trades	Detects machine laboring, binding, and tightness
Sheet Metal	Detects machine malfunction
Welding	Detects machine malfunction and determines penetration, polarity, and amperage setting from sound of arc

II. Sensory

B. Kinesthetic

1. Obtains kinesthetic information

TRADES	Situations Where Kinesthetic Information is Obtained
Auto Mechanics	Feels for exhaust leaks; tightens bolts
Cosmetology	Feels hair for damage, texture, brittleness, and amount
Drafting	Adjusts ruling pen
Electricity	Feels wire for damage
Electronics	Feels operation of rotary devices
Machine Trades	Feels for machine vibration; tightens bolts
Sheet Metal	Feels for leaks; tightens bolts
Welding	Tightens thimbles; feels for penetration of weld

II. Sensory

B. Kinesthetic

2. Uses kinesthetic information

TRADES	Situations Where Kinesthetic Information is Used
Auto Mechanics	Locating rough wheel bearing, gear noises, or exhaust leaks; tightening bolts, adjusting fan belts
Cosmetology	Checking hair for damage, brittleness, texture, and amount; checking tension on cold wave rod
Drafting	Adjusting ruling pens
Electricity	Locating broken wires under insulation, tightening screws
Electronics	Checking rotary devices, tightening screws
Machine Trades	Locating surface defects in molds, tightening bolts, adjusting micrometer, vernier, and calipers
Sheet Metal	Checking for sags and rises in metal; tightening screws and bolts
Welding	Checking weld penetration, tightening bolts

II. Sensory

C. Olfactory

1. Obtains olfactory information

TRADES	Situations Where Olfactory Information is Obtained
Auto Mechanics	Smells engines, transformers, fluids, etc.
Cosmetology	Smells fluids
Drafting	None
Electricity	Smells circuits (for overheating)
Electronics	Smells circuits (for overheating)
Machine Trades	Smells machinery, electrical components, etc.
Sheet Metal	Smells machinery
Welding	Smells machinery, transformers, etc.

II. Sensory

C. Olfactory

2. Uses olfactory information

TRADES	Situations Where Olfactory Information is Used
Auto Mechanics	Determines too rich fuel mixture, excessive oil burning; or overheated motor, transformer, hypoid tube, or automatic transmission fluid
Cosmetology	Checking solutions; locating overheated hair dryer
Drafting	None
Electricity	Determines that motor or generator is overheated, coil is burned, or that electrolytic capacitor is shorted
Electronics	Determines that circuit is overheated (as above)
Machine Trades	Determines that components or machines are overheated, or that cutter speed is too fast
Sheet Metal	Determines that motor or machine is overheated
Welding	Determines that rectifier, cable, or transformer is overheated

II. Sensory

D. Visual

1. Obtains visual information

TRADES	Situations Where Visual Information is Obtained
Auto Mechanics	Inspects valves, pistons, points, etc.; reads dials, guages, scales
Cosmetology	Inspects hair, nail polish; read indicators and scales
Drafting	Inspects drawing; reads scales
Electricity	Inspects insulation, commutators, etc.; reads dials, guages, scales
Electronics	Inspects insulation, components, etc.; reads dials and scales
Machine Trades	Inspects finished work, cutter chips; reads dials, guages, and scales
Sheet Metal	Inspects finished work; reads guages and scales
Welding	Inspects finished work; reads dials, guages and scales

II. Sensory

D. Visual

2. Uses visual information

TRADES	Situations Where Visual Information is Used
Auto Mechanics	Determines that valves or pistons are burned, ignition points pitted; discriminates exhaust smoke color; reads dials, guages, and scales
Cosmetology	Determines hair length and color; reads dials and scales
Drafting	Checks drawings; determines colors for graphs and charts; reads scales
Electricity	Determines that material is burned; that carbon deposits are on motor commutators; color coding on components; reads dials, gauges, and scales
Electronics	As above; adjusts television
Machine Trades	Checks work; determines cutter dullness from chips; reads dials, guages, and scales
Sheet Metal	Checks works; determines type of metal; reads guages and scales
Welding	Checks work; determining flame color, type of metal; reads dials, guages, and scales

III. Covert Behavior

A. Selection

1. Selects work media based on available information

TRADES	Sources of Information Used to Select Work Media						
	Instructor or Supervisor	Texts or Hand Books	Specification Sheets	Product Catalogs	Films, film strips and slides	Job Sheets	Other
Auto Mechanics	✓	✓					
Cosmetology							
Drafting	✓	✓	✓	✓			
Electricity	✓	✓	✓	✓			Customer
Electronics	✓	✓				✓	
Machine Trades	✓	✓					
Sheet Metal		✓					
Welding	✓	✓			✓		

III. Covert Behavior

A. Selection

2. Selects the tools, equipment, and material required to perform the operations

TRADES	Sources of Information Used to Select the Tools, Equipment and Material Required to Perform the Operations						
	Instructor or Supervisor	Texts or Hand Books	Specification Sheets	Product Catalogs	Films, film strips and slides	Job Sheets	Other
Auto Mechanics	✓	✓				✓	
Cosmetology		✓	✓	✓	✓		Some are regulated by State Board
Drafting	✓	✓			✓	✓	
Electricity	✓					✓	Partially based on degree of quality and precision reqd.
Electronics	✓	✓		✓			
Machine Trades	✓	✓	✓	✓			
Sheet Metal	✓					✓	
Welding	✓	✓		✓			

III. Covert Behavior

A. Selection

3. Selects the appropriate storage for tools and equipment

Sources of Information Used to Select the Appropriate Storage for Tools and Equipment

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All eight of the trades use the instructor and manuals for sources of information on appropriate storage for tools and equipment.

III. Covert Behavior

A. Selection

4. Selects the work operations to be performed

TRADES	Sources of Information for Selecting the Work Operations to be Performed				
	Instructor or Supervisor	Texts or Handbooks	Specification Sheets	Job Sheets	Other
Auto Mechanics	✓	✓		✓	Customer
Cosmetology	✓	✓			Patron
Drafting	✓	✓		✓	
Electricity	✓			✓	
Electronics	✓	✓		✓	
Machine Trades	✓	✓	✓		
Sheet Metal	✓	✓			
Welding	✓	✓			

III. Covert Behavior

A. Selection

5. Selects the time, place, and sequence of operations

TRADES	Sources of Information for Selecting the Time, Place, and Sequence of Operations			
	Instructor or Supervisor	Texts or Handbooks	Job Sheets	Other
Auto Mechanics	✓	✓		
Cosmetology	✓	✓		Patron
Drafting	✓	✓	✓	
Electricity	✓		✓	
Electronics	✓	✓		
Machine Trades	✓			Availability of equipment
Sheet Metal	✓		✓	
Welding	✓			

III. Covert Behavior

A. Selection

6. Selects the appropriate scale of measurement, unit of measurement, and level of precision

TRADES	Sources of Information for Selecting the Appropriate Scale of Measurement, Unit of Measurement, and Level of Precision			
	Instructor or Supervisor	Texts or Handbooks	Specification Sheets	
Auto Mechanics	✓	✓	✓	
Cosmetology	✓	✓	✓	
Drafting	✓	✓		
Electricity	✓	✓	✓	
Electronics	✓	✓	✓	
Machine Trades	✓		✓	
Sheet Metal	✓	✓		
Welding	✓	✓		

III. Covert Behavior

A. Selection

7. Selects the scale of dimensions for a drawing

TRADES	Sources of Information Used to Select the Scale of Dimensions for a Drawing		
	Instructor	Text	Other
Auto Mechanics			
Cosmetology			
Drafting	✓	✓	Company policy
Electricity	✓	✓	
Electronics	✓	✓	
Machine Trades	✓		Based on object size
Sheet Metal	✓		Always full scale
Welding			

III. Covert Behavior

A. Selection

8. Selects the view(s) to be presented in a drawing

TRADES	Sources of Information Used to Select the Views to be Presented in a Drawing		
	Instructor	Text	Other
Auto Mechanics			
Cosmetology	✓	✓	
Drafting	✓	✓	
Electricity	✓	✓	
Electronics	✓	✓	
Machine Trades			
Sheet Metal	✓		
Welding	✓	✓	

III. Covert Behavior

A. Selection

9. Selects the appropriate product or service for the customer

TRADES	Sources of Information Used to Select the Appropriate Product or Service for the Customer			
	Customer	Specification Sheets	Manuels	Other
Auto Mechanics	✓	✓	✓	
Cosmetology	✓	✓	✓	Regulations by State Board
Drafting	✓	✓	✓	Bill of materials
Electricity	✓	✓	✓	
Electronics	✓	✓	✓	
Machine Trades				
Sheet Metal	✓	✓		
Welding	✓	✓		

III. Covert Behavior

B. Problem Solving

1. Trouble shooting the situation

Trades	General Trouble Shooting Strategy	Reference Sources to Relate Symptoms to Causes
Auto Mechanics	Attempt to localize problem	Sun test sheets, Snap-on test sheets, textbooks
Cosmetology	Analyze hair	Case histories, textbooks
Drafting	Check drawing	12 point check list
Electricity	Test continuity of wires, coils, etc.	Manufacturer's instruction manuals with trouble shooting charts
Electronics	Be logical, look for the obvious	Sams Photofacts
Machine Trades	Checking feed engagement of lathes and mills	Machine Shop Theory and Practice, Use and Care of Twist Drills
Sheet Metal	None	
Welding	None	Texts

III. Covert Behavior

B. Problem Solving

2. Based on an analysis of the work media, determines which changes must be made to produce correct work media

In all eight of the trades, students are taught how and when to analyze the work media to determine which changes must be made to produce correct work media.

III. Covert Behavior

B. Problem Solving

3. Reads the measurement indicated on a multiple scale measuring instrument

TRADES	Multiple Scale Measuring Instrument Used		
	Yes	No	
Auto Mechanics	✓		
Cosmetology		✓	
Drafting	✓		
Electricity	✓		
Electronics	✓		
Machine Trades	✓		
Sheet Metal		✓	
Welding	✓		

III. Covert Behavior

B. Problem Solving

4. Converts a statement of the problem to an equation or formula

TRADES	Example Problems of Converting a Statement of a Problem to a Mathematical Equation
Auto Mechanics	Student is told to determine a gear or compression ratio
Cosmetology	Student is told to determine a fair price for service based upon time and materials
Drafting	Student is told to determine the area of a 6-inch circle
Electricity	Student is told to determine the resistance of a circuit when a voltage drip is encountered
Electronics	Student is told to determine the current of a circuit given its resistance and potential
Machine Trades	Student is told to convert drawing dimension to machine movements
Sheet Metal	Student is told to determine the area and circumferance of pipes
Welding	Student is told to determine the hypotenuse of a triangular figure

III. Covert Behavior

B. Problem Solving

5. Resolves problems or complaints concerning the product or service

In all eight of the trades the student learns to resolve complaints concerning the product or service.

III. Covert Behavior

C. Visualization

1. Given a textual or vocal description, visualizes a stationary three-dimensional object

TRADES	Representative Situations of Visualizing a Stationary Three-Dimensional Object When Given a Textual or Vocal Description
Auto Mechanics	Student is told to go get a 5/8" box wrench
Cosmetology	Patron describes a hairdo and beautician either does hairdo or sketches and then does hairdo
Drafting	Student is told to select a bar compass
Electricity	Student is told to select a pair of side-cutting pliers
Electronics	Student is told to select a 504 vacuum tube from a box of used parts
Machine Trades	Student is told to obtain a specific surface finish on a machine part
Sheet Metal	Student is told to draw a perspective drawing of eaves
Welding	Student is given specifications for a job and visualizes the set-up

III. Covert Behavior

C. Visualization

2. Given a textual or vocal description, visualizes a moving three-dimensional object

TRADES	Representative Situations of Visualizing a Moving Three-Dimesional Object When Given a Textual or Vocal Description
Auto Mechanics	When told about the process, a student visualizes a piston moving in a cylinder
Cosmetology	When student hears the word "teasing" she visualizes the process
Drafting	When a gear arrangement is described to a student, he makes a perspectice drawing showing the movement of the gears
Electricity	When student hears the word "soldering" he visualizes the process
Electronics	When student is told about cutting out and replacing a resistor, he visualizes the process
Machines Trades	When instructor describes a machinery procedure, student visualizes the process
Sheet Metal	When instructor describes making a 90° bend on the folding machine, student visualizes the process
Welding	When instructor describes the T.I.G. weld, student visualizes the process

III. Covert Behavior

C. Visualization

3. Given a two-dimensional drawing, visualizes a stationary three-dimensional object

TRADES	Representatives Situations of Visualizing a Stationary Three-Dimensional Object When Given a Two-Dimensional Drawing
Auto Mechanics	Student is given a drawing of a connecting rod and and he visualizes an actual connecting rod
Cosmetology	Student visualizes a completed hairdo when shown drawings of the setting arrangement
Drafting	Student visualizes the completed house when shown drawings of the floor plan and plane views
Electricity	Student visualizes an actual electric motor when shown a drawing of one
Electronics	Student visualizes an actual circuit when shown its schematic
Machine Trades	Student visualizes a completed part when shown its drawing
Sheet Metal	Student visualizes a finished duct when shown its pattern
Welding	Student visualizes a completed weld when shown its blueprint

III. Covert Behavior

C. Visualization

4. Given a two-dimensional drawing, visualizes a moving three-dimensional object

TRADES	Representative Situations of Visualizing a Moving Three-Dimensional Object When Given a Two-Dimensional Drawing
Auto Mechanics	Student visualizes a choke system in operation when shown a cutaway drawing
Cosmetology	Student visualizes the process of permanent waving when shown drawings
Drafting	Student visualizes a machine in operation when shown its drawings
Electricity	Student visualizes the operation of a machine when shown its drawings in a service manual
Electronics	Student visualizes actual TV flicker when shown photographs of flicker
Machine Trades	Student visualizes the required machinery process when shown drawings of the part to be machined
Sheet Metal	Student visualizes how a folding machine operates when shown photographs
Welding	Student visualizes a welding process when shown photographs of the process

III. Covert Behavior

C. Visualization

5. Given a three-dimensional object, visualizes in two dimensions

TRADES	Representative Situations of Visualizing in Two Dimensions When Given a Three-Dimensional Object
Auto Mechanics	None
Cosmetology	Students visualize, and then draw, the views of a hairdo when presented a model or manikin
Drafting	Students visualize, and then draw, the views of any object presented to them
Electricity	Students visualize, and then draw, the schematic of a circuit after being given the circuit
Electronics	Students visualize, and then draw, the schematic of a circuit after being given the circuit
Machine Trades	None
Sheet Metal	Students visualize, and then draw, the views of a duct after looking at it
Welding	None

III. Covert Behavior

C. Visualization

6. Given a photograph or perspective drawing, visualizes in two dimensions

TRADES	Representative Situations of Visualizing in Two Dimensions When Given a Photograph or Perspective Drawing
Auto Mechanics	None
Cosmetology	None
Drafting	Students visualize, and then draw, the views of an object in a photograph or perspective drawing
Electricity	Students visualize, and then draw, the schematic of a circuit shown in a photograph or perspective drawing
Electronics	Students visualize, and then draw, the schematic of a circuit shown in a photograph or perspective drawing
Machine Trades	None
Sheet Metal	Students visualize, and then draw, the views of a duct shown in a perspective drawing
Welding	None

III. Covert Behavior

C. Visualization

7. Given a textual or vocal description, visualizes in two dimensions

TRADES	Representative Situations of Visualizing in Two Dimensions When Given a Textual or Vocal Description
Auto Mechanics	Student visualizes, and then draws, the schematic of an auto's electrical system when given its specifications
Cosmetology	Student visualizes, and then draw, the views of a hairdo when given a vocal description
Drafting	Student visualizes, and then draws, the views of an object when given a textual or vocal description
Electricity	Student visualizes, and then draws, the schematic of a circuit when given a textual or vocal description
Electronics	Student visualizes, and then draws, the schematic of a circuit when given a textual or vocal description
Machine Trades	None
Sheet Metal	Student visualizes, and then draws, a pattern of a duct when given a textual or vocal description
Welding	Student visualizes, and then draws, the views of an object when given a textual or vocal description

III. Covert Behavior

D. Application of Knowledge

1. Uses knowledge of engineering principles

TRADES	Engineering Principles Used				
	Stress	Strain	Elasticity	Motion	Other
Auto Mechanics	✓	✓	✓	✓	
Cosmetology			✓		
Drafting	✓	✓	✓	✓	
Electricity				✓	
Electronics				✓	
Machine Trades	✓	✓	✓		
Sheet Metal				✓	
Welding	✓	✓	✓	✓	Elongation, yield point, tensil strength, hardness

III. Covert Behavior

C. Visualization

5. Given a three-dimensional object, visualizes in two dimensions

TRADES	Representative Situations of Visualizing in Two Dimensions When Given a Three-Dimensional Object
Auto Mechanics	None
Cosmetology	Students visualize, and then draw, the views of a hairdo when presented a model or manikin
Drafting	Students visualize, and then draw, the views of any object presented to them
Electricity	Students visualize, and then draw, the schematic of a circuit after being given the circuit
Electronics	Students visualize, and then draw, the schematic of a circuit after being given the circuit
Machine Trades	None
Sheet Metal	Students visualize, and then draw, the views of a duct after looking at it
Welding	None

3

III. Covert Behavior

C. Visualization

6. Given a photograph or perspective drawing, visualizes in two dimensions

TRADES	Representative Situations of Visualizing in Two Dimensions When Given a Photograph or Perspective Drawing
Auto Mechanics	None
Cosmetology	None
Drafting	Students visualize, and then draw, the views of an object in a photograph or perspective drawing
Electricity	Students visualize, and then draw, the schematic of a circuit shown in a photograph or perspective drawing
Electronics	Students visualize, and then draw, the schematic of a circuit shown in a photograph or perspective drawing
Machine Trades	None
Sheet Metal	Students visualize, and then draw, the views of a duct shown in a perspective drawing
Welding	None

III. Covert Behavior

C. Visualization

7. Given a textual or vocal description, visualizes in two dimensions

TRADES	Representative Situations of Visualizing in Two Dimensions When Given a Textual or Vocal Description
Auto Mechanics	Student visualizes, and then draws, the schematic of an auto's electrical system when given its specifications
Cosmetology	Student visualizes, and then draw, the views of a hairdo when given a vocal description
Drafting	Student visualizes, and then draws, the views of an object when given a textual or vocal description
Electricity	Student visualizes, and then draws, the schematic of a circuit when given a textual or vocal description
Electronics	Student visualizes, and then draws, the schematic of a circuit when given a textual or vocal description
Machine Trades	None
Sheet Metal	Student visualizes, and then draws, a pattern of a duct when given a textual or vocal description
Welding	Student visualizes, and then draws, the views of an object when given a textual or vocal description

III. Covert Behavior

D. Application of Knowledge

1. Uses knowledge of engineering principles

TRADES	Engineering Principles Used				
	Stress	Strain	Elasticity	Motion	Other
Auto Mechanics	✓	✓	✓	✓	
Cosmetology			✓		
Drafting	✓	✓	✓	✓	
Electricity				✓	
Electronics				✓	
Machine Trades	✓	✓	✓		
Sheet Metal				✓	
Welding	✓	✓	✓	✓	Elongation, yield point, tensil strength, hardness

✓ (2)

III. Covert Behavior

D. Application of Knowledge

2. Uses knowledge of the physics and chemistry of heat

Physics and Chemistry of Heat	Trades							
	Auto Mechanics	Cosmetology	Drafting	Electricity	Electronics	Machine Trades	Sheet Metal	Welding
Temperature	✓	Not Applicable	✓	✓	✓	✓		✓
Expansion and Contraction								
Coefficient of linear expansion	✓			✓		✓		✓
Coefficient of cubical expansion	✓							✓
British thermal units	✓			✓				✓
Melting point	✓			✓	✓	✓	✓	✓
Latent heat				✓				✓
Transference of heat	✓			✓	✓	✓		✓
Thermal conductivity	✓			✓	✓	✓		✓
Effect of heat on mechanical properties of metals	✓		✓	✓	✓	✓	✓	✓
Formation of metallic crystals	✓			✓	✓	✓		✓
Heat treatment of metals								
Hardening	✓		✓			✓		✓
Tempering	✓		✓			✓		✓
Annealing	✓		✓			✓		✓
Normalizing	✓		✓			✓		✓
Effect of deformation on properties of metal	✓		✓			✓		✓
Stress and distortion	✓		✓			✓	✓	✓

III. Covert Behavior

D. Application of Knowledge

3. Uses knowledge of specific machines

TRADES	Representative Examples of the Machines Used
Auto Mechanics	Valve refacer, pin hone, grinders, drill press
Cosmetology	Color machine, hair dryer, electric manicure, electric clippers
Drafting	Drafting machine, blueprint machine
Electricity	Drill press, lathe, bench grinder, power winch, boring machine
Electronics	All basic test equipment such as meters and scopes
Machine Trades	Lathe, shaper, milling machine, power saw, drill press, planer
Sheet Metal	Hand drills, rolls, folders, drill press, brakes, lock formers, shears
Welding	A.D. welder, D.C. welder, radio graph, T.I.G., M.I.G., carbon arc, arc air, shears, drill press, side grinders

III. Covert Behavior

D. Application of Knowledge

4. Uses knowledge of electrical and electronic principles

Electrical and Electronic Principles	Trades							
	Auto Mechanics	Cosmetology	Drafting	Electricity	Electronics	Machine Trades	Sheet Metal	Welding
Static electricity (electron theory; distribution of charge)	✓			✓	✓			✓
Conductors and insulators	✓	✓		✓	✓			✓
Electrical currents	✓	✓	✓	✓	✓	✓		✓
Voltage	✓	✓	✓	✓	✓	✓		✓
Amperage	✓	✓	✓	✓	✓	✓		✓
Resistance	✓	✓	✓	✓	✓			✓
Ohm's Law (kinds of electricity)	✓		✓	✓	✓			✓
Series and Parallel Circuits	✓			✓	✓			✓
Magnetism (attraction and repulsion)	✓			✓	✓	✓		
Electro-magnetism	✓			✓	✓			
Dynamos and generators	✓			✓	✓			✓
Alternating current	✓	✓		✓	✓			✓
Direct current	✓	✓		✓	✓	✓		✓
Rectifiers and filters	✓			✓	✓			✓
Amplifiers and oscillators				✓	✓			
Electrodes	✓	✓		✓	✓	✓		✓
Converter				✓	✓			✓
Closed, ground, open, and short circuits	✓	✓		✓	✓			✓
Polarity	✓	✓		✓	✓			✓
Discharge machining						✓		

III. Covert Behavior

D. Application of Knowledge

5. Uses knowledge of drawing principles

Drawing Principles	Trades							
	Auto Mechanics	Cosmetology	Drafting	Electricity	Electronics	Machine Trades	Sheet Metal	Welding
Thread symbols and classifications	✓		✓			✓		✓
Wire measurement symbols	✓		✓	✓	✓			✓
Architectural symbols			✓	✓				✓
Theory of shape description		✓	✓			✓	✓	✓
Perspective			✓			✓	✓	✓
Principles of views			✓	✓		✓	✓	✓
Form of letters used in drawings			✓					
Dimensioning			✓					
Tolerances						✓		
Blue print reading						✓		
Welding symbols								✓
Symbols of materials								✓
Drawing and trade symbols								✓

III. Covert Behavior

D. Application of Knowledge

6. Uses knowledge of chemical reactions

Chemical Reactions	Trades							
	Auto Mechanics	Cosmetology	Drafting	Electricity	Electronics	Machine Trades	Sheet Metal	Welding
States of matter (solid, liquids, gases)	✓	✓	✓	✓	✓		✓	✓
Elements, compounds, mixtures	✓	✓	✓	✓				✓
Properties of specific element	✓	✓	✓	✓				✓
Oxidation and reduction	✓	✓	✓	✓			✓	✓
Combustion	✓		✓	✓				✓
Metal alloys	✓		✓	✓		✓	✓	✓
Electrical current reactions (Ex. chemical reactions in batteries)	✓	✓		✓	✓			✓
Discharge Machining						✓		✓
Metal Granular								✓

III. Covert Behavior

D. Application of Knowledge

7. Uses knowledge of current trends in the trade

Students in all eight of the trades are presented information on current trends within their fields.

III. Covert Behavior

D. Application of Knowledge

8. Uses knowledge of mathematics

Mathematical Processes Used	Trades: Auto Mechanics	Cosmetology	Drafting	Electricity	Electronics	Machine Trades	Sheet Metal	Welding
Addition, subtraction, multiplication, and division of integers	✓	✓	✓	✓	✓	✓	✓	✓
Addition, subtraction, multiplication, and division of common or decimal fractions (finds least common denominator)	✓	✓	✓	✓	✓	✓	✓	✓
Addition, subtraction, multiplication, and division of algebraic expressions	✓		✓	✓	✓	✓	✓	✓
Conversion of common fractions, improper fractions, and decimal fractions	✓		✓	✓		✓	✓	✓
Calculation of:								
(1) percentages	✓	✓		✓	✓			
(2) interest	✓			✓				
(3) averages	✓	✓	✓	✓				✓
(4) ratios	✓	✓	✓	✓	✓	✓		✓
(5) proportions	✓	✓	✓	✓	✓	✓	✓	✓
(6) square roots			✓	✓	✓	✓		✓
(7) areas of objects		✓	✓	✓		✓	✓	✓
(8) volume of objects	✓	✓	✓	✓		✓	✓	✓
Algebraic processes	✓		✓	✓	✓	✓		✓
Geometric processes			✓	✓	✓	✓	✓	✓
Trigonometric processes			✓	✓	✓	✓	✓	✓
Matrix Algebra				✓				

III. Covert Behavior

D. Application of Knowledge

9. Uses knowledge of the principles of metallurgy

Principles of Metallurgy	Trades							
	Auto Mechanics	Cosemtology	Drafting	Electricity	Electronics	Machine Trades	Sheet Metal	Welding
Plasticity	✓		✓			✓		✓
Brittleness	✓		✓			✓		✓
Malleability	✓		✓			✓		✓
Ductility	✓		✓			✓	✓	✓
Tenacity	✓		✓			✓		✓
Hardness	✓		✓			✓		✓
Creep	✓	Not Applicable		Not Applicable		✓		✓
Fatigue	✓		✓			✓		✓
Production of metals (Ex. - steel)	✓		✓			✓		✓
Weld decay	✓							✓
Identification of metals by testing	✓					✓	✓	✓
Soldering					✓			

III. Covert Behavior

D. Application of Knowledge

10. Uses knowledge of physics

Physics	Trades							
	Auto Mechanics	Cosemtology	Drafting	Electricity	Electronics	Machine Trades	Sheet Metal	Welding
Pressure	✓		✓	✓	✓	✓		✓
Gravity	✓		✓	✓		✓		✓
Vacuum	✓			✓				✓
Work, Energy, Power, Horsepower	✓	Not Applicable	✓	✓	✓	✓	Not Applicable	✓
Inertia	✓		✓	✓	✓	✓		
Torque	✓		✓	✓	✓	✓		
Friction	✓		✓	✓	✓	✓		✓

III. Covert Behavior

D. Application of Knowledge

11. Uses knowledge of physiology

Physiology	Trades							
	Auto Mechanics	Cosmetology	Drafting	Electricity	Electronics	Machine Trades	Sheet Metal	Welding
Cells, tissues		✓						
Organ systems		✓						
Skeletial system		✓						
Muscle system	✓	✓				✓		✓
Nervous system		✓						✓
Circulatory system		✓						✓
Endocrine system		✓	Not Applicable	Not Applicable	Not Applicable		Not Applicable	
Excretory system		✓						
Respiratory system		✓						✓
Digestive system		✓						
Skin		✓						
Hair		✓						
Nails		✓						
Light Therapy								

III. Covert Behavior

D. Application of Knowledge

12. Uses knowledge of safety principles, equipment, and clothing

SAFETY RULES	TRADES							
	Auto Mechanics	Cosmetology	Drafting	Electricity	Electronics	Machine Trades	Sheet Metal	Welding
Wear safety glasses	✓			✓	✓	✓	✓	✓
Wear safety shoes						✓	✓	✓
Wear appropriate clothing						✓	✓	✓
Remove jewelry					✓	✓		
Do not horseplay	✓	✓	✓	✓	✓	✓	✓	✓
Do not smoke in areas of fire danger	✓	✓				✓		✓
Keep a well ventilated shop	✓							✓
Avoid smelling pungent materials		✓	✓					
Maintain a clear work area	✓	✓		✓	✓	✓	✓	✓
Observe ground connection	✓			✓	✓		✓	✓

Specific Safety Rules for Each Trade Area

Auto Mechanics

1. Use proper devises and procedures for raising and blocking vehicles.
2. Never use compressed air except for specific purpose.

Cosmetology

1. Always close razor when not in use.
2. Do not use electrodes after alcohol has been put on the scalp.
3. Do not permit cold wave solution to enter eyes.
4. Always test temperature of water on hand before putting on head.

Drafting

1. Do not tilt stools backwards on two legs.

Electricity

1. Never handle picture tubes by the neck.
2. Use correct tools for tube change.
3. Allow components to cool beofe working on them.

Electronics

1. Provide guard rails and toe boards on elevated platforms and especially on rolling scaffolds.
2. Lock coster brakes to prevent rolling scaffold from moving while in working position.

Specific Rules for High Voltage Work

3. Use approved fuse pullers.
4. Stand on a good rubber mat.
5. Use rubber gloves at all times.
6. Keep one hand behind you or in your pocket.

Machine Trades

1. Never walk away from a running machine.
2. Always stop machine to make adjustments.
3. Use safety guards on your machine.

Sheet Metal

1. Wear soft leather gloves.

Welding

1. Guard rotating equipment.
2. De-energize all equipment before repairing or replacing parts.
3. Stand to side of regulator when opening valve on cylinder.

TRADE	Safety Equipment	Safety Clothes
Auto Mechanics	Eye protection, respirators	Short sleeves, rubber gloves (for handling batteries)
Cosmetology	Goggles or sun glasses, eye pads, razor guard	Cobbler aprons, plastic cape, rubber or plastic gloves
Drafting	Exhaust fan in Blue Print Room	
Electricity	Eye protection, rubber floor mats, isolation transformer	Gloves*
Electronics	Eye protection, rubber blankets and mats, fuse pullers, shorting sticks, film badges or pocket dosimeters, respirators, rubber blankets	Laboratory coats, coveralls, welding hoods, rubber gloves*
Machine Trades	Eye protrection, safety helmet, machine guards, first aid supplies	Shop apron, hair net*, safety shoes, gloves*
Sheet Metal	Hard hat, eye protection, hammers, chisels and punches with no mushroom heads	Safety shoes, soft leather gloves
Welding	Fire blanket, face shields, eye protection protective lenses for hoods and goggles, equipment guards	Leather sleeves, jackets, chaps, aprons, gloves

* Sometimes

III. Covert Behavior

D. Application of knowledge

13. Uses knowledge of trade terminology

In all eight of the trades, students are taught specific trade terminology.

IV. Communicative Behavior

A. Oral

1. Orally communicates information

TRADES	Example Situations Where Tradesman Must Orally Communicate Information
Auto Mechanics	Explaining to a customer the trouble with his auto and the repairs needed
Cosmetology	Discusses with a patron new trends in hair coloring and styles
Drafting	Draftsman might be asked to explain how a machine could be speeded up. After calculating gear ratios, he could provide an answer
Electricity	Electrician might find overloaded circuits in a residence and suggest that the owner approve installations of additional circuit capacity.
Electronics	Trouble shooting equipment normally demands communication between parties concerned
Machine Trades	Tradesman must frequently discuss tolerances, fits, completion dates, etc., with his foreman
Sheet Metal	Tradesman must frequently discuss job requirements with his foreman or customer
Welding	Tradesman must frequently discuss job requirements with his foreman or customer

IV. Communicative Behavior

A. Oral

2. Uses courteous forms of oral expression

Students in all eight of the trades are taught, at least to a limited extent, courtesy.

IV. Communication Behavior

A. Oral

3. Speaks with a pleasant, modulated voice

Cosmetology is the only trade of the eight in which students are taught to speak in a pleasant, modulated voice.

IV. Communicative Behavior

A. Oral

4. Collects information by asking relevant questions

Tradesmen in all eight of the trades collect information by questioning their customer or foreman.

IV. Communicative Behavior

B. Written

1. Prepares forms and sales contracts

TRADES	Kinds of Forms on Sales Contracts Prepared
Auto Mechanics	Repair order sheets and repair completed sheets
Cosmetology	Bill of sales, records
Drafting	Bill of materials, specifications
Electricity	None
Electronics	Work orders and bill of sales
Machine Trades	Work orders
Sheet Metal	Material list and cost
Welding	Bill of sales

IV. Communicative Behavior

B. Written

2. Uses Reference Materials

TRADES	Reference	Used By: Students	Used By: Tradesmen
Auto Mechanics	Glenn's Auto Mechanics	✓	✓
	Motor Service Encyclopedia	✓	✓
	Motor's Auto Repair Manual	✓	✓
	Delmar	✓	✓
Cosmetology	Standard Textbook of Cosmetology	✓	
	Principles & Practices of Cosmetology	✓	
	How to Do Better Hair Coloring	✓	
	Mathematics for Cosmetology	✓	
	Modern Makeup Books	✓	
	Van Dean Manual	✓	
	All About Wigs	✓	
	NHCA Quarterly Edition	✓	
	Various pamphlets from mfgs.	✓	
	Practical and related work books	✓	
	Cosmetology State Board Review	✓	✓
	Wall Charts	✓	✓
	American Hairdresser	✓	✓
	Modern Beauty Shop	✓	✓
	Transperancies		
Drafting	Sweet's Catalog Industrial & Plant Engineering	✓	
	Engineering Drawing	✓	
	General Motors Drafting Standards	✓	
	Mechanical Engineering Handbook	✓	✓
	Machinery Handbook	✓	✓
	Steel Construction Handbook	✓	✓
	Boston Gear Manual	✓	✓
	Foote Bro. Gear Manual	✓	✓
	Bearing Manual	✓	✓
	Motor Manual	✓	✓

IV. B. 2. (continued)

TRADES	Reference	Used By: Students	Used By: Tradesmen
Electricity	National Electric Code and Blueprint Reading	✓	
	Electric Circuits and Machines	✓	
	Fundamentals of AC & AC Circuit Analysis	✓	
	Vacuum Tube and Semi-Conductor Fundamentals	✓	
	Basic Electronic Circuits and Systems	✓	
	Fundamentals of Transistor Electronics	✓	
	Fundamentals of Synchros with Circuit Applications	✓	
	Synchros and Sernomechanisms Training Manual	✓	
	Shop Practices	✓	
	Basic Electrical Principles	✓	
	National Electric Code Book		✓
	Specifications a) Architect b) Engineer		✓
	Manufacturer's Instruction Manuals		✓
	National Electrical Code and Blue-print Reading		✓
	Union Jurisdictional Rules and/or Bylaws & Agreements		✓
Electronics	Electric Circuits	✓	
	Basic Mathematics for Electronics	✓	
	Transistor Physics and Circuits	✓	
	Introductory Applied Physics	✓	
	Electronics in Industry	✓	
	Fundamentals of Electronics	✓	
	Digital Computer Principles	✓	
	Basic Television	✓	
	Service manuals and commercial literature; e.g., Sam's Photo-facts		✓

IV. B. 2. (continued)

TRADES	Reference	Used By	
		Students	Tradesmen
Machine Trades	Machinist Hand Book	✓	✓
	American Machinist	✓	✓
	Manufacturer's Drill-Tap Size	✓	✓
	Fraction to Decimal Charts	✓	✓
	Right Angle Trigonomerty	✓	✓
	Machinists	✓	✓
	Tool Makers Handy Book	✓	✓
	Speed & Feed Charts	✓	✓
	Steel Charts	✓	✓
	Decimal/Fraction Equivalents	✓	✓
Sheet Metal	Sheet Metal Math	✓	
	Sheet Metal No. 1	✓	
	Sheet Metal No. 2	✓	
	Sheet Metal No. 3	✓	
	Air Conditioning Metal Layout	✓	
Welding	Welding Skills and Practices	✓	
	Blueprint Reading for Welders	✓	
	New Lessons in Arc Welding	✓	
	The Pipe Fitter's and Pipe Welder's Handbook	✓	
	Pipe Fitter Pipe Welders Manual	✓	✓
	Vest Pocket Manual for Rod or Electrode Identification	✓	✓

IV. Communicative Behavior

C. Non-verbal

1. Uses non-verbal communication

TRADES	Non-Verbal Communication Used? Yes	No
Auto Mechanics	✓	
Cosmetology	✓	
Drafting		✓
Electricity	✓	
Electronics		✓
Machine Trades	✓	
Sheet Metal	✓	
Welding	✓	

APPENDIX B

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON THE OPERATION OF SCREWDRIVERS

APPENDIX B

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON THE OPERATION OF SCREWDRIVERS

The objective of this study was to determine the efficiency and effectiveness of self-instruction for teaching the operation of hand tools. The hand tools selected were various standard screwdrivers, the stubby screwdriver, the Phillips screwdriver, the off-set screwdriver, and the spiral-ratchet screwdriver. Hand tool operation was a skill determined to have specific applicability to each trade constituting trade and industrial education.

General Behaviors Involved

Twelve behaviors from the behavioral catalog constitute the skill of hand tool operation for the specific case of screwdrivers. These are listed below.

I,B,1. Assumes proper position of body and hands to use an instrument or tool

I,B,2. Holds tool at appropriate angle to work media

I,B,4. Applies sufficient force and pressure to use tool or instrument

I,C,4. Applies tool or work media with a circular motion

II,B,1. Obtains kinesthetic information

II,B,2. Uses kinesthetic information

II,D,1. Obtains visual information

II,D,2. Uses visual information

III,A,2. Selects the tools, equipment, and material required to perform the operations

III,C,3. Given a two-dimensional drawing, visualizes a stationary three-dimensional object

III,D,12. Uses knowledge of safety principles, equipment, and clothing

III,D,13. Uses knowledge of trade terminology.

Procedure

Eight tasks culminating with the evaluation of the self-instructional unit were conducted.

Objective Specification

An initial task was formulating the objectives for the self-instructional unit. These are listed below.

1. Given a set of vocational situations, subjects will be able to correctly select those situations requiring the use of a screwdriver.

2. Given drawings of standard, Phillips, and offset screwdrivers, subjects will be able to label all parts.

3. Given sketched situations requiring the use of a screwdriver, subjects will be able to name and recognize from these drawings the most appropriate and efficient screwdriver to use.

4. Given a board with a variety of screws in it, subjects will be able to select the correct screwdrivers and correctly demonstrate their use.

5. Given a set of drawings of screwdriver blades, subjects will be able to identify those requiring dressing.

6. Given a screwdriver requiring dressing, subjects will be able to correctly dress it on a grinding wheel.

Subject-Matter Study

The subject-matter study included relevant vocational materials, discussions with vocational educators, and discussions with two hand tool manufacturers. From this study, subject matter relevant to the above objectives was drawn together.

Strategy Development

The third task completed was developing a strategy to be incorporated in the self-instructional unit.

Strategy development included consideration of the type of instructional materials that would be included, the sequence of the materials, the kinds of student responses that would be called for, and the types of behavioral-change procedures that would be used.

Method Application

Construction of the self-instructional unit represented the fourth task. The resulting unit can be characterized as a linear-instructional one made up of frames requiring both constructed and multiple-choice responses. Shaping was the primary behavioral-change procedure used. The frames included line drawings of screwdrivers and sketches of situations in which the students had to determine the correct screwdriver to use. Sketches also were used to illustrate such points as the proper procedure for dressing a damaged screwdriver, how to properly grip screwdrivers, etc. The total number of frames making up the unit was 65.

Criterion-Test Development

Two criterion instruments were developed. One was a 28-item written test designed to cover informational points included in the program (e.g., names of screwdriver parts, how to determine correct screwdriver size).

The second criterion instrument was a check list covering the four critical points that must be done during the dressing of a damaged screwdriver blade. These points were (1) grinding angle, (2) grinding rate, (3) using a screw of the correct size to determine when the dressed blade is the correct size, and (4) using water to cool the screwdriver blade during dressing.

Empirical Try-Out

Procedure. The empirical try-out of the self-instructional unit involved three students: one from automotive mechanics, one from machine trades, and one from welding. All three students were juniors at the Southwestern Technical School, Grove City, Ohio. The students were given a brief description of the work, and how they could assist with it. They also were told that their performance during the initial try-out would in no way affect their class grades. Finally, they were encouraged to ask questions or offer comments as they went through the self-instructional units.

Each student was pre-tested using the 28-item written test. They also were given the task of dressing a damaged screwdriver blade. Their performance was evaluated using the four-point check list. The students then worked through the self-instructional unit. At the conclusion of instruction, the same criterion instruments were re-administered.

Results. The results of the empirical try-out were quite encouraging. On the 28-item written test, the mean pre-test score was 14.3 and the mean post-test score was 27.0. The mean pre-test score on the performance task was 2.7 and the mean post-test score was 3.7. The G values (actual gain/possible gain) for the written test and the performance test were 0.93 and 0.75 respectively.

The error rate for the self-instructional unit ranged from 2.63 to 6.57 percent with a mean error rate of 4.38 percent.

Instruction-Unit Revisions

As might be expected, only minor revisions to a few frames were necessary. They were completed prior to the final evaluation.

Final Evaluation

Procedure. The final evaluation involved 19 students from Middletown High School, Middletown, Ohio. Eleven were sophomore pre-vocational students; the remaining eight were junior students in sheetmetal. The administrative procedures were identical to those used in the empirical try-out.

Results. The results from the final evaluation using both criterion instruments are presented in Table B-1.

TABLE B-1. EVALUATION RESULTS

N	Possible Score	Pre-test Mean	Post-test Mean	Mean Gain	Possible Gain	G
19	28	12.8	24.8	12.0	15.2	0.79
19	4	2.0	3.2	1.2	2.0	0.61

The differences between the pre- and post-test means were tested for significance using a t-test for correlated means. For the written and performance tests, these differences were significant at the 0.001 level (t = 14.81 and t = 4.80 respectively).

The G value for the performance test, although quite acceptable, was not as high as was expected. One possible reason for this could have been that the junior students had had instruction on dressing a screwdriver and this instruction differed somewhat from that included in the self-instructional unit.

To determine if this factor significantly affected performance-test results, a separate analysis of the performance-test data for sophomores (N = 11) and juniors (N = 8) was conducted. The results are presented as Table B-2.

TABLE B-2. PERFORMANCE TEST RESULTS FOR SOPHOMORES AND JUNIORS

N	Possible Score	Pre-test Mean	Post-test Mean	Mean Gain	Possible Gain	G
11	4	1.82	3.27	1.45	2.18	0.67
8	4	2.25	3.13	0.88	1.75	0.50

A t-test for comparison of changes was conducted on the difference between the two mean gain scores. This difference was not significant at the 0.05 level (t = 1.50). This meant that it could not be safely concluded that there were other than chance differences between the performance of the two groups.

The error rate on the self-instructional unit during the final evaluation was, on the average, 5.9 percent (range = 0 to 15.8 percent). The average time required for completion was 20.9 minutes.

Conclusions

From the results, it can be seen that a fairly typical, linear self-instructional unit can be reasonably effective for teaching both the verbal and manipulative skills involved in the operation of screwdrivers. There appears to be, however, differential effectiveness. That is, the self-instructional unit appeared to be more effective for the verbal skills than the manipulative skills.

APPENDIX C

THE DEVELOPMENT AND EVALUATION OF
A SELF-INSTRUCTIONAL UNIT ON
THE OPERATION OF THE HACKSAW

APPENDIX C

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON THE OPERATION OF THE HACKSAW

The objective of this study, like that for the operation of screwdrivers, was to determine the efficiency and effectiveness of self-instruction for teaching the operation of hand tools. The specific hand tool selected was the hacksaw. The skill of hand tool operation was determined to have specific applicability to most trades included in trade and industrial education.

General Behaviors Involved

The total number of behaviors from the behavioral catalog making up operation of the hacksaw (as a specific case of hand tool operation) was 17. These are listed below.

I,B,1. Assumes proper position of body and hands to use an instrument or tool

I,B,2. Holds tool at appropriate angle to work media

I,B,4. Applies sufficient force and pressure to use tool or instrument

I,C,3. Applies tool to work media with a sawing motion

I,C,6. Applies tool to work media at appropriate rate of speed

I,D,3. Inserts or removes work media, equipment or tools in a machine or fixture

I,D,4. Adjusts or positions tools, parts, equipment or work media

I,D,5. Secures tools, equipment, and/or work media; removes securing devices

II,B,1. Obtains kinesthetic information

II,B,2. Uses kinesthetic information

II,D,1. Obtains visual information

II,D,2. Uses visual information

III,A,2. Selects the tools, equipment, and material required to perform the operations

III,A,3. Selects the appropriate storage for tools and equipment

III,C,3. Given a two-dimensional drawing, visualizes a stationary three-dimensional object

III,D,12. Uses knowledge of safety principles, equipment, and clothing

III,D,13. Uses knowledge of trade terminology.

Procedure

The development and evaluation of the self-instructional unit included eight tasks.

Objective Specification

The first task was concerned with specifying the objectives for the self-instructional unit. The objectives formulated were that the student will be able to specify in writing the following:

1. the parts of a hacksaw when given a drawing
2. the proper blade to use when given a written description of a situation
3. the correct direction for inserting a blade
4. the lengths and teeth-per-inch available in hacksaw blades
5. the correct grip for a hacksaw
6. the correct angle for starting a cut
7. the correct rate for sawing
8. the correct way to store a hacksaw.

Subject-Matter Study

The major subject-matter sources were vocational instructional materials, discussions with vocational educators, and discussions with tradesmen. From these sources, relevant subject matter for the self-instructional unit was assembled.

Strategy Development

The development of the instructional strategy to be incorporated in the self-instructional unit was the third task completed. This task included determining precisely the subject matter that would be included, its sequence, the types of responses required from the student, and the behavioral-change procedures that would be employed.

Method Application

The application of self-instructional methods represented a fourth task. The resulting self-instructional unit had a linear format with frames requiring both constructed and multiple-choice responses. The principal behavioral-change procedure incorporated was shaping. Line drawings and sketches were included to teach such behaviors as proper blade insertion, proper sawing angle, proper grip of the hacksaw, etc. The total number of frames constituting the unit was 63.

Criterion-Test Development

One 30-item written test was developed for the self-instructional unit. Because the manipulative behaviors involved were, according to vocational educators and tradesmen, not a problem, no performance task was developed. (These persons revealed that the troublesome areas were such things as selecting the correct blade, the correct sawing rate, etc. That is, the major troublesome areas in hacksaw operations are those areas specified as the objectives.) The criterion test, therefore, was made up of questions covering these troublesome areas. Some test items included sketches and line drawings.

Empirical Try-Out

Procedure. Three junior students in machine trades at the Southwestern Technical School, Grove City, Ohio, were employed for the empirical try-out. A brief description of the work being done by the project staff was given, followed by an explanation that their participation in the work would not affect their class grades. They were instructed to ask questions and offer comments as part of their participation.

Following the administration of the 30-item test, the students worked through the self-instructional unit. Following this, the 30-item test was administered as a post-test.

Results. The mean pre-test score was 5.7 and the mean post-test score was 28.0. The G value (actual gain/possible gain) measuring the effectiveness of the self-instructional unit was 0.92.

The mean error-rate was 10 percent with a range of 5 to 17 percent.

Instructional-Unit Revisions

Although the results of the empirical try-out were quite encouraging, a close examination of student responses revealed a "piling up" of errors on the frames designed to teach blade selection. Consequently, practice frames for this instructional area were added. Minor revisions on a few other frames also were made. The revised self-instructional unit contained 71 frames.

Final Evaluation

Procedure. The final evaluation of the instructional unit employed 15 sophomore students from machine trades and automotive mechanics at the Patterson Cooperative High School, Dayton, Ohio. The administrative procedures were similar to those used for the empirical try-out.

Results. The results generated by the 30-item criterion test during the final evaluation are presented as Table C-1.

TABLE C-1. EVALUATION RESULTS

N	Possible Score	Pre-test Mean	Post-test Mean	Mean Gain	Possible Gain	G
15	30	11.7	29.1	17.4	18.3	0.95

A t-test for correlated means revealed that the pre-test/post-test difference was significant at the 0.001 level (t = 8.60). As can be seen from Table C-1, the G value indicated that the self-instructional unit was very effective.

The average error rate was 14 percent (range = 5 to 36 percent). The average time required to complete the instructional unit was 35 minutes (range = 30 to 45 minutes).

Conclusions

The results of this study in part substantiate the findings from the evaluation conducted in connection with operation of screwdrivers. That is, a fairly typical, linear self-instructional unit can be quite effective for teaching behaviors associated with hand tool operation. Although the unit designed for operation of the hacksaw was principally concerned with verbal information, it is precisely these types of behaviors that are particularly troublesome in its operation. Consequently, it is reasonable to conclude that operation of the hacksaw is greatly improved as a function of the self-instructional unit.

APPENDIX D

THE DEVELOPMENT AND EVALUATION OF
A SELF-INSTRUCTIONAL UNIT ON
COMMUNICATING COURTEOUSLY

APPENDIX D

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON COMMUNICATING COURTEOUSLY

The objective of this study was to determine the efficiency and effectiveness of self-instruction for teaching the skill of oral communication. The specific case selected of this skill was courteous communication in cosmetology. Oral communication was found to be applicable to all trades studied. The specific case selected (courteous communication) is a particularly troublesome area in cosmetology.

General Behaviors Involved

Six general behaviors from the behavioral catalog are viewed as making up courteous communication. These are listed below.

II,A,1. Obtains auditory information

II,A,2. Uses auditory information

IV,A,1. Orally communicates information

IV,A,2. Uses courteous forms of oral expression

IV,A,3. Speaks with a pleasant, modulated voice

IV,A,4. Collects information by asking relevant questions

Procedure

The development and evaluation effort associated with this self-instructional unit included six tasks.

Objective Specification

An initial task was specifying the objectives for the self-instructional unit. An overall objective was formulated: given a specific case of discourteous oral communication, the student will be able to identify the discourteous features of the communication and modify these features so that the communication is courteous.

Five enabling objectives also were specified.

(1) Given a series of courteous and discourteous behavioral traits (e.g., being friendly but impersonal), the student will be able to discriminate the courteous from the discourteous traits.

(2) Given a series of semi-structured courteous and discourteous dialogues in which the differences become progressively more subtle, the student will be able to discriminate the courteous from the discourteous dialogues.

(3) Given a series of semi-structured situations, the student will be able to respond courteously in dialogue.

(4) Given a series of unstructured courteous and discourteous dialogues in which the differences become progressively more subtle, the student will be able to discriminate the courteous from the discourteous dialogues.

(5) Given a series of unstructured situations, the student will be able to initiate courteous communication or respond with courteous communication in dialogue.

Subject-Matter Study

The principal subject-matter sources examined were vocational and non-vocational materials. Additionally, discussions with cosmetology educators served as subject-matter inputs. From these sources, relevant subject matter was gathered.

Strategy Development

A third task was formulating an instructional strategy. During this task, subject matter was selected, its sequence was determined, the mode of presentation was considered, and behavioral-change techniques were selected.

Method Application

The method-application task resulted in the self-instructional unit on communicating courteously. The unit consisted of three major sections. The first section dealt with teaching the student behavioral traits (e.g., ridiculing people, trying to understand another person's viewpoint, guiding the topic of conversation) contained in oral communication and to make discriminations between courteous and discourteous traits as they were demonstrated by printed dialogues.

The second section of the program contained two sub-sections. In the first sub-section, the student listened to a tape-recorded, discourteous cosmetologist-customer dialogue and then to a courteous dialogue for the same situation. After hearing the dialogues, the students selected from a set of three alternatives what the cosmetologist did to change the dialogue from discourteous to courteous. The actions taken by the cosmetologist were drawn from the behavioral traits contained in the first section of the program.

In the second sub-section, the students first listened to a tape-recorded, discourteous dialogue by a cosmetologist. The students were then required to write out a courteous dialogue for the situation and record it on a second tape recorder. After recording their dialogues, the students were provided with a list of discourteous behavioral traits and instructed to check their dialogue as to whether it contained any of the discourteous traits. If their dialogue contained more than two of the discourteous behavioral traits, they were instructed to write a new dialogue, record it, and evaluate it.

Thus, the second section first demonstrates to students what can be done to improve the courtesy of dialogues, then teaches them to develop their own dialogues, and, finally, teaches them to evaluate their own dialogues.

The third section of the program was similar in format to that employed for the second section. However, whereas the second section dealt with such situations as greeting customers and making them feel welcome, the third section was concerned with extending student behaviors to other common situations.

Besides tape recordings, the self-instructional unit contained drawings, response booklets, instructions, check lists, and printed dialogues. The principal behavioral change techniques employed were discrimination training, shaping, and controlled transfer of training demonstrations. Because of the format of the unit, it did not contain "frames" in the usual sense of the term.

<u>Criterion-Test Development</u>

As the fifth task of the developmental effort, a criterion instrument was formulated. This instrument consisted of a set of ten printed, discourteous dialogues.

A simple attitude scale also was developed. Included in this scale were provisions for students to indicate their relative preference for self-instruction, textbooks, and lectures.

Empirical Try-Out

Procedure. The empirical try-out employed six female, junior students from the cosmetology program at Heath High School, Heath, Ohio. The students were given information concerning the nature of the work being conducted by the project staff and told that their participation in no way would affect their class grades. They also were instructed on the use of the tape recorders.

Each student then was given the ten discourteous dialogues and instructed to write a courteous "replacement" for each dialogue. Each student then proceeded through the self-instructional unit. Following the instruction, each student prepared "new" replacement dialogues for the ten discourteous ones making up the criterion instrument. As the final activity, each student completed the simple attitude scale.

Results. The primary results from the empirical try-out were ten pairs of pre- and post-instructional dialogues for each student. Each ten pairs were typed with the pre- and post-instructional order for each pair being randomized.

Three professional cosmetologists were asked to serve as judges. The judges' task was to read each pair of typed dialogues for each student (a total of 60 pairs) and to judge which dialogue in each pair was the more courteous. Because of the random ordering, the judges did not know which dialogue in a pair was the pre-instructional one nor which was the post-instructional one.

The results of these judgments are presented as Table D-1. A plus sign (+) means that a judge rated the post-instructional dialogue as more courteous than its pre-instructional counterpart. A minus sign (-) means the opposite (i.e., the pre-instructional dialogue was rated more courteous than the post-instructional one). From Table D-1, it can be seen that inter-judge reliability was fairly good.

Table D-2 summarizes the data of Table D-1 by presenting the number of times each student's post-instructional dialogue was judged to be more courteous than her pre-instructional dialogue. (The maximum number of times would be 30.) Also included is each student's average class grade.

TABLE D-1. JUDGE'S RATINGS OF COMPARATIVE COURTESY FOR PRE- AND POST-INSTRUCTIONAL DIALOGUES

	Student 1			Student 2			Student 3			Student 4			Student 5			Student 6		
	Judge			Judge			Judge			Judge			Judge			Judge		
Dialogue	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	-	-	-	+	+	+	+	+	+	+	-	+	-	-	-	-	-	-
2	+	+	+	+	-	+	+	+	+	-	-	-	-	-	-	-	-	+
3	+	-	-	-	+	+	+	+	+	+	-	+	-	-	-	+	+	+
4	+	+	+	+	+	-	+	+	+	+	-	+	-	-	-	+	+	+
5	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
6	+	-	+	-	+	+	-	+	+	+	-	+	+	+	+	+	+	+
7	+	-	+	+	+	+	+	+	+	-	-	-	+	-	+	-	-	-
8	-	+	+	-	-	-	+	+	-	+	+	+	+	+	+	+	-	+
9	-	+	-	+	+	+	+	+	-	+	-	+	+	-	-	-	-	+
10	+	+	+	-	-	-	-	+	+	+	-	+	-	-	-	+	+	+

TABLE D-2. SUMMARY OF JUDGMENTS

Student	Judgment Frequency*	Percent	Class Grade
1	18/30	60.0	B
2	20/30	66.6	B-
3	26/30	86.6	A
4	18/30	60.0	A
5	12/30	40.0	C
6	19/30	63.3	B
Average	18.8/30.0	62.2	-

*Number of times post-instructional dialogue judged more courteous than pre-instructional dialogue (maximum = 30).

Assuming that by chance half of the judges would rate the post-instructional dialogue as more courteous than the pre-instructional dialogue, the above findings were interpreted to mean that although the self-instructional unit apparently produced some learning, it was not a significant amount.

The results from the attitude scale generally indicated that the students enjoyed the instruction. Additionally, self-instruction was preferred over textbooks and lectures (average rank of 1.66). The average ranks for textbooks and lectures were 1.83 and 2.50 respectively.

The average time required for completion of the self-instructional unit was 100 minutes (range - 90 to 120 minutes). Because of the nature of the unit, error rate was not an appropriate measure.

Instructional-Unit Revision

An examination of intra-unit performance by the students revealed no significant problems. Upon reviewing the ten dialogues employed for the pre- and post-testing, it was suspected that they may have been too easy because of certain behavioral traits in them. That is, it was suspected that a better measure of the self-instructional units might be obtained with an improved set of criterion instrument.

The possibility of doing this was investigated. It was found, unfortunately, that because of other commitments of the students to a subsequent self-instructional unit (giving a basic haircut), further trials requiring their time could not be arranged until later in the 1967-1968 school year. Because of time limitations, it was not possible to make the necessary arrangements for additional empirical try-outs and a final evaluation with another institution.

Conclusions

It is known that with the criterion instrument employed, no appreciable improvement in student performance attributable to the self-instructional unit was measured. A revised, more sensitive criterion instrument, however, might yield quite different results. Therefore, final conclusions should be reserved until after additional work has been completed.

APPENDIX E

THE DEVELOPMENT AND EVALUATION
OF A SELF-INSTRUCTIONAL UNIT ON
THE USE OF SOUND AS A DIAGNOSTIC
TOOL FOR AUTOMOBILE ENGINE MALFUNCTION

APPENDIX E

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON THE USE OF SOUND AS A DIAGNOSTIC TOOL FOR AUTOMOBILE ENGINE MALFUNCTION

The objective of this study was to determine the efficiency and effectiveness of self-instruction for teaching the skill of auditory diagnosis. The specific case of auditory diagnosis selected was the use of sound as a diagnostic tool for automobile engine malfunction. Auditory diagnosis was found to be applicable to all trades comprising trade and industrial education except drafting.

General Behaviors Involved

Auditory diagnosis involves two general behaviors from the behavioral catalog.

II,A,1. Obtains auditory information

II,A,2. Uses auditory information

Procedure

Two tasks were completed in connection with this study.

Objective Specification

An initial task was specifying the objectives for the self-instructional unit. The tentative objective specified was: given an automobile engine with any one of the common malfunctions associated with selected engine parts, the student will be able to identify the malfunction by listening to the sound it produces within an automobile engine. The malfunctions originally included were associated with the following engine parts:

(1) main bearing

(2) flywheel

(3) rod bearing

(4) piston pin, piston, and connecting rod

(5) valves

(6) hydraulic lifters

(7) timing gear

(8) crankshaft

(9) water pump

(10) fan belt

(11) fan

(12) intake system

(13) exhaust system.

Subject-Matter Study

A second task was determining the subject matter to be included in the self-instructional unit. Tape recordings appeared to be the best way to obtain controlled auditory stimuli for the unit. Consequently, arrangements were made to tape record the sounds of common malfunctions associated with the previously specified engine parts. These sounds were recorded at the automotive shop of Ironton High School, Ironton, Ohio, using a four-track, stereo tape recorder.

After completion of the recordings, a second tape was prepared. This tape included what was judged to be the best (i.e., the most characteristic) of the originally taped sounds. The second tape was played for a group of "competent amateur" mechanics at Battelle. Their task was to identify the common engine malfunction represented by each tape-recorded sound. They could not do this.

Recognizing that the Battelle personnel were only amateur mechanics, arrangements were made to run the same test with expert diagnosticians from three new-car dealerships in the Columbus, Ohio, area. The expert diagnosticians also failed to identify the sounds significantly better than chance.

The expert diagnosticians offered some reasons as to why they thought they could not identify the sounds. One was that with the tape recordings, the diagnostician was not able to manipulate engine speed. This, they believe, is important for many kinds of identifications. A second reason offered was that diagnosticians use certain non-aural cues in the identification process. These were missing in the tape recordings.

Finally, expert diagnosticians use spatial cues in diagnosis. For example, if one can hear the noise near the fan belt but not near the bell housing, this has certain meaning. As another example, in some cases a stethoscope is used near certain cylinders.

Although considerable effort had been expended, it was decided not to continue work on using sound as a diagnostic tool for automobile engine malfunction. Time and fund limitations did not permit undertaking investigation of another specific case of the auditory diagnosis skill.

Conclusions

From the preliminary findings, however, some conclusions can be drawn. One is that although sound is an important stimulus in diagnosing automobile engine malfunction, it is not the only one. Certain visual or kinesthetic cues also are important (e.g., presence of dripping oil, tension on a fan belt). Further, there is an interaction between sound stimuli and spatial position of the listener. Apparently, in many cases, spatial location is as important as the sound stimuli.

APPENDIX F

THE DEVELOPMENT AND EVALUATION OF
A SELF-INSTRUCTIONAL UNIT ON
SOLVING MATHEMATICAL WORD PROBLEMS

APPENDIX F

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON SOLVING MATHEMATICAL WORD PROBLEMS

The objective of this study was to determine the efficiency and effectiveness of self-instruction for solving mathematical word problems. This skill was applicable to all trades within trade and industrial education. Further, according to vocational educators, it represents a particularly troublesome instructional area.

General Behaviors Involved

Three general behaviors from the behavioral catalog constitute mathematical word-problem solving:

II,D,1. Obtains visual information

III,B,4. Converts a statement of the problem to an equation or formula

III,D. Application of knowledge.*

Procedure

Eight tasks were conducted in connection with this study.

Objective Specification

An initial task was specifying the objective for the self-instructional unit. The objective specified was: given a trade-specific mathematical word problem, the student will be able to solve the problem correctly by using the self-instructional unit.

Word problems were defined as any mathematical problem written in words representing a translation of mathematical notation that require an equation or numerical answer.

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*Specific knowledge varies as a function of trades.

Subject-Matter Study

A second task of the study was developing appropriate subject matter for inclusion in the self-instructional unit. This was done in connection with a Battelle mathematician.

Strategy Development

A third task was developing a strategy for the self-instructional unit. A major consideration was the sequence of mathematical operations. This was handled by flow charting those mathematical operations to be included in the self-instructional unit. Operations included were those associated with arithmetic, algebra, geometry, and basic trigonometry. The behavioral-change technique decided upon was a controlled guidance of the student to be provided by a series of sequenced steps (corresponding to those in the flow charts).

Method Application

The strategy was incorporated into a 40-page, semi-programmed booklet. Each page contained either a procedural step or a decision step. The booklet was free of trade-specific, mathematical word-problems.

Criterion-Test Development

Because of the nature of the self-instructional unit, it was not necessary to develop any specific criterion instruments. Rather, trade-specific, mathematical word-problems represented the "criterion instruments".

First Empirical Try-Out

Procedure. The first empirical try-out of the self-instructional unit involved 15 senior electronics students from the Southwestern Technical School, Grove City, Ohio. The students were given a brief description of the work being done by the project staff and told that participation would not affect their class grades. Each student was then given the self-instructional unit and six word problems selected by their instructor.

Results. Only one student completed the six word problems in the one-hour period devoted to the try-out. No student, however, went entirely through the self-instructional unit for any one word problem. In all cases, it appeared to the project staff that the students were hesitant to use the unit.

A brief discussion was held following the one-hour session. Students said they thought they were being tested. They said they read the first four pages or so of the self-instructional unit, but then worried because they didn't know how to solve the problems.

Instructional-Unit Revision

Two revisions of the self-instructional unit were made based upon the experience of the first empirical try-out. One was reducing the number of steps included from 40 to 25. This did not alter the strategy but did condense it. The second revision resulted in including an example word problem that demonstrated how to use the unit.

Second Empirical Try-Out

Procedure. The second empirical try-out employed two junior students in electronics at the Southwestern Technical School. Approximately the same procedure as that for the first try-out was employed except that the non-testing nature of the try-out was emphasized.

Results. After one student had used the self-instructional unit for solving three word problems he asked if he could just solve the remaining three. This implied that the student was primarily interested in arriving at solutions to the problems using a strategy he already had learned rather than in learning the use of a new strategy.

A rather extensive discussion with the two students revealed that although they would have preferred to learn the strategy earlier, they already had learned one that they believed to be workable. Consequently, they said, the self-instructional unit, rather than helping them solve word problems, interfered with their performance.

Third Empirical Try-Out

Procedure. Using the same self-instructional unit, a third empirical try-out was conducted to determine the extent to which similar results might be obtained. This try-out employed two junior students in machine trades at the Southwestern Technical School. The same procedures were followed.

Results. The results of the third empirical try-out were essentially the same as those obtained for the second try-out.

Conclusions

The results of the empirical try-outs reveal that strategies for solving mathematical word problems are learned by students prior to the vocational-education level. Further, regardless of the efficiency or effectiveness of the learned strategies, students are quite reluctant to change them.

The self-instructional unit probably should be introduced to students during junior high school, or, possibly, at the elementary level. At the vocational-education level, such instruction appears to be too late.

Finally, in the discussions, students indicated that they liked the self-instructional approach employed. Therefore, the problems with this unit appear to be related to subject matter rather than to self-instructional methodology.

APPENDIX G

THE DEVELOPMENT AND EVALUATION
OF A SELF-INSTRUCTIONAL UNIT
ON VISUALIZATION

APPENDIX G

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON VISUALIZATION

The objective of this study was to determine the efficiency and effectiveness of self-instruction for teaching "visualizing" behavior. This skill is applicable to all trades within trade and industrial education. The specific case of the skill selected was going from a two- or three-view orthographic drawing of an object to its isometric drawing. Within drafting specifically, this skill is quite important and is difficult for students to acquire.

General Behaviors Involved

The principal general behavior from the behavioral catalog involved in this skill is:

III,C,3. Given a two-dimensional drawing, visualizes a stationary three-dimensional object.

Procedure

Eight tasks constituted the work of this study.

Objective Specification

Specifying the objective of the self-instructional unit was one of the initial tasks completed. The objective specified was: upon completing the self-instructional unit, students, after viewing an orthographic drawing of an object, will be able to select the corresponding isometric drawing significantly more frequently than students who have not completed the self-instructional unit.

Subject-Matter Study

The principal subject matter sources employed were standard reference books, draftsmen, and vocational educators. From these sources, relevant subject matter was secured.

Strategy Development

Certain basic instructional-strategy decisions were made as a result of conducting this task. One involved subject matter. It was believed that if students could be shown that most objects regardless of complexity are made up from four basic shapes (i.e., box, prism, wedge, and cylinder), this would greatly facilitate the "visualization" of objects.

Another decision involved how this sort of training might be accomplished. A "lean" programming procedure appeared reasonable. That is, after brief, initial training, students would be given an opportunity to attempt the terminal behaviors immediately. If they could do this, they could move on to another "trial". If they could not, they would be given additional, more detailed training prior to another attempt at the terminal behaviors with the student deciding when he had had enough of the detailed training. That is, this procedure would permit the student to attempt the terminal behaviors whenever he decided to do so.

Consistent with these considerations, the behavioral-change technique selected was a facilitated trial-and-error learning with the facilitation directed toward reducing trial errors. The principal subject matter decided upon was drawings of objects that represent complex machined parts.

Method Application

Conducting this task resulted in a self-instructional unit that although basically a linear one, provided students with the option of moving to criterion frames at many points. The first section of the unit provided training on the four basic shapes previously cited. The next section provided demonstration training on how the four basic shapes make up a more complex, example object.

The remaining eight sections contained the facilitated trial-and-error sequences--one sequence per section. Each section presented a two- or three-view orthographic drawing of an object at the beginning and a set of four isometric drawings at the end, with one of the four being the correct match for the orthographic drawing. Between these drawings were orthographic and isometric drawings that gave the student, as he moved through them, progressively more cues. At any point (including the initial orthographic drawing or any "cue" frame), the student could go directly to the isometric drawings at the end of the sequence and make his selection.

In summary, the self-instructional unit contained three discernible sections: one for initial training on basic shapes, one for demonstration training on how the basic shapes make up a more complex, example object, and the final section consisting of eight facilitated trial-and-error sequences.

Criterion-Test Development

This task was concerned with developing criterion instruments for assessing the effectiveness of the self-instructional unit. To develop the instruments, 20 objects were selected by a vocational educator in drafting. A two- or three-view orthographic drawing was prepared for each object depending on the number of views necessary to represent it completely. Also for each object, a set of four isometric drawings were made. One drawing correctly represented the object--the other three were similar, but incorrect representations.

Three draftsmen and one psychologist were asked to rank the 20 objects with respect to visualization difficulty. Using an ABBA procedure on the 20 ranked objects, two groups of ten objects each (assumed to be of about equal visualizing difficulty) were formed. The drawings associated with each group of objects became the alternate forms of the criterion instrument. Each form contained ten items; each item consisted of one two- or three-view orthographic drawing and a set of four isometric drawings, one of which corresponded with the orthographic drawing.

Empirical Try-Out

Procedure. The empirical try-out employed two drafting and two machine trades students at the Southwestern Technical School, Grove City, Ohio. All four students were juniors and considered by their instructors as "average". The students were given a brief review of the work being conducted by the project staff and told that their participation would not affect their class grades. They were encouraged to offer comments, questions, or suggestions as part of their participation.

One drafting and one machine trades student were given Form A of the criterion instrument as a pre-test. The other two students were given Form B for the same purpose. For each of the ten items, the students were given the orthographic drawing, asked to study it, and then asked to select what they judged to be the corresponding isometric drawing. The students were not allowed to flip back and forth between the orthographic and isometric drawings.

Following the pre-testing, each student worked through a self-instructional unit. At the completion of training, each student was post-tested using the form of the criterion instrument not used for his pre-testing. The post-testing followed the same procedure as the pre-testing.

Results. The mean score for Form A of the test was 58 percent and for Form B 63 percent. This indicated a fairly good equivalence for the two forms.

The mean pre-test score for all students was 53 percent; 68 percent represented the mean post-test score. A G value of 0.32 indicated the effectiveness of the self-instructional unit.

Instructional-Unit Revision

Very little intra-unit information indicating necessary improvements was obtained. It was noted, however, that the G value for the two drafting students (0.63) was considerably better than that for the two machine trades students (0.09). This suggested that the self-instructional unit might be differentially effective in favor of drafting students. Consequently, it was decided to employ only drafting students in the final evaluation.

Final Evaluation

Procedure. The final evaluation employed 30 drafting students from Heath High School, Heath, Ohio (17 seniors and 13 juniors). Three groups of ten each were randomly formed: a control group, an experimental group 1, and an experimental group 2. The control group was given the two forms of the criterion instrument (order of presentation of Form A and B alternated). Experimental group 1 was pre-tested, administered the self-instructional unit, and post-tested (order of presentation of Form A and B alternated). Experimental group 2 received the self-instructional unit and was post-tested (Form A and B employed equal number of times). Experimental group 2 was included to check for any facilitating effect from pre-testing.

The administrative procedures were similar to those used in the empirical try-out.

Results. The average time required for the 20 students to complete the self-instructional unit was 49.1 minutes. The pre- and post-instructional results for the final evaluation are presented as Table G-1.

TABLE G-1. EVALUATION RESULTS

Group	Pre-test Mean (Percent)	Post-test Mean (Percent)	G
Experimental I	75	74	-0.05
Experimental II	-	74	-
Control	74	76	0.08

From Table G-1, it is apparent that the self-instructional unit had no facilitating effect. It also is apparent that the students did very well on the pre-tests. This is surprising; the criterion instruments were judged to be quite difficult by practicing draftsmen.

The data also were analyzed to determine whether or not the students selected the correct isometric drawing more frequently when it was presented in a standard rotation than when it was presented in some nonstandard rotation. In seven of the twenty test items the correct isometric was presented in a standard rotation. The remaining thirteen items had the correct isometric presented in some nonstandard position.

The items from all pre- and post-tests were pooled (i.e., 10 items per test times 50 tests = 500 items). Of the 500 items, 175 were correct isometrics in standard rotation (i.e., 7/20 times 500 = 175), and 325 were correct isometrics in nonstandard rotation (13/20 times 500 = 325). It was found that 87 percent of the items in standard rotation (i.e., 152) had been correctly selected. The percentage of items in nonstandard rotation that had been correctly selected was 68 (i.e., 221 items). Applying a t-test for correlated means revealed that this difference was significant at the 0.01 level.

The results indicate that the self-instructional unit had no facilitating affect on students' ability to select the correct isometric drawing for an object presented orthographically. The results also indicate that it is significantly more difficult to select the correct isometric when it is presented in some nonstandard rotation than when it is presented in a standard rotation.

Conclusions

At least two conclusions appear to be justified by the results. First, the self-instructional unit should be evaluated using a younger and/or more naive group of students. The students used in this evaluation entered with the ability to perform quite well. Second, visualizing, as defined in this study, apparently is a function of the rotation factor with better visualizing associated with the standard rotation.

APPENDIX H

THE DEVELOPMENT AND EVALUATION
OF A SELF-INSTRUCTIONAL UNIT
ON THE CAUSES OF TIRE WEAR

APPENDIX H

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON THE CAUSES OF TIRE WEAR

The objective of this study was to determine the efficiency and effectiveness of self-instruction for teaching the skill of visual diagnosis. This skill was found to have applicability to all trades within trade and industrial education. The specific case selected was diagnosing the causes of tire wear--a skill of importance within automotive mechanics.

General Behaviors Involved

The following behaviors from the behavioral catalog are involved in the specific case of visual diagnosis represented by diagnosing the causes of tire wear.

II,D,1. Obtains visual information

II,D,2. Uses visual information

III,A,9. Selects the appropriate product or service for the customer

III,D,10. Uses knowledge of physics.

Procedure

The work associated with this study can be grouped into seven tasks.

Objective Specification

As the result of an initial task, the objective for the self-instructional unit was formulated: given a photograph or drawing of a tire that has worn as the result of:

(1) cornering,

(2) positive or negative camber,

(3) over- or under-inflation,

(4) high-crowned roads,

(5) overloading,

(6) excessive toe-in or toe-out,

(7) mechanical difficulties, or

(8) severe braking,

the student will be able to state correctly:

(1) the probable cause(s) of the wear,

(2) the reasons why the tire has worn in the manner shown, and

(3) the name(s) of the procedure(s) to be followed to correct the cause(s) of the wear.

Subject-Matter Study

As a second task, three primary subject-matter sources were considered: instructional materials, inputs from vocational educators, and inputs from tire-manufacturing companies. From these sources, relevant subject-matter was gathered.

Strategy Development

Another early task was developing a strategy for the self-instructional unit. The primary results were twofold: (1) the decision to use highly illustrated materials, and (2) the decision to use a combination of shaping and discrimination training as the behavioral-change technique.

Method Application

The self-instructional unit resulting from the method-application task contained 113 frames in a linear format. A photograph or a cartoon-type illustration was included in each frame. Sections of the unit were designed for (1) shaping diagnostic behaviors, (2) visual discriminations, (3) practice on visual diagnosis, and (4) review of major behaviors. Student response requirements were both constructed and multiple choice.

Criterion-Test Development

A fifth task was developing criterion instruments to be used for evaluating the self-instructional unit. Two instruments were developed. One was a 17-item written test covering the types of tire wear resulting from different problems such as overloading, high-crowned roads, etc. The second instrument was an 18-item photograph test that required students to give the causes of the tire wear evidenced in the photographs and the procedures required to correct the problems. A brief attitude scale also was developed.

Empirical Try-Out

Procedure. The empirical try-out involved five sophomore students enrolled in the industrial arts program at Grandview High School, Grandview, Ohio. The students were given a brief explanation of the work the project staff was conducting and were told that their participation in the try-out would not affect their class grades. Questions, suggestions, or comments were encouraged from them.

The students were pre-tested using both criterion instruments, followed by administration of the self-instruction. As each student finished the instruction, he was given the attitude scale and then was post-test using the same two criterion instruments. Because of scheduling requirements at the school, the training of the students occurred in two sessions separated by 24 hours.

Results. The pre- and post-test data for the students are presented as Table H-1. The first row of data (possible score = 17) resulted from the written test, the second row (possible score = 18) from the photograph test, and the third row (possible score = 35) from a combination of the two tests.

TABLE H-1. EMPIRICAL TRY-OUT RESULTS

N	Possible Score	Pre-test Mean	Post-test Mean	Mean Gain	Possible Gain	G
5	17	2.9	11.3	8.4	14.1	0.60
5	18	1.9	11.9	10.0	16.1	0.62
5	35	4.8	23.2	18.4	31.2	0.59

As can be seen, the results from the two criterion instruments are favorable and quite similar. The pre-test/post-test differences for the written test, the photograph test, and the combined tests were all significant at the 0.01 level (t = 6.13, 5.34, and 6.81 respectively). A t-test for correlated means was used.

As part of the attitude scale, students were asked to rank five types of instructional methods and materials, including the type of self-instruction that had been employed. Audio-visual aids received the highest average rank (1.4), followed by self-instruction (1.8), workbooks (3.5), lectures (3.8), and textbooks (4.0). On the other attitude-scale items, the students responded quite favorably to self-instruction.

The average error rate on the self-instructional unit was 14 percent. The range was from 5 to 27 percent.

Instructional-Unit Revision

From the results of the empirical try-out, no particular areas of the self-instructional unit requiring revision could be identified (post-test errors were fairly well distributed across all items). Consequently, no significant changes were made. However, because of the 24-hour break that occurred, a final evaluation was believed to be necessary.

Final Evaluation

Procedure. For the final evaluation, five students also were employed. Three were in welding and two were students in machine trades. All were juniors at the Southwestern Technical School, Grove City, Ohio. The administration procedures, except for the 24-hour break, were similar to those used in the empirical try-out.

Results. The data from the final evaluation are presented as Table H-2. The data arrangement is the same as in Table H-1.

TABLE H-2. EVALUATION RESULTS

N	Possible Score	Pre-test Mean	Post-test Mean	Mean Gain	Possible Gain	G
5	17	2.4	10.2	7.8	14.6	0.53
5	18	1.5	9.8	8.3	16.5	0.50
5	35	3.9	20.0	16.1	31.1	0.52

From Table H-2 it can be seen that the results from the written and photograph tests again were quite similar. In general, however, the results from the final evaluation were not as favorable as those from the empirical try-out. The pre-test/post-test differences, however, were significant at the 0.01 level for the written test ($t = 7.96$), at the 0.05 level for the photograph test ($t = 3.48$), and at the 0.02 level for the combined tests ($t = 4.24$). A t-test for correlated means also was used for these results.

On the attitude scale, the highest average rank for instructional methods and materials was given to audio-visual aids (1.25), followed by self-instruction (2.0), lectures (2.5), textbooks (3.7), and workbooks (4.0). Again, the other items on the attitude scale revealed that students liked the self-instruction quite well.

The average error rate for the self-instructional unit was 9.4 percent, with a range of 4 to 21 percent. The average time required to complete the unit was 65 minutes.

Conclusions

From the results that were obtained, the self-instructional unit appears to be a reasonably effective and efficient instructional tool. Additionally, the students were well motivated by the unit, and expressed a distinct liking for the methods of instruction incorporated in it.

APPENDIX I

THE DEVELOPMENT AND EVALUATION OF
A SELF-INSTRUCTIONAL UNIT ON
THE IDENTIFICATION OF METALS

APPENDIX I

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON THE IDENTIFICATION OF METALS

The objective of this study was to determine the efficiency and effectiveness of self-instructional methods for teaching sensory discrimination--a skill applicable to all trades within trade and industrial education. The specific case of sensory discrimination selected was the identification of metals. Metals identification is of considerable importance in machine trades; it also is important in sheetmetal and welding.

General Behaviors Involved

The identification of metals, as a specific case of sensory discrimination, involves five behaviors from the behavioral catalog.

II,B,1. Obtains kinesthetic information

II,B,2. Uses kinesthetic information

II,D,1. Obtains visual information

II,D,2. Uses visual information

III,D,9. Uses knowledge of the principles of metallurgy

Procedure

Nine tasks were conducted in connection with this study.

Objective Specification

An early task was specifying the objective for the self-instructional unit. An overall objective was stated: given a piece of any one of the following metals:

(1) stainless steel,

(2) high speed steel,

(3) tool steel,

(4) cold-roll machine steel,

(5) hot-roll machine steel, or

(6) aluminum,

the student will be able to identify the metal by using the most efficient sequence of the following tests:

(1) appearance test,

(2) spark test,

(3) file test,

(4) magnetic test, and

(5) corrosion test.

Subject-Matter Study

Three primary subject-matter sources were employed during this task: (1) standard references on metals, (2) information from an industrial firm, and (3) a vocational educator. From these sources, relevant subject matter was obtained.

Strategy Development

This task was concerned with such matters as how the metals tests would be included, how they would be sequenced for efficient identification of metals, and the behavioral-change technique to be employed. The result of this task was the instructional strategy to be incorporated in the self-instructional unit.

Method Application

This task was concerned with instructional-unit construction. The unit developed contained 250 frames; however, about 180 of these constituted a highly branched "game" designed to take students through the process of efficiently using metals tests to identify metals.

Line drawings were included to illustrate spark patterns. The section of the program not devoted to the game was constructed according to a linear format. Shaping combined with discrimination training was the principal behavioral-change technique employed for the non-game section. Student-response requirements were constructed responses and multiple-choice responses.

Criterion-Test Development

Two criterion instruments were developed. One was a 20-item written test covering informational points about the various metals and the metals tests. The second instrument was a performance test and required the student to identify metal specimens. The scoring procedure for the performance test provided for scores on correct metal-specimen identification and for scores relevant to the sequence of tests used to identify the specimens.

The metals tests used with the performance test were simulated, yet sufficiently realistic according to the vocational educator.

Additionally, a simple attitude scale was developed. This was subsequently used in the final evaluation.

First Empirical Try-Out

Procedure. The first empirical try-out involved three junior, machine trades students from Southwestern Technical School, Grove City, Ohio. An explanation of the work the project staff was conducting was given to them. Further, the students were told that their participation in the try-out would not affect their class grades. Finally, they were encouraged to offer comments, questions, or suggestions.

The students were pre-tested with the 20-item written test and the performance test. The performance test included seven metal specimens (the six cited in the objective, but with tool steel presented as a bar and as a rod). Following these procedures, both students worked through the self-instructional unit. At the conclusion of instruction, each student was post-tested using both the written and the performance test.

Results. The pre- and post-test results from the first empirical try-out are presented as Table I-1. The first row of data is that obtained from the written test; the second row is that obtained from the metals-identification part of the performance test; the third row is the data from the sequence-of-tests section of the performance test.

TABLE I-1. FIRST EMPIRICAL TRY-OUT RESULTS

N	Possible Score	Pre-test Mean	Post-test Mean	Mean Gain	Possible Gain	G
3	20	5.7	8.7	3.0	14.3	0.21
3	7	2.3	3.0	0.7	4.7	0.15
3	7	1.7	3.7	2.0	5.3	0.38

As can be seen from Table I-1, the self-instructional unit had very little effect. No tests of significance were employed on these data.

The average error rate for the self-instructional unit was 27 percent, with a range from 12 to 45 percent. The approximate time required for the students to complete the units was an hour and a half.

To determine if the results were a function of the students or the self-instructional unit, it was decided to conduct a second empirical try-out prior to making any instructional revisions.

Second Empirical Try-Out

Procedure. The second empirical try-out employed three additional junior students from machine trades at Southwestern Technical School. Most of the procedures used were the same as those for the first empirical try-out.

One major procedural difference, however, was that rather extensive discussions were held with the students as they went through the self-instructional unit. Most of these centered around student errors in an attempt to determine error causes. Three causes were identified: (1) insufficient opportunity for practice and review, (2) overly difficult vocabulary in some frames, and (3) confusion in the game section of the program.

Because of the discussions, error rate and time data were not accurate. The pre- and post-test scores were quite similar to those resulting from the first empirical try-out.

Instructional-Unit Revision

Based upon information obtained from the two try-outs, major revisions to the self-instructional unit were made. These revisions included providing more review and practice frames, eliminating many frames, simplifying vocabulary, and eliminating the game section. The revised unit contained a total of 71 frames.

In the revised unit, a Ruleg format was employed (e.g., a rule is given, illustrated, and practiced). Response requirements were not changed. An 18-frame review section was included at the end of the unit.

Final Evaluation

Procedure. The final evaluation employed 11 junior students in the machine trades program at Patterson Cooperative High School, Dayton, Ohio. The procedures employed were similar to those for the empirical try-outs. No discussions, however, were held. Additionally, the number of metal specimens was increased from seven to ten to preclude the students from using a "process of elimination" upon them. In addition to the seven specimens previously cited, another aluminum, stainless steel, and high speed steel specimen were included. A final, procedural difference was that the attitude scale was administered following the post-testing.

Results. The pre- and post-test results are presented as Table I-2. Again, the first row presents written-test data. The second and third rows present respectively the data from the metals-identification section and the sequence-of-tests section of the performance test.

TABLE I-2. EVALUATION RESULTS

N	Possible Score	Pre-test Mean	Post-test Mean	Mean Gain	Possible Gain	G
10*	20	8.6	15.8	7.2	11.4	0.63
10*	10	3.6	6.6	3.0	6.4	0.47
10*	10	4.0	6.5	2.5	6.0	0.42

*One student's data were not analyzed because he failed to complete the self-instructional unit.

The mean pre-test/post-test difference for the written test was found to be significant at the 0.01 level (t = 3.53; t-test for correlated means). For the metals-identification section of the performance test, this difference also was significant at the 0.01 level (t = 3.90). Finally, the pre-test/post-test difference for the sequence-of-tests section of the performance test was significant at the 0.02 level (t = 3.03). As can be seen from Table I-2, on the whole, the G values are acceptable.

One item on the attitude scale asked the students to rank instructional methods and materials. The highest average rank (1.3) was given to self-instruction, followed by audio-visual aids (1.9), textbooks (3.0), lectures (3.3), and workbooks (4.1). The other items on the attitude scale resulted in quite favorable responses by the students toward self-instruction.

The average error rate on the revised self-instructional unit was seven percent, with a range of 0 to 19 percent. The average time required to complete the unit was approximately 45 minutes.

Conclusions

The revised self-instructional unit appears to do a reasonably effective and efficient job of teaching sensory discrimination in its specific form of identifying metals. The unit should be used principally within machine trades, but quite likely would be valuable for students in sheetmetal and welding. Finally, it appears that student attitudes toward the self-instructional unit would be quite favorable in future applications.

APPENDIX J

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON HOW TO DO A GOOD JOB AT WORK

APPENDIX J

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON HOW TO DO A GOOD JOB AT WORK

The objective of this study was to determine the efficiency and effectiveness of self-instruction for teaching the skill of performance evaluation. The specific, selected case of performance evaluation was how to do a good job at work. This skill was found to be applicable to each trade within trade and industrial education.

General Behaviors Involved

The primary behavior from the behavioral catalog involved in this skill is as follows.

IV,A,4. Collects information by asking relevant questions

Unquestionably, other behaviors are involved; however, they are of such a general nature that they are not included in the catalog.

Procedure

Six tasks were conducted in connection with this study.

Objective Specification

An early task concerned formulating the objective for the self-instructional unit. The following objective was specified: upon completing the self-instructional unit, the student will be able to:

(1) State that during a job interview he would obtain the following information from a prospective employer:

(a) Exactly what jobs he will and will not be doing,

(b) What things about the job are most important to the company,

(c) The rules of the company, and

(d) What benefits can be obtained from doing a good job.

(2) State that two reasons for doing a good job are:

(a) To make more money, and

(b) To enjoy the job more.

(3) State that he should evaluate his work as often as possible and at least once a day.

Subject-Matter Study

Another early task was consideration of subject matter. Generally, the body of information surrounding reinforcement theory represented the primary subject-matter source. The particular aspect of this information considered to be most directly relevant is the empirical data demonstrating the criticalness of reinforcement in establishing and maintaining behavior.

Strategy Development

The primary consideration involved in this task was mode of presentation and the subject matter to be included in the presentation. An auditory mode was decided upon; subject matter decisions provided for a lecture-type, detailed explanation of how to do a good job accompanied by an example job-interview situation that demonstrated the application of information presented in the lecture.

Method Application

The method-application task resulted in a 12-minute tape recording that presented, in an explanative manner, information cited in the objective. Additionally, a job-interview situation was acted out in a dialogue fashion. This example demonstrated how to apply various aspects of what had been covered in the oral explanation (particularly how to ask questions). The students were not required to respond during the tape recording.

Criterion-Test Development

An eight-item written test was developed. The test items covered the critical points included in the unit.

It was realized that the written test was a proximate criterion instrument and that how students performed on the job would be the ultimate measure of the self-instructional unit's effectiveness. However, it was believed that the written test would provide sufficiently valid data to permit a reasonable evaluation of the unit.

A simple attitude scale also was developed for use in the evaluation.

Empirical Try-Out

No empirical try-out of this self-instructional unit was judged to be necessary. This was because the relatively limited requirements for student activity minimized the information that could be obtained. Consequently, no empirical try-out was conducted.

Final Evaluation

Procedure. The final evaluation employed three different classes at the Southwestern Technical School, Grove City, Ohio. One class was made up of 12 senior students in electronics. This class was rated as "probably the school's best class" by school personnel. Another class consisted of 13 senior students in automotive mechanics--depicted as "probably the school's worst class". The third class was made up of 16 senior drafting students who were judged as "about an average class for the school".

The three classes were viewed as one control group (the drafting students) and two experimental groups (the electronics students and the automotive mechanics students).

The two experimental groups were treated separately. Each group was given an explanation of the work the project staff was doing and were told that their participation would not affect their class grades. They were then instructed to listen to the tape recording. The groups were not told that they would be tested. It was observed that the electronics students took extensive notes on what they heard.

At the completion of the tape recording, the students in both experimental groups were given the eight-item test. They also were given a small card summarizing the major points presented. It was suggested that they put this card in their billfolds and refer to it after they were working on a job. Finally, they were asked to complete the simple attitude scale.

The control group was simply given the eight-item test without having heard the tape recording.

Results. The written-test data are presented as Table J-1.

TABLE J-1. EVALUATION RESULTS

Group	N	Possible Score	Mean Score	G*
Experimental 1 (Electronics)	12	8	7.33	0.52
Experimental 2 (Automotive Mechanics)	13	8	5.00	0.10
Combined Experimental	25	8	6.12	0.30
Control (Drafting)	16	8	4.44	-

*Calculated using control group's mean score as a pre-test score.

Statistical tests were conducted on several differences between mean scores. The difference between the mean score of the control group and that of the combined experimental groups was significant at the 0.05 level ($t = 2.37$). The experimental 1/control difference was significant at the 0.001 level ($t = 4.74$), while the experimental 1/experimental 2 difference was significant at the 0.01 level ($t = 3.03$). The difference between mean scores of the experimental 2 group and the control group was not significant.

The student responses on the attitude scale were favorable toward the self-instructional unit. The electronics students believed that the tape recording was more useful and they enjoyed it more than the automotive mechanics students. All students, however, appeared to like the self-instructional method.

Conclusions

The self-instructional unit appears to be a somewhat effective way to teach job-performance behaviors. A tentative conclusion is that note-taking somewhat facilitates learning from the tape. Another very tentative conclusion is that the unit may be differentially effective--in the direction of being more effective for more capable students.

APPENDIX K

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON HOW TO GIVE A BASIC HAIRCUT

APPENDIX K

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON HOW TO GIVE A BASIC HAIRCUT

The objective of this study was to determine the efficiency and effectiveness of self-instruction for teaching the skill of task performance. Task performance was found to be widely applicable--it is involved in every trade within trade and industrial education. The specific case of task performance selected for this study was how to give a basic haircut--a skill of considerable importance in cosmetology.

General Behaviors Involved

Eleven behaviors from the behavioral catalog constitute the specific case of task performance represented by how to give a basic haircut. These are listed below.

I,B,1. Assumes proper position of body and hands to use an instrument or tool

I,B,2. Holds tool at appropriate angle to work media

I,C,2. Applies tool to work media with vertical motion

I,C,5. Applies tool to work media with a scissors motion

II,B,1. Obtains kinesthetic information

II,B,2. Uses kinesthetic information

II,D,1. Obtains visual information

II,D,2. Uses visual information

III,A,4. Selects the work operations to be performed

III,A,5. Selects the time, place, and sequence of operations

III,D,13. Uses knowledge of trade terminology

Procedure

Seven tasks were completed in connection with this study.

Objective Specification

An early task was formulating the objectives for the self-instructional unit. The following objective was specified: after completing the self-instructional unit, the student will be able to demonstrate the task-related behaviors stated below.

(1) Given drawings of a pair of scissors and a razor, the student will be able to name their parts.

(2) The students will be able to sketch four- and five-section parting of the hair.

(3) The students will be able to explain, in writing, how, when, and where hair is thinned.

(4) The students will be able to name and explain, in writing, the methods and the different implements used in thinning the hair.

(5) The students will be able to name and explain, in writing, the methods and the different implements used in shingling.

(6) The students will be able to define specific terms involved in giving a basic haircut.

Subject-Matter Study

Another early task was examining subject-matter sources. The principal ones examined were instructional materials and reference materials. Additionally, the inputs of a vocational educator in cosmetology were secured. From these sources, relevant subject matter was obtained.

Strategy Development

The principal considerations during this task were selection of subject matter to be included in the self-instructional unit, sequencing of the subject matter, the behavioral-change technique to be employed, and student-response requirements.

Method Application

The method-application task resulted in the completed self-instructional unit. The primary behavioral-change technique incorporated was shaping. The unit contained 107 frames, was in a linear format, and employed many drawings to illustrate points and to provide samples for which students were to construct matched responses. Response requirements included constructed-verbal and constructed-sketching. Selection from among multiple choices was a third response requirement.

Criterion-Test Development

The criterion instrument developed as the result of this task was a 36-item test that required informational-type answers and sketches to illustrate various haircutting techniques.

Additionally, a simple attitude scale was developed.

Empirical Try-Out

Because of limitations on the time of cosmetology students available to the project staff, no empirical try-out with these students was possible. The self-instructional unit was, however, tried with a junior member of the Battelle staff. The results of this trial were quite encouraging.

Instructional-Unit Revisions

No revisions were found to be necessary based upon the limited "empirical try-out".

Final Evaluation

Procedure. The final evaluation employed 26 junior students in cosmetology at Heath High School, Heath, Ohio. The students were given a brief description of the work the project staff was doing and were told that their participation in the evaluation would not affect their class grades. The students then were pre-tested with the 36-item test, administered the self-instructional unit, post-tested with the test, and asked to complete the simple attitude scale.

Results. The pre- and post-test results are presented as Table K-1.

TABLE K-1. EVALUATION RESULTS

N	Possible Score	Pre-test Mean	Post-test Mean	Mean Gain	Possible Gain	G
26	36	22.5	35.0	12.5	13.5	0.93

As can be seen from Table K-1, the pre-test mean was higher than is normally desirable. An examination of test items revealed that the greatest gain was realized from those items having to do with equipment and hair-sectioning procedures. The least gain was realized from those items having to do with evaluating haircuts and with proper lengths for cutting different textures of hair. The junior year is the first year of the cosmetology program at Heath High School and the self-instructional unit was evaluated after the students had had approximately three months of instruction. Because of this, it is likely that the kinds of information covered by the test items on which pre-test scores were high, had been given to the students prior to the evaluation.

In spite of the high pre-test scores, the difference between the pre- and post-test means was significant at the 0.001 level. Similarly, the G value (0.93) indicated that the program was quite effective.

The average error rate for the unit was 4 percent (range = 0 to 17 percent). The average time required to complete it was 32 minutes (range = 20 to 55 minutes).

One item on the attitude scale asked the students to rank self-instruction, textbooks, and lectures. The average ranks assigned to these were 1.1, 1.9, and 2.8 respectively. On another item, the students were simply asked whether or not they liked the self-instruction. Of the 26 students, 25 said they did. On another item, the students were asked if the self-instructional unit was too easy or too hard. All 26 responded that it was just right.

Conclusions

It is reasonable to believe that the self-instructional unit would be very effective for students just beginning instruction on giving a basic haircut. That is, it is likely that a decrease in pre-test scores would not appreciably affect post-test scores because the unit contains what can be judged as adequate instruction related to all items.

On the whole, it can be concluded that the self-instructional unit would be quite effective and efficient for use with beginning cosmetology students.

APPENDIX L

THE DEVELOPMENT AND EVALUATION OF
A SELF-INSTRUCTIONAL UNIT ON
LETTERING

APPENDIX L

THE DEVELOPMENT AND EVALUATION OF A SELF-INSTRUCTIONAL UNIT ON LETTERING

The objective of this study was to determine the efficiency and effectiveness of self-instruction for teaching the skill of two-dimensional form construction. This skill is applicable to all trades in trade and industrial education. The specific case of two-dimensional form constructi n selected was lettering--a skill of considerable importance in drafting.

General Behaviors Involved

Five behaviors from the behavioral catalog are viewed as constituting the specific skill of lettering.

I,C,1. Applies tool to work media with a horizontal motion

I,C,2. Applies tool to work media with a vertical motion

I,C,4. Applies tool to work media with a circular motion

II,D,1. Obtains visual information

II,D,2. Uses visual information

The number of tasks conducted during the course of this study was eight.

Objective Specification

An initial task was formulating the objective for the instructional unit. The objective specified was: for all students receiving the self-instructional unit, judges (drafting supervisors or practicing draftsmen) will rate the post-instructional lettering of students as superior to their pre-instructional lettering for 90 percent of the students.

Subject-Matter Study

The subject-matter-study task was primarily concerned with standard drafting references and information obtained from practicing draftsmen.

During this task, it was determined that there are seven principal characteristics of good lettering: (1) correctly formed letters, (2) correctly spaced letters, (3) correctly spaced words, (4) uniform height, (5) uniform slant, (6) constant font, and (7) uniform darkness.

From examining presently available drafting references, it was suspected that the number and sequence of strokes recommended for forming letters was unrealistic. Therefore, it was decided to determine empirically how practicing draftsmen form letters and digits. Nine draftsmen at Battelle were asked to make each letter of the alphabet and the ten digits (0 through 9). An observer recorded the sequence and number of strokes used by them. As was expected, both differed considerably from the procedures recommended in the references. However, there was good homogeneity among the draftsmen's methods. The most typical finding was that practicing draftsmen used fewer strokes than recommended in forming letters and digits. This was especially true of the digits. Therefore, it was decided that the self-instructional unit should be based upon the procedures demonstrated by practicing draftsmen.

Strategy Development

An assumption underlying the task of strategy development was that in order for students to become competent in lettering, they must practice. It was believed, however, that they should practice only correct lettering. Further, it was believed that the practice of correct lettering would be facilitated if students first could discriminate correct from incorrect lettering.

It followed, then, that the instructional strategy should provide for training on such discriminations prior to practicing. Consequently, the behavioral-change technique decided upon was a combination of discrimination training and shaping. The response requirements were multiple choice and constructed responses.

Method Application

The self-instructional unit that resulted from the method-application task contained 63 frames. Its format was linear and consisted of two major sections.

The first section contained instruction on six of the seven characteristics of good lettering (the correctly-formed-letters characteristic was not included in this section). Following this, they were given training on discriminating between letters having uniform and nonuniform height. This was followed by training on discriminating between letters having uniform height and slant and those having non-uniform height and slant. This was continued until training on discriminating between "good" and "bad" letters on all six characteristics was reached. This sequence went, it was judged, from the most simple discrimination (height) to the most difficult discrimination (all six characteristics combined).

The second section contained instruction on forming letters and digits. Again, the sequence for this section was judged to go from easy formations (e.g., "I" and "L") to the most difficult ones (e.g., "Q" and "S"). Following this, instruction on lettering short sentences was included for practice on spacing. Throughout this section, the students were required to critique their own work employing the discrimination abilities taught in the first section.

Criterion-Test Development

This task resulted in two criterion instruments. The first required students to generate a sample of their lettering behavior. This sample included all letters of the alphabet and all digits (0 through 9). The second instrument required the student to discriminate between proper and improper lettering by having him identify lettering errors in a lettered sentence. Two forms of this instrument were developed.

Empirical Try-Out

Procedure. The empirical try-out employed three junior drafting students from Southwestern Technical School, Grove City, Ohio. The students were given a brief description of the work the project staff was doing and were told that their participation would not affect their class grades. They were encouraged to offer comments, questions, or suggestions during their participation.

The students were asked to produce the lettering sample and were given one form of the discrimination test. They then proceeded through the self-instructional unit. Upon completing the unit, they were again asked to produce the same lettering sample and were given the alternate form of the discrimination test.

Results. On the discrimination test, the pre-test mean was 67 percent;* the post-test mean was 74 percent. This difference was not a significant one. The G value was 0.20.

An examination of the lettering samples revealed that four of the six post-instructional samples appeared to be better than the pre-instructional samples (letters and digits for each student were examined separately). Since three samples would be judged better by chance, this was not viewed as a significant finding.

The average error rate for the instructional unit was 12 percent (range = 8 to 15 percent). The average time required to complete it was 124 minutes (range 119 to 129 minutes).

Instructional-Unit Revisions

Changes were made in the unit based upon the results of the try-out. These changes did not affect the overall structure or length of the unit.

Final Evaluation

Procedure. The final evaluation employed 13 junior drafting students from Heath High School, Heath, Ohio. The procedures used were similar to those employed for the empirical try-out.

Results. The results from the discrimination tests are presented as Table L-1. The difference between means was not significant.

TABLE L-1. EVALUATION RESULTS FOR DISCRIMINATION TESTS

N	Possible Score (Percent)	Pre-test Mean (Percent)	Post-test Mean (Percent)	Mean Gain (Percent)	Possible Gain (Percent)	G
13	100	76	81	7	32	0.22

*Percents were used because the two forms of the discrimination test had different numbers of discriminations.

The pre- and post-instructional lettering samples were judged by five experienced Battelle draftsmen. For each pair of samples, the judges did not know which sample was pre-instructional nor which was post-instructional.

The results of the judging were that 48 percent of the post-instructional samples were judged to be superior to their pre-instructional counterparts, ten percent were judged to be equal, and 42 percent of the post-instructional samples were judged to be inferior to their pre-instructional counterparts. Inasmuch as 50 percent of the post-instructional lettering samples would be judged superior by chance, these findings were viewed as non-significant.

The average error rate for the self-instructional unit was 12 percent (range = 6 to 26 percent). The average time required to complete it was 119 minutes (range = 70 to 147 minutes).

Conclusions

The results indicate that the self-instructional unit was not especially effective. Two confounding effects, however, may have been operating. First, the unit was administered in December; therefore, the students had had approximately three months in which to practice lettering. This likely increased their pre-instructional lettering ability. Second, the students felt that the unit was too long, even with a 15-minute break in the middle. They complained of being tired at the end which may have, at least partially, accounted for poor post-instructional lettering.

It appears that the self-instructional unit might be made more effective by a revision designed to shorten it. On the other hand, an evaluation with students who are just beginning lettering instruction might show that the unit is effective in its present form.