AN ABSTRACT OF THE THESIS OF

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Title: A STUDY OF THE WHOLE JOB (MULTI-POSITION) APPROACH AS COMPARED TO THE TRADITIONAL (SINGLE-POSITION) APPROACH IN THE DEVELOPMENT OF ARC WELDING SKILLS

Abstract approved: Redacted for privacy
Dr. Pat H. Atteberry

The major consideration of this study was the testing of the superiority of the whole or part method for developing basic arc welding skills. Data were also generated which facilitated investigation of: (1) the relationship of welding skill development to cognitive attainment of welding information as measured by welding proficiency posttest scores and written test scores, respectively; (2) a comparison of skill development among three levels of students grouped according to welding proficiency pretest scores; and (3) a comparison of welding skill development of students in separated and mixed (whole or part method) welding sections.

Fifty-five students comprised the population for this study. Subjects were selected from beginning welding students enrolled in day or

evening programs at Everett Community College during the Fall and Winter quarters of the 1971-72 school year. Students selected for participation were programmed through a 15-hour practice session running flat and overlapping flat beads.

Students were tested and paired according to similarity of welding proficiency pre-test scores. Pairs were split or arbitrarily assigned to the whole or part method of learning.

Four welding sections were homogeneous; that is, contained only whole- or part-method students. All other welding sections were heterogeneous; that is, both whole- and part-method students learning together.

Three welding positions, horizontal, vertical, and overhead, were selected as the learning elements used to test the whole versus part method of learning. That concept was implemented by assigning students to one of two sequences.

Whole-method, experimental students practiced a total of 45 hours. The welding practice sessions were divided into three equal parts, time-wise. Each student practiced one-third of each session on horizontal fillet welds, one-third on vertical fillet welds, and one-third on overhead fillet welds. This schedule was followed until 45 hours of practice were completed.

Part-method, control students utilized the following sequence: (1) fifteen hours of welding practice on horizontal fillet welds, then (2) 15 hours of welding practice on vertical fillet welds, and finally

(3) 15 hours of welding practice on overhead fillet welds.

Upon completion of a 45-hour practice schedule, all students made fillet weld test plates in the three positions and were tested on the cognitive aspects of welding which were judged relevant. The welding proficiency and cognitive test scores provided the data for the statistical test of each of the hypotheses.

Within the limits of this study, the following conclusions are evident concerning the hypotheses:

1. Whole (experimental) and part (control) method students demonstrated no statistically significant difference in the level of welding proficiency.
2. Students who scored highest on the pre-test demonstrated statistically significant higher welding proficiency post-test scores than students who scored lowest on the pre-test.
3. Whole-method students in mixed classes demonstrated statistically higher welding proficiency post-test scores than their counterparts in segregated classes.
4. There was practically no linear relationship or commonality between welding proficiency post-test scores and cognitive test scores.

A Study of the Whole Job (Multi-position) Approach as Compared to the Traditional (Single-position) Approach in the Development of Arc Welding Skills

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CHAPTER I

INTRODUCTION

Numerous experiments designed to investigate the whole versus part learning question have been reported since Steffens first conducted her research in 1900 (59). The conflicting results of these studies demonstrate that relatively little is known of the effectiveness of either the whole or part methods.

The whole- versus part-method studies have provided some insights as to possible factors which may influence the effectiveness of either method. One such factor is the tendency of the whole method of instruction to be superior when used to develop closely related motor skills.

Arc welding proficiency requires mastery of the fundamental skills necessary to weld in all positions. These skills are closely related. Therefore, this study, employing the development of arc welding skills through the use of the whole versus part learning methods, may validate the influence of the similarity factor upon the effectiveness of either method.

In addition, and equally important, this study may encourage experimentation and the development of new perspectives on the part of welding curriculum developers and instructors relative to the current arc welding instructional methodology.

Statement of the Problem

The central problem of the study was to determine whether, if given a defined amount of learning time, utilization of the whole job learning approach (S's practicing horizontal, vertical, and overhead arc welding skills in each laboratory session) is superior to the part job approach (S's develop arc welding skills sequentially; that is, horizontal, vertical, overhead).

To complete this study, the following questions were formulated. Within these questions the term "groups" will mean Sequence #1 (Part Method) and Sequence #2 (Whole Method). The term Class 3, Class 2, and Class 1 will imply the following:

Class 3 - subjects scoring three on the pretest,

Class 2 - subjects scoring two on the pretest, and

Class 1 - subjects scoring one on the pretest.

Questions Relative to the Study

Will the use of the whole method of skill development in weldor training influence the effectiveness of instruction significantly as demonstrated by a comparison of post-test scores of the group?

Will the use of the whole method of skill development in weldor training be equally effective for each of the three classes?

Will the demonstrated (test score) knowledge of information pertinent to welding in the given positions provide an indicator of welding skill proficiency developed within the limits of this study?

Will the method of student class assignment, that is, students of the same sequence in a class compared to students of both sequences in a class, influence the welding proficiency post-test scores among the groups?

Hypotheses of the Study

The following null hypotheses were tested in consideration of the questions generated in the statement of the problem:

1. There is no significant difference in the welding proficiency post-test scores of the whole-method group and the part-method group.
2. There is no significant difference in welding proficiency post-test scores of whole- and part-method students among the classes.
3. There is a significant relationship between the post-test scores of knowledge pertinent to welding in the given positions and the welding proficiency post-test scores among the students.

4. There is no significant difference in the welding proficiency post-test scores among the groups due to the grouping of all the students in one sequence in the same class as compared to classes having both sequences of students.

Limitations of the Study

The following limitations were imposed in this study:

1. The population of this study was limited to students enrolled in the Everett Community College, Fall and Winter terms, 1971-72.
2. The time element was limited to a total of 60 hours of arc welding for each subject. Welding practice periods were of two and three hours duration.
3. The electrode used was the AWS-ASTM Type E-6010, 1/8" and 5/32" diameter.
4. The fillet weld was employed as the practice exercise.

Assumptions

This study assumes the following:

1. The population is representative of students enrolled in other welding programs.
2. The time element is sufficient to provide some measurable basic skill development in the various positions.

3. The fillet weld practice exercise is a relevant exercise for weldor training.

4. For the purposes of this study, the consequence of the instructor variable is random, and therefore not a factor for consideration.

Definition of Welding Terms

The source of the following definitions was the Welding Encyclopedia (64). In some instances the definition was written by the researcher. For example, the E-6010 electrode was not identified specifically by the text cited.

Fillet Weld - A weld of approximately triangular cross section, as used on a top joint, tee joint, or corner joint between two surfaces at approximately right angles to each other.

AWS - American Welding Society, 345 East 47 Street, New York 100107.

ASTM - American Society for Testing Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

E-6010 Electrode - An all position D-C reverse polarity, spray type electrode. Used on mild steel, galvanized plate, and some low alloy steels to produce welds with high mechanical properties. This electrode meets radiographic requirements when used for multi-pass applications in the vertical and overhead positions.

Horizontal Position Fillet Weld - The position of welding wherein welding is performed on the upper side of an approximately horizontal surface and against an approximately vertical surface.

Overhead Weld - A position of welding in which the filler metal is deposited from the underside of the joint and the face of the weld is approximately horizontal.

Vertical Position - The position of welding wherein the axis of the weld is approximately vertical.

Flat Position - A position of welding in which the filler metal is deposited on the topside of the joint and the face of the weld is approximately horizontal.

Welder - Machine for doing welding.

Weldor - An operator of welding equipment or an operator who makes the welds.

Whole-Part Definitions and Methodology

The whole and part methods for this study were assigned in the following manner:

Whole Method

All S's will practice for 45 hours but divide each welding practice period into three equal parts and will devote one-third of the period to horizontal fillet welds, one-third of the period to vertical fillet welds, and one-third of the period to overhead fillet welds.

Part Method

All S's will practice for 45 hours utilizing the following schedule:

1. Fifteen hours of practice on horizontal fillet welds.
2. Fifteen hours of practice on vertical fillet welds.
3. Fifteen hours of practice on overhead fillet welds.

Several sub-classes of the part-method of learning and the methodology employed by psychological researchers are described as:

> 1. In the pure part method each part is separately learned to a criterion, after which all the parts are repeated in sequence, as a whole until the whole has been brought to the criterian already attained by each part.
>
> 2. By the progressive part method, parts one and two are mastered separately and then combined to form a whole. Part three is next learned separately, then practiced with parts one and two, and so on by the progressive addition of parts until the original whole has been learned.
>
> 3. The repetitive part method consists of mastery of part one, then practice of parts, one, two, and three together, and so on, until all have been learned (35, p. 499).

Rationale for the Study

Research of this problem will test the stated hypotheses and may also serve to attain the following secondary objectives:

1. To test the validity of the current learning sequences used to teach the welding positions.

2. To stimulate research in the field of welding instruction.
3. To provide welding educators with a new frame of reference for viewing their current welding methodology.

These objectives evolved as a result of conclusions reached by a review of literature related to research of arc weldor training methodology, correspondence with authors of welding texts, correspondence with professional organizations and proprietary welding schools, and personal contacts with welding educators. From these activities the following conclusions were formulated:

1. There is a paucity of research in welding instruction.
2. Industrial demands for weldors are causing increasing demands for weldor training in both public and private schools.
3. Most welding educators seem to be able to live with their assumptions as to the consequences of their instructional activities and they tend to resist change.
4. The current arc weldor training methodology derived from "experiences of many able men" should be tested by research of its instructional methods to determine its efficiency.

Each of the conclusions cited above is important if one considers the implications of possible improvement of the weldor training methodology. The benefits to learners, training institutions, and industry by the more efficient use of energy and resources have no calculable dollar value. But this consideration might well help the nation take a small step toward a more competitive position in the industrial world. Therefore, a brief review of the basis of each of these conclusions follows.

The Lack of Research

A review of the literature indicates little research in the area of welding instructional methods. The existing studies have dealt with the relationship of polysensory instructional aids and length of welding laboratory periods. Little of the research has explored the area of weldor training using a job analysis approach with an emphasis on sequences of learning the required skills, or determining the relative difficulty acquiring these skills. As a result, many of the welding instructional methodologies have, since their inception, not been validated. This point is clearly shown if one examines the evolution of welding training techniques.

Evolution of the Arc Welding Curriculum

The arc welding curriculum presently employed by most welding schools emerged in the 1920's and, after 50 years of technological advancement, looks about the same as it was at conception. Authorities in the field of welding who wrote during the period from 1900 to 1931 provided little or no detail concerning arc weldor training.

Hubert (29), writing in 1932, recommends the traditional pattern of sequences for arc weldor training exercises--namely, flat, horizontal, vertical, and overhead. This sequence has prevailed for most welding schools as many of the writers of welding texts continued Hubert's methodology (2, 48, 60).

Several authors did alter their sequence slightly; Sosnin (57) suggests that the horizontal be taught last, while Althouse (1), Pierre (42), and Potter (45) combined the horizontal position with the vertical and followed with the overhead position last. Yet the great majority of welding schools still follow the learning sequence for part-method development of basic skills outlined by Hubert. This statement is not to imply that the weldor training has not been influenced by advancing technology, because changes have been made. With the advent of the heavily coated electrode, new metals, new equipment, arc welding processes, and plastic welding, for example, the welding curriculum was revised to pace advances in technology. Yet, students beginning a program to develop the skills necessary for proficiency in arc welding are still exposed to a welding curriculum founded, in part, by history and tradition without the benefit of research of possible alternatives or improvement in the learning experience. Perhaps, if weldor trainers and the industry had tested their assumptions as to the consequences of their weldor training methods, the welding schools might be able to supply the increasing demand for the weldors needed today with less cost in human and material resources.

The Projected Need for Weldors and the Implications of this Need for Welding Schools

An increasing demand exists for the many applications of arc welding which is a tool of many occupations. Labor department projections suggest a rapid increase in the number of welding jobs during the 70's due to expansion and increased activity in the metalworking industry; the wider use of the welding process and openings due to retirement and deaths are factors cited by the Bureau of Labor Statistics. Additional weldors will be needed in maintenance, repair, and production.

The Bureau of Labor Statistics projects a need for 23,000 weldors per year during the 1970-1980 decade (37). This need for weldors is presently reflected by increased demands for weldors in industry. Industry's in-house weldor training programs supply only a fraction of their total need. Public and proprietary schools have assumed the responsibility of supplying qualified weldors which industry needs but does not train.

Welding schools of all types are experiencing expanding enrollments for weldor training. Learners are having to wait for an opportunity to gain welding skills. Everett Community College, Everett, Washington, has scheduled welding classes from 8:00 A.M. to 10:00 P.M. five days a week with an additional eight hours on Saturday; yet students have been turned away each quarter. This situation exists in many community colleges and vocational schools which offer weldor training. Expansion of facilities and staff are needed to meet this demand for the training of weldors. The costs of operating a welding program are as high or higher than most curricula. Improvement in weldor training methods might well produce a significant saving in dollars and other resources. Whether these more effective learning methods can be developed and implemented depends on the attitude of welding educators and professionals toward research and change.

Reactions to the Study

The magnitude of this problem may be reflected by the reactions of various people concerned with weldor training toward this study which encompass the continuum from rejection to genuine interest. Many welding instructors wanted nothing to do with this research, while others thought it might be interesting to try. The most challenging comments were provided by an author of welding texts and a professional in the welding field who, in answer to this researcher's letter (see Appendix A), stated:

> So far as I know there has been no formal research on the subject of your question, but there is considerable background of experience. The experience of many able men in

> the area of weldor training indicates that it is simply impossible to teach a beginner to weld in several different positions during the same time span. He MUST be taught in the easiest position (flat) first then gradually progress to the more difficult areas (58).

This view sums up the attitude of many welding educators who seem to believe that their methods are the best. Others approach this research with an open mind as was demonstrated by Mr. Cary, Director, Hobart Brothers Technical Center, when he wrote:

> You have hit upon an interesting question concerning training for all position welding sequentially versus simultaneously. . . .
>
> We would be greatly interested in your approach, since we do actually consider our school as a laboratory for trying new and better teaching techniques, equipment, etc. If you have any success in this venture, we would be most happy to make our own evaluation of this technique. Therefore, we would appreciate receiving a copy of your proposal for this study (9).

Another positive view toward this study was received from Mr. Laurence E. Poteat, Director of Education for the American Welding Society, when he replied, "Your subject is a very interesting one and the results should be of interest to all people training weldors" (44).

Although there is both interest and a definite rejection on the part of welding educators toward this study, progress may result from this attempt to open their minds with a seed of doubt. Most weldor educators are eager to provide the most effective learning experiences possible so that they can help produce weldors with proficiency to do the job required by industry. Their efforts in the past have provided a vital element in our great industrial advancement. While the weldor is utilized more and more in this era of welded products and structures of all types, the day of the steel riveter has all but disappeared. The men and women who do this welding were, for the greater part, trained in schools and industry. They are skilled and competent in their area of welding, and the future weldors will be of the same caliber as their predecessors. This is as it should be, but the questions arise, "Should their training experience be the same as those whom they follow? Is there a better methodology which might be applied to train weldors more quickly, more economically, and possibly produce a more productive weldor?" These questions can only be answered if welding educators begin to analyze their methodology and explore the alternative learning experiences, sequences, and techniques.

Research is necessary to either validate the traditional practices used to train weldors or to provide new and better practices which can withstand the test of additional research. Hopefully, this study will stimulate interest on the part of the professional educators in welding and other occupations to analyze their assumptions as to the consequences of their training methodology to see if they are in fact providing the learner with the most effective and efficient learning experiences. To this end, regardless of the results of this study, the information concerning this effort will be widely disseminated for weldor trainers to consider. A few candles may be lit to guide other researchers down the path to better instructional techniques for learners.

Summary

Projected needs for competent weldors suggest that in the decade of the 70's, many tens of thousands of weldors will be trained in the public, proprietary, and industrial schools of the nation. Yet the welding curriculum of these schools continues to be based on the "experience of many able men" with little or no research to validate the effectiveness of this traditional methodology.

Institutions and industries, who invest both energy and resources to develop competent weldors, should be informed of the cost effectiveness of current training methods. The learner should be exposed to the most effective and efficient learning experiences to develop the necessary skills and knowledges to become a competent weldor with the smallest expenditure of his resources.

Information related to the cost effectiveness of the current weldor training methodology will be generated only through research which is designed to challenge the assumptions of weldor educators, past and present, as to the consequences of their methods. New and radical methodology, in terms of current practices, should be instituted by researchers to validate welding curriculum and instructional techniques or provide new and more effective instructional techniques. This study may provide alternative approaches for the sequencing of the welding positions to be learned by students. In addition, this study may stimulate interest and thereby promote research in the area of weldor training.

CHAPTER II

REVIEW OF LITERATURE

The review of literature relevant to this project will be presented in three sections: (1) review of research of the whole-part learning question, (2) representative studies relative to research of the whole-part learning question involving motor-skill development, and (3) representative studies pertinent to welding education.

Selected Reviews of Whole-Part Learning Research

Many insights concerning early studies of the whole-part question were provided by Grace McGeoch in 1931. Her critical analysis produced the following data:

1. Only 6 of 30 investigations provide results which are statistically valid.
2. The results suggest that the relative efficiency of the whole- and part-methods of learning and retention may be influenced by the following factors as stated by McGeoch:
   a. Subjects--age, training, memorizing ability, and intelligence.
   b. Material--type, nature, difficulty, and length.
   c. Practice--amount and distribution and nature of practice periods.

d. Form of the part method used.

e. Method of measuring learning efficiency.

f. Method of measuring retention efficiency.

g. Length of interval (34, p. 713-739).

Generalizations concerning the effect of these factors are not evident from the experimental data even though the whole method does seem most efficient with subjects of higher intelligence.

From the experimental data available, the question of superiority of either the whole or part method of learning was unresolved.

May Seagoe's reevaluation of the whole-part learning question graphically demonstrates the number of studies favoring the whole or part method in five-year periods. Types of materials used to investigate the whole-part method were also charted (53). In addition, this researcher was the first to define a qualitative whole as having three primary qualities:

1. It is definitely segregated. It is relatively independent, isolated, and autonomous, possessing its own individual entity. Other wholes are excluded from existence for the learner in the perception of a true whole.
2. It possesses "form-quality" or unity, built around a central function. It is an organized, functional unit with decisive internal dynamic relations. It possesses clearness,

definiteness, solidity, regularity, harmony, coherence, and symmetry.

3. It is more than a sum of its parts; it is a rational structure. Hence, a homogeneous field cannot constitute a whole, because taking out one part of it leaves the whole unchanged. A whole is causally coherent, a unit in which changing one section changes the entire structure (53).

J. McGeoch's and Irons' writing in 1952 suggest that research results had been far from uniform on the whole-part question. This review of the whole-part learning research indicated that the data obtained by Grace McGeoch still prevailed despite numerous additional studies (35).

A more recent review by Cunningham (18) summarizes 70 years of whole-part learning research by citing headings which presume to influence the effectiveness of the part method. Cunningham states:

> The advantages identified for part learning as opposed to whole learning can be summarized under the following headings: the length-difficulty relationship, the research on step size, positive transfer, and anchor points.

In addition, Cunningham points out that headings found to ascribe disadvantages for the part learning are:

> (1) interpart interference, (2) forgetting of earlier parts, (3) place associations, (4) lack of an integrated whole, and (5) negative transfer of part- and whole-organization (18, p. 389-390).

Analysis of these whole-part learning studies and reviews indicates that resolution of the superiority of either method prevails at the "insight" level. In addition, the last 20 years of research indicate an improvement in the validity of statistical methodology as this factor is no longer cited in the most recent review.

Selected Whole-Part Motor-Skill Learning Literature

Early studies, 1917-1930, of the whole-part learning question involving skill development used a variety of motor-skill learning materials. Mazes were employed by several researchers with the resulting data favoring the part-learning method (5, 40). Three studies utilizing cardboard puzzles, finger sequences, and mirror drawing also substantiated the superiority of the part-learning methods (27, 31, 33). Conversely, several researchers using typing, piano scores, and card sorting as vehicles to answer the whole-part learning question reported findings supporting the whole-method approach (6, 8, 16).

More recent whole-part learning research investigating motor-skill development has employed a variety of learning situations. McGuigan and MacCaslin, in a study designed to evaluate the whole and part methods in learning a perceptual motor skill (firing an army rifle), found that the whole method may be superior to the part or incomplete part method. The part method involved breaking the whole into sub-tasks. The S's received instruction on each sub-task, but the total job (actual act of firing) was not reached until the last four hours of the 28-hour experiment. The whole-method learning approach involved performing all the sub-tasks each time the S's received instruction including the actual firing of the weapon (36).

In a study hypothesizing (1) superiority of the part-method of learning highly organized motor skill when the degree of prior familiarization with the task is high, and (2) superiority of the whole method when the degree of familiarization with the task is low, Ritchie's data did not confirm either hypothesis. Twenty-eight "little leaguers' " batting ability provided the basis of prior familiarization with the motor skill. After the initial grouping, each group was subdivided into a whole-method and a part-method sub-unit. Analysis of batting provided the skills' sub-elements. The instructional stimulus was a short, sound film which demonstrated the basic battery skills in a self-instruction context (50).

Juggling provided the vehicle for a study by Knapp and Dixon which was designed to test the whole versus repetitive part method, and the whole versus a free choice of part and/or whole method. In both cases, the whole-learning method subjects tended to reach the criterion most rapidly (30).

Niemeyer used swimming as the learning situation to research the whole-part learning question. Teaching the stroke as a unit, subjects learned how to swim sooner, further, faster, and with better form than those using the part-learning method (38).

Another study utilized memorizing piano music and practice as the learning material. Eight measure-units of music were learned to criterion by the whole, half-part, and quarter-part practice methods. The resulting data revealed no significant difference between the three methods in attainment of the criterion (52).

The studies cited above demonstrate the diversity of materials and conditions used to answer the whole-part question. Extrapolation of the insights generated by the numerous whole-part studies to specific areas of instruction, welding for example, is difficult without additional research. For occupations requiring specific motor skills, the lack of research of instructional methodology is quickly evident upon examination of the literature.

Literature Related to Welding Instruction

This section cites selected studies which relate to the following aspects of weldor training: (1) studies analyzing the aptitudes needed for arc welding and suggested methods for testing welding aptitudes, and (2) recent research pertinent to weldor education.

One of the major objectives of the welding-training programs is to provide the learner with a series of experiences designed to develop the motor skills necessary for proficiency in arc welding. Bourassa describes three motor-skills which are used in welding as follows: manual dexterity, the ability to make skillful, controlled arm and hand manipulations at a rapid rate (required to hold and manipulate the electrode); visual acuity, the ability to perceive a fine visual stimuli (required to observe the size and shape of the molten puddle and to differentiate between the metal and the slag); and depth perception, the ability to perceive the differences in distances of stimuli (required to enable a weldor to hold the electrode a uniform distance from the molten puddle) (7).

Continuing research by the United States Training and Employment Service, designed to validate the General Aptitude Test Battery (GATB), includes several classifications of arc weldors as well as many other occupations. Because of the extensive research base, the GATB is recognized as one of the better validated multiple aptitude test batteries in existence for use in vocational guidance.

The GATB consists of 12 tests which measure nine aptitudes:

> General Learning Ability, Verbal Aptitude, Numerical Aptitude, Spatial Aptitude, Form Perception, Clerical Perception, Motor Coordination, Finger Dexterity, and Manual Dexterity. The aptitude scores are standard scores with 100 as the average for the general working population, with a standard deviation of 20 (21).

The GATB study No. 2619 describes

> . . . research undertaken for the purpose of developing GATB norms for the occupation of Welder, Arc (Welding) 810.884. The following norms were established:

GATB Aptitude	Minimum Acceptable GATB, B-1002 Scores
S-Spatial Aptitude	85
M-Manual Dexterity	85

In this study Spatial Aptitude is necessary for interpretation of diagrams and blueprints and for positioning and assembly of workpieces. Manual Dexterity is necessary for set-up of equipment and in guiding of electrode during welding (19, p. 1-4).

The guidance services, testing, and software are available at all local offices of State Employment Services.

Additional insights concerning tests of motor ability which may be relevant to weldors today were reported by Seashore in 1942. Methods were devised to test hand steadiness, hand manipulation, and postural steadiness (55). All of these abilities are most important in the act of arc welding and might well provide a basis for both research effort and guidance for students.

Literature Related to Weldor-Training Methodology

The paucity of research in the field of weldor-training methodology is readily evident from the review of literature. The few studies involving methods of teaching welding involve different approaches to the problem than those undertaken by this researcher. Chrisman, in a study of the effectiveness of audio-visual programmed instruction and the traditional lecture-demonstration methods of teaching arc welding, found that the audio-visual programmed method of instruction was effective (11). In a study of the effect of the length of the welding class, Rosin, using an experimental polysensory-instructional system for learning high level perceptual motor skills and knowledge, found that students in two-hour classes did at least as well as students in three-hour classes when knowledge and performance were measured (51).

Also, the United States Navy Training Research Laboratory has conducted several recent studies involving weldor-training. Caviness approached the weldor-training problem using a systems technique to develop an experimental welding curriculum designed to reduce failures and improve the end product, competent weldors. Task analysis was employed to generate a task inventory of all elements required for welding on non-nuclear surface vessels. Next, the task inventory was translated to a set of training exercises. This process not only provided a method for obtaining performance objectives, but also generated an inventory of subordinate skills and knowledge for training and instruction (10).

In a search for weldor competencies for agricultural machinery maintenance weldors, Hansen reported the ten most needed competencies for these weldors to be:

1. Understanding of affect of amperage, arc length, speed of travel and angle of electrode on weld quality.

2. Ability to make welds in horizontal, vertical, and overhead positions.
3. Understanding of properties of metals as they affect weldability.
4. Ability to select proper electrode and amperage setting.
5. Understanding of properties and uses of various electrodes.
6. Understanding of safe operating procedures for arc welding.
7. Ability to prepare and fit pieces to be joined.
8. Ability to position, clamp, and weld metals to control distortion.
9. Ability to weld cast and malleable iron using steel and nickel electrodes.
10. Ability to recognize and make corrections for weld defects (28, p. 76).

Bacon, in a study designed to develop a program for welding technicians, received inputs from over 250 respondents who employed weldors or welding technicians. This study revealed the importance placed on training arc weldors when 100 percent of the respondents suggested that all welding school trainees develop proficiency in arc welding (3).

Summary of Related Literature

Analysis of the related whole-part learning methods literature reveals the use of either method which may produce superior learning under certain conditions. The major factors which influence the effectiveness of the whole-part learning method, as suggested by Grace McGeoch, and more recently Cunningham, are:

1. The length-difficulty relationship.
2. The step size.
3. Transfer.
4. Interference between parts.
5. Form of parts or wholes used (18, 34).

Woodworth suggests employing the whole method; and if the learners encounter difficulty, the learner switches to part method until the difficulty is corrected. Then the learner returns to the whole method (65, p. 786).

Research more closely related to the development of motor skill indicates some learning activities employing the whole-learning method may be more quickly learned. The studies involve such a diversity of learning situations that extrapolation of results to other learning situations is difficult.

Welding studies directed especially at weldor training are few in number. Instructional materials, time factors, and task analysis are several of the areas of weldor training which have been studied. More research in materials and methods of welding instruction is needed to validate or revise current practices.

CHAPTER III

PROCEDURAL DESIGN OF THE STUDY

Using the development of elementary arc welding skills as the learning material, the major focus of this study was to test the whole- versus part-learning methods to determine if one learning method was more effective than the other. The conduct of this study and the data generated were obtained through the cooperation of Everett Community College, Miss Jeannette Poore, President, and the staff of their welding department where the research was implemented.

Methodology

Participant Selection Criterion

The following criteria were used in the selection and retention of participants for this study:

1. Students enrolled in the Everett Community College welding program during the Fall and Winter quarters of the 1971-72 school year.
2. Students with little or no previous welding experience. The term "little" means the inability to weld in any position other than the flat position.
3. Fifty-five subjects met the criterion cited above and the

additional criteria of 60 hours of welding laboratory practice using either the whole or part method of learning.

Grouping of Participants

The subjects were grouped, whole- or part-learning method, according to their pretest scores. Subjects with like pretest scores were paired and assigned to the whole or part groups. Fall quarter four welding classes, with a total of 28 students, were grouped so that two classes contained only part, sequence number one, subjects while the other two classes contained only whole, sequence number two, subjects. A fifth class was made up of both sequences of subjects. In the Winter quarter, all classes contained both whole and part subjects.

Sequence sheets were developed to provide each subject with instructions and a time sheet (Appendix B).

Evaluation Techniques for Welding Proficiency

Criteria for the pretest and post-test of welding proficiency were selected from current evaluation techniques and/or researcher experience.

Pretest

During the fifteenth hour of the initial practice period, each subject produced a test plate, 3" x 8" x 1/4" mild steel, using 40 percent overlapping stringer beads, one layer, E6010-1/8" electrodes in the flat position. Evaluation of the pretest using a three point scale, good = 3, average = 2, poor = 1, was based on uniformity of height, width, and ripples of the welds. One expert evaluated these plates.

Post-Test

During the sixtieth hour of the subjects' controlled laboratory experience, each one produced 1/4" fillet weld test plates in the horizontal, vertical, and overhead positions using E6010-1/8" electrodes.

Test plate details similar to those employed by other welding schools were distributed to students (see Appendix C for sample detail sheet) (46, p. 39).

Evaluation of the test plates generally follows the specifications for fillet weld soundness test. The contour portion of the test was evaluated by one expert, while the fusion and soundness portions were evaluated by another expert. AWS Code of Minimum Requirements for Instruction of Welding Operators, Part A-1945, Figure 1, Page 9, provided the test details. Employing a detailed, step-by-step procedure, the welds were evaluated (Appendix D).

Cognitive Proficiency Test Procedure

Evaluation of the subject's knowledge of information pertinent to welding safety in the given positions was obtained as follows:

1. Analysis of the tasks and information required to weld safely with some degree of knowledge of operating procedures was conducted by the researcher. From this analysis, four general objectives with sub-elements specifically identified were derived.
2. Using the specific items as test elements, a test was developed to measure the subjects' knowledge of these elements (Appendix E).
3. The welding instructors were informed, verbally and in writing, of the material to be included in their instructional methodology and the time and procedure for administering the test (Appendix F).

Statistical Design

The analysis of variance was used to test the following hypotheses:

1. There is no significant difference in welding proficiency post-test scores of the whole-method group and the part-method group.

2. There is no significant difference in the welding proficiency post-test scores of whole- and part-method students among the classes.

3. There is no significant difference in the welding proficiency post-test scores among the groups due to the grouping of all the students in one sequence in the same class as compared to classes having both sequences of students.

The F statistic, with alpha = .05 as the level of significance, was employed to reach conclusions concerning the hypotheses testing.

Testing of the Final Hypothesis

There is a significant relationship between the test scores of knowledge pertinent to welding in the given positions, and the welding proficiency post-test scores among the students was statistically tested using Pearson's r statistic. The resulting coefficients of correlation were used to estimate relations between the sets of variables in terms of percentage of commonality between them, the strength of the linear relationship, and the direction of the relationship.

CHAPTER IV

ANALYSIS OF DATA--DISCUSSION OF FINDINGS

This chapter presents the data, methods of analysis, results of the analysis of data, and a discussion of the results of the analysis of data for each of the four hypotheses cited previously. The analysis of data and discussion of findings will follow the same order as the hypotheses appear in Chapter III. All data collected were tabulated and processed by the computer center at Oregon State University. Therefore, only the hypothesis, raw data, and pertinent computer print-out items are presented and discussed.

Analysis of Data for the First Hypothesis

The analysis of variance was used to statistically test the first null hypothesis; there is no significant difference in the welding proficiency post-test scores of the whole-method learning group and the part-method learning group. The F statistic, with alpha = .05 as the level of significance, was employed. Test scores for the groups are shown in Table 1. These test scores were programmed into the computer using a one-way classification analysis of variance. Table 2 presents the data and F value generated from the welding proficiency post-test scores of the whole and part groups by the computer. Average group welding proficiency test scores are shown in Table 3.

Table 1. Post-test welding proficiency scores by whole- and part-method learning groups.

Whole-method student scores	Part-method student scores
100	99
98	97
98	97
97	95
96	95
96	94
96	94
96	94
95	94
95	93
94	92
94	92
91	92
89	91
88	87
87	87
87	85
87	84
86	83
86	83
85	82
85	81
84	80
84	78
84	78
83	76
82	76
	70

N = 55; 27 whole-method learning students, 28 part-method learning students

Table 2. Analysis of variance table of the mean group welding proficiency post-test scores used to test the first hypothesis; there is no significant difference in the welding proficiency post-test scores of the whole-method learning group and the part-method learning group.

Source of variation	df	SS	MS	F
Groups	1	1. 25131332E 02	1. 25131332E 02	2. 6853
Error	53	2. 46970503E 03	4. 56982082E 01	
Total	54	2. 59483636E 03		

Table 3. Average group welding proficiency post-test scores.

Whole-method learning group	Part-method learning group
90. 48148	87. 46429

Discussion of Findings

The first null hypothesis is retained because the computed F value (2. 6853) is smaller than the tabular F value (4. 02) (14).

The data generated to test the whole versus part methods of learning the basic fundamentals of welding in the given positions (horizontal, vertical, and overhead) suggest that neither method is superior for this limited population sample. The importance of this statement lies in the possibility that the traditional method of teaching arc welding fundamentals is not the only way to provide effective learning experiences for arc welding students.

Another factor brought to light by the performance of the whole-method students is the hierarchical ordering of the welding sequences based on difficulty of the position. Whole-method learners were able to practice welding in the horizontal, vertical, and overhead positions during their first welding session without any apparent difficulty or frustrations above those encountered by part-method students welding in the horizontal position during their first welding session.

Traditionally, most welding instructors and welding textbook writers have told students that vertical and overhead welding positions were the most difficult. Whole-method students participating in this study did not verify this myth.

Analysis of Data for the Second Hypothesis

The analysis of variance was used to statistically test the second null hypothesis; there is no significant difference in the welding proficiency post-test scores among the classes. The F statistic, with alpha = .05 as the level of significance, was utilized. Test scores for the students in each class are shown in Table 4. These class test scores were programmed into the computer using a one-way classification analysis of variance. Data generated from the class welding proficiency post-test scores by the computer are shown in Table 5. The average mean class welding proficiency scores are shown in Table 6.

Discussion of Findings

The data revealed that there was a significant difference between the classes on the basis of welding proficiency post-test scores. Rejection of this hypothesis is statistically shown by the computed F value (5.9748) being larger than the tabular F value (4.03) (14).

Students who pretested highest, scored higher on the welding proficiency post-test. The average class welding proficiency post-test score for Classes 3 and 2 was 91.35714 and 89,25000, respectively. Class 1 learners had an average class welding proficiency post-test score of only 80.00000. N for Class 1 was only 5. Therefore, this hypothesis requires further testing.

Table 4. Welding proficiency post-test scores of students by classes.

Class assigned (pretest welding proficiency score)	Whole-method student welding proficiency post-test scores	Part-method student welding proficiency post-test scores
3	98	95
	97	94
	96	93
	95	92
	94	87
	87	84
	85	82
2	100	99
	98	97
	96	97
	96	95
	96	94
	95	94
	94	94
	91	92
	89	92
	88	91
	87	87
	86	85
	85	83
	84	83
	84	80
	84	78
	83	78
	82	76
1	87	81
	86	76
		70

Table 5. Analysis of variance of the mean class welding proficiency post-test scores used to test the second hypothesis; there is no significant difference in the welding proficiency post-test scores among the classes.

Source of variation	df	SS	MS	F
Class	2	4.84872078E 02	2.42436039E 02	5.9748
Error	52	2.10996429E 03	4.05762363E 01	
Total	54	2.59483636E 03		

Table 6. Average class welding proficiency post-test score.

Class 3	Class 2	Class 1
91.35714	89.25000	80.00000

Analysis of Data for the Third Hypothesis

Analysis of variance was employed to statistically test the third hypothesis; there is no significant difference in the welding proficiency post-test scores among the groups due to the grouping of all students of one sequence in the same class (separated) as compared to classes having both sequences of students (mixed). The F statistic, with alpha - .05 as the level of significance, was utilized. Welding proficiency post-test scores for the groups are shown in Table 7. These post-test scores were programmed into the computer, using a one-way classification analysis of variance for both the whole-method group (sequence 2) and the part-method group (sequence 1). Tables 8 and 10 present the statistical data resulting from the treatment of the welding proficiency post-test scores according to method of grouping students by the computer. The average welding proficiency post-test scores for the groups, based on separated or mixed grouping, are shown in Tables 9 and 11.

Discussion of Findings

The third null hypothesis was tested in two parts: (1) the whole-method separated group compared to the whole-method mixed group, and (2) the part-method separated group compared to the part-method mixed group.

Table 7. Welding proficiency post-test scores of whole- and part-method students in separated and mixed welding classes.

Whole-method student welding proficiency post-test scores		Part-method student welding proficiency post-test scores	
Mixed classes	Separated classes	Mixed classes	Separated classes
100	98	99	94
97	98	97	93
96	91	97	92
96	88	95	92
96	87	95	92
96	86	94	91
95	86	94	83
95	85	94	83
94	85	87	82
94	84	87	81
89	84	85	80
87	83	84	78
84	82	76	78

Analysis of the data for the whole-method groups shown in Table 8 reveals a rejection of the null hypothesis because the computed F value of 11.05315 is larger than the tabular value at both the .05 and .01 levels of significance (14).

The analysis of data for the part method, Table 10, indicates the null hypothesis is retained as the computed F value of 3.87733 is smaller than the tabular value of 4.26 (14).

Statistically, there is no significant difference among the part-method groups due to grouping of part-method students in either separated or mixed welding sections when welding proficiency post-test scores are used as the variable. The opposite is indicated for the

Table 8. Analysis of variance of the welding proficiency post-test scores used to test the whole-method portion of the null hypothesis; there is no significant difference in the welding proficiency post-test scores among the groups due to the grouping of all students of one sequence in the same welding section as compared to welding sections having both sequences of students.

		Whole-method groups		
Source of variation	df	SS	MS	F
Between	1	2.586153832E 02	2.586153832E 02	11.05315
Error	24	5.615384636E 02	2.339743598E 01	
Total	25	8.201538467E		

Table 9. Average welding proficiency post-test scores for the whole-method groups in separated and mixed welding sections.

Whole-method group	
Type of section	Average group score
Separated	87.46154
Mixed	93.76923

Table 10. Analysis of variance of the welding proficiency post-test scores used to test the part-method portion of the null hypothesis; there is no significant difference in the welding proficiency post-test scores among the groups due to grouping of all students of one sequence in the same welding section as compared to welding sections having both sequences of students.

Source of variation	df	Part-method groups SS	MS	F
Between	1	1.625000000E 02	1.625000000E 02	3.87733
Error	24	1.005846153E 03	4.191025639E 01	
Total	25	1.168346153E 03		

Table 11. Average welding proficiency post-test scores for the part-method groups in separated and mixed welding sections.

Part-method group Type of section	Average group score
Separated	86.07692
Mixed	91.07692

whole-method group which was assigned to a mixed welding section. In this latter case, the whole-method students in mixed sections demonstrated statistically higher mean scores than their counterparts in separated welding sections.

Welding proficiency post-test scores and knowledge (cognitive) test scores are presented in Table 12.

Figure 1 contains the scattergram generated by plotting the welding proficiency post-test scores and the cognitive test scores as coordinates on the graph.

The computed correlation coefficient for the data presented in Table 12, using Pearson's r statistic, was -0.0663229.

Discussion of Findings

There is no significant relationship between the cognitive test scores of knowledge pertinent to welding in the given positions, and the welding proficiency post-test scores among the students. The Pearson's r value of -0.0663229 provides the following information:

1. The percentage of commonality is less than one percent between the cognitive test scores and the welding proficiency post-test scores among the students.
2. The strength of the linear relationship is considered to be practically nonexistent.
3. The sets of information, cognitive test scores, and welding proficiency post-test scores do not covary (15).

Table 12. Welding proficiency and cognitive test scores of students used to statistically analyze the fourth hypothesis; there is a significant relationship between the test scores of knowledge pertinent to welding in the given positions, and the welding proficiency post-test scores among the students.

Student number	Welding proficiency post-test score	Cognitive test score	Student number	Welding proficiency post-test score	Cognitive test score
1	95	64	29	95	85
2	94	80	30	94	76
3	93	88	31	96	76
4	92	80	32	98	64
5	87	60	33	97	72
6	84	80	34	87	56
7	82	68	35	85	84
8	94	76	36	89	80
9	85	64	37	95	80
10	87	56	38	96	76
11	97	72	39	100	80
12	97	80	40	96	76
13	95	68	41	84	52
14	76	80	42	87	80
15	99	72	43	96	76
16	94	80	44	94	76
17	92	80	45	88	76
18	92	72	46	98	84
19	94	72	47	84	80
20	80	88	48	91	88
21	91	76	49	83	68
22	83	68	50	82	64
23	78	92	51	85	80
24	78	92	52	84	76
25	83	84	53	86	60
26	76	72	54	87	64
27	81	80	55	86	72
28	70	84			

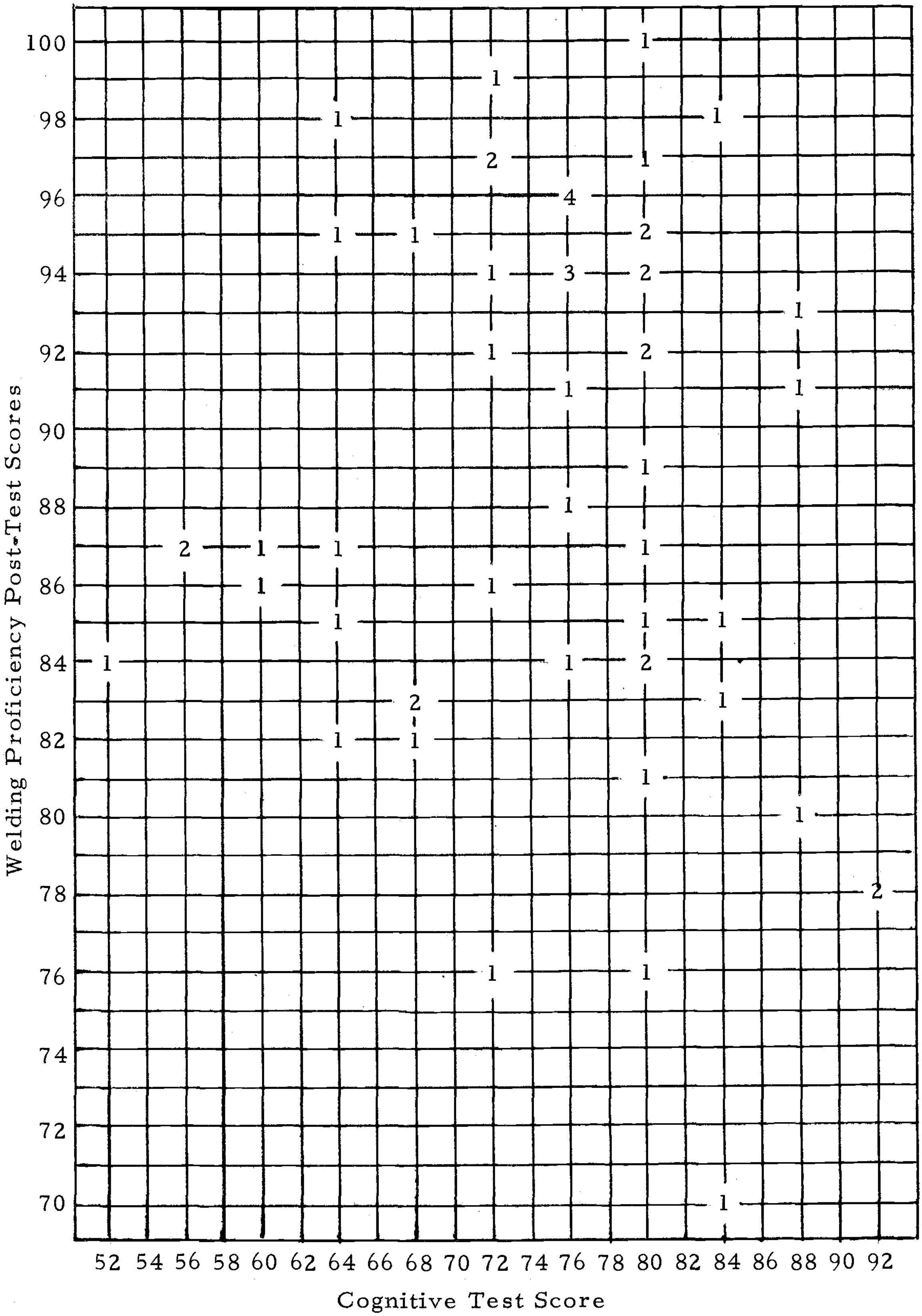

Figure 1. Scattergram of linear relationship of welding proficiency and cognitive test scores.

The analysis of data (welding proficiency post-test scores compared to cognitive test scores) reveals little relationship exists between these two variables. The inference suggested here is the development of welding proficiency occurs regardless of the knowledge the learners have gained in related welding information. This finding is supported by Colville's study which utilized ball rolling, catching, and archery to test the effect of knowledge of mechanical principles on initial learning of the skill (13). One conclusion of this experiment was that "there was no evidence that instruction concerning mechanical principles utilized in the performance of a motor skill facilitates the initial learning of the skill to any greater extent than an equivalent amount of time spent in practicing the skill" (13, p. 326).

While extrapolation of results of Colville to the welding situation is questionable, both the physical education and the welding activity involve motor-skill development related to hand-eye coordination. Furthermore, ths researcher's experience with welding students suggests that it is possible for students with limited ability to learn welding information, mathematics, metallurgy, layout, and the like, to develop welding proficiency and employability.

Obviously, these weldors are limited in areas of employability but there are industrial environments which can utilize weldors with these limited capabilities.

Within the limitations of this experiment, there seems to be little relationship between welding proficiency and knowledge of information considered to be pertinent to welding safely and efficiently in the given positions.

CHAPTER V

SUMMARY OF FINDINGS, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Summary of Findings

Statistical analysis of the data using the F statistic, at the .05 level of significance, produced the following results:

1. Both the whole and part methods of developing arc welding skills are equally effective.
2. Whole-method students in mixed classes demonstrated more arc welding skill development than whole-method students in separate classes. This finding did not apply to the part-method students.
3. Students who exhibited the most arc welding skill at the end of the 15-hour pre-session continued to demonstrate this advanced proficiency in the post-test.
4. There is very little relationship between the ability to develop arc welding skills and the amount of knowledge the learners have assimilated concerning the welding equipment, materials, and safety involved in the welding process.

Conclusions

The major conclusion accomplished by this research is that the traditional part-method of developing basic arc welding skills is not the only methodology which can effectively produce equal results. The findings clearly indicate that the whole method of developing arc welding skills is found to be equally effective.

Another conclusion resulting from this study suggests students be allowed to try several learning methods to find one which works best for them rather than the traditional lock-step method. Whole-method learners, in mixed classes, demonstrated higher welding proficiency test scores than whole-method students in separate classes. Part-method students in mixed classes had higher average scores than part-method students in separate classes. Variables not identified explicitly in this study exert a positive influence upon the skill development rate of students in mixed classes.

The amount of welding information a student has learned concerning the welding process is not a factor which influences the ability to develop arc welding skills. This conclusion is warranted by the lack of relationship between the welding proficiency and cognitive test scores. Students were able to develop welding skills with limited knowledge of the technical information related to the welding process.

Each of the conclusions cited should provide welding curriculum personnel and researchers with considerable material for research and review in light of the current welding methodology employed in most welding schools.

Implications

As a result of this study of the whole versus part method of learning basic arc welding skills, several factors suggest future considerations for welding educators. That the traditional, part method, is not the only way to effectively train weldors becomes apparent from the evidence produced by this research. Within the limits of this study, the whole-method approach of learning the basic arc welding skills is as effective as the part-method. In view of this hypothesis, it would seem that current part-method weldor training practices should be reevaluated and alternative methods considered.

Alternative instructional models should be developed, tested, evaluated, and revised until a more effective weldor training system is available for learners. New weldor training models should include the following elements as possible factors for consideration: (1) diversity of practice exercises, (2) motivating situations, (3) flexibility, and (4) individualization of instruction.

The whole-learning method could be incorporated into the welding curriculum to provide diversity of practice experiences which are not evident in traditional welding instructional techniques. Whole-method students have a variety of exercises to practice, that is, horizontal, vertical, and overhead positions, during each welding session. As a result, whole-method students may be challenged, but not bored. On the other hand, part-method welding students may practice the same exercise for many hours and possibly lose interest in the task before gaining proficiency and moving on to the next task. The element of diversity may well be a motivational factor of prime importance.

Incorporation of the whole-learning method into the weldor training instructional system does not infer that the part method will be discarded. Flexibility of method should be maintained. Learners who experience difficulty with the whole method of learning should have the opportunity of using the part method. Students might also begin their welding skill development with the whole method and upon experiencing a problem with a sub-task, switch to the part method and concentrate on learning the sub-task. Once the sub-task has been learned to a given level of proficiency, the learner could then continue learning using the whole method.

Flexibility of learning methods provides an element of individualized instruction. A combination of whole- or part-method learning experiences which allows the learner to opt one method of learning or the other may provide a learning environment which promotes motivation. This motivational element may be implicit in the results of grouping students in mixed or segregated sections and analyzing the mean scores of the groups. Students in welding sections which included both whole- and part-method learners demonstrated higher mean welding proficiency post-test scores than their counterparts in segregated classes.

Recommendations for Additional Research

The results of this study and the researcher's experience in the weldor training field suggest the following questions be considered as areas for further research:

1. What is the influence of transfer of learning in the whole versus part method of learning arc welding skills?
2. What is the influence of arc welding skill upon the attainment of oxyacetylene welding skills, and vice versa?
3. What is the influence of either arc or oxyacetylene welding skill upon the learning of tungsten inert gas arc welding (TIG) and metallic inert gas arc welding (MIG)?
4. Is the whole or part method most cost effective for training weldors?
5. What in fact are the competencies, skills, and knowledge required by the various levels of welding jobs?
6. Is there no significant difference in welding proficiency test scores between the whole- and part-method learning groups of welding students?

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APPENDICES

APPENDIX A

Researcher's Letter

3270 Market Street, NE
Salem, Oregon 97301
October 29, 1971

Mr. E. Fenton, Sec.-Treas.
American Council of the
International Institute of Welding
345 East 47 Street
New York, New York 10017

Dear Mr. Fenton:

At the present time I am a candidate for an Ed. D. in Industrial Education at Oregon State University. My dissertation concerns one aspect of training welders. The statement of the problem of my study is as follows:

> "The central problem of the study is to determine whether, given a defined amount of learning time, utilization of the whole job approach (S's practicing horizontal, vertical, and overhead arc skill development exercises each laboratory session) is superior to the part job approach (S's developing arc-welding skills sequentially, i. e., horizontal, vertical, and overhead)."

A review of the available literature reveals little or no research involving the various methods of providing learning experiences for welder trainees. Can you provide any information pertaining to welding research which is pertinent to my area of research?

Your cooperation will be appreciated and if you are interested, a copy of the proposal for the study will be sent to you upon request.

Sincerely,

Roland C. Stemmer

APPENDIX B

Name | Number

SEQUENCE #1 -- 45 hours

The following schedule is provided for you to help you develop your welding skill in manual arc welding. You are encouraged to follow this schedule and also keep a daily record of your welding time each day.

Practice Schedule

1. First 15 hours - horizontal fillet welds, Tee joint, stringer beads, 1/8 inch -- E6010 for the first two layers, 5/32 inch -- E6010 for the additional layers.

   When you have completed 15 hours of horizontal welding, report to the instructor for a demonstration in vertical position welding.

2. Second 15 hours - vertical fillet welds, Tee joint, stringer beads, 1/8 inch E-6010 electrodes for the first two layers, 5/32 E-6010 electrodes for the additional layers.

   When you have completed 15 hours of vertical welding, report to your instructor for a demonstration in overhead position welding.

3. Final 15 hours - overhead fillet welds, Tee joint, stringer beads, 1/8 inch E-6010 electrodes for the first two layers, 5/32 inch E-6010 electrodes for the additional layers.

When you have finished the 15 hours of overhead welding, report to your instructor for instructions and give the instructor this sequence sheet.

IF THERE ARE ANY INSTRUCTIONS ON THIS SHEET THAT YOU DO NOT UNDERSTAND, TALK TO YOUR INSTRUCTOR ABOUT THEM.

Time Sheet -- Time to be Recorded Daily

Horizontal Fillet
Date
Hours

Vertical Fillet
Date
Hours

Overhead Fillet
Date
Hours

Name ____________________ Number ____________________

SEQUENCE #2

The following schedule is provided for you to help you develop your welding skill in manual arc welding. You are encouraged to follow this schedule and also keep a daily record of your welding time each day

Practice Schedule

1. Each welding lab period, you will practice running fillet welds using stringer beads in the horizontal, vertical, and overhead position.

2. The lab time should be divided into three equal parts and one-third of the time spend in each position. Example: A two-hour lab -- forty minutes in each position.

3. The electrodes to be used will be E-6010. One-eighth inch electrodes for the first two layers and five-thirty-seconds inch electrodes for additional layers.

4. When you have completed forty-five hours of this schedule, report to your instructor for instructions and give the instructor this sequence sheet.

IF THERE ARE ANY INSTRUCTIONS ON THIS SHEET THAT YOU DO NOT UNDERSTAND, TALK TO YOUR INSTRUCTOR ABOUT THEM.

Time Sheet -- Time to be Recorded Daily

Date ____________________
Hours ____________________

Date ____________________
Hours ____________________

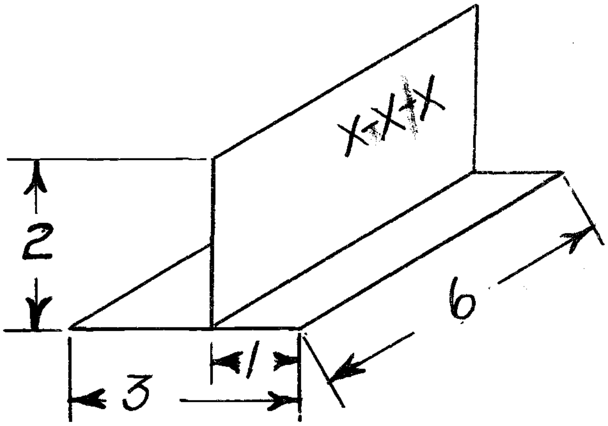
Date ____________________
Hours ____________________

APPENDIX C

Post-Test Plate Detail Sheet

POST-TEST PLATE DETAIL SHEET

Each student will do a quarter-inch fillet weld in each position. Stringer beads will be used as indicated in the figures below.



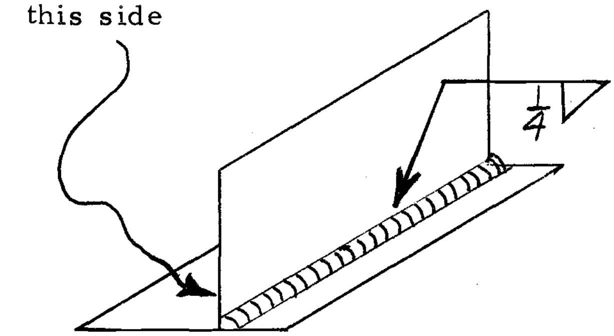
Stamp student number, sequence number and position number, as indicated (x-x-x).

Tack weld at each end.

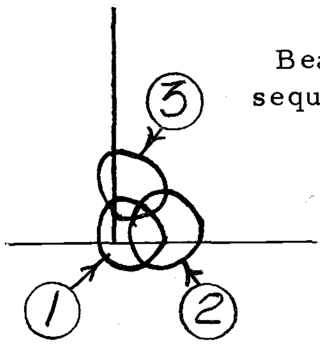
BILL OF MATERIAL

1 pc. 1/4 x 3 x 6 mild steel-ASTM A-7
1 pc. 1/4 x 2 x 6 mild steel-ASTM A-7

WELDING PROCEDURE



Position	Position number	Electrode size
Horizontal	1	1/8"
Vertical	2	1/8"
Overhead	3	1/8"



Bead sequence

TEST BAR PREPARATION: None

APPENDIX D

Welding Proficiency Post-Test Procedure

FILLET WELD SOUNDNESS TEST PROCEDURES

Step 1. The six inch test plates will be marked so that the test weld is divided into six one-inch segments on both sides and both plates.

Step 2. The total weld surface will be examined visually for uniformity and smoothness. The weld will then be evaluated using the three point scale indicated on the evaluation sheet. Three being good, two average, and one being less than average.

Step 3. The face of the weld will be examined for undercut and/or overlay. If there is visible undercut or overlay in any of the one-inch segments, one point is subtracted for each inch segment with such an occurrence. Six points are given for a weld with no undercut or overlay.

Step 4. The weld is broken and the exposed weld is visually examined for fusion and soundness.

Step 5. The broken weld is examined for root penetration. If there is evidence of lack of root penetration, one point is subtracted for each inch segment with such an occurrence. Six points are given for root penetration the entire length of the weld.

Step 6. The broken weld is examined for incomplete fusion of the weld and base metal. One point is subtracted for each inch segment (both sides included) with such an occurrence. Six points are given for a weld with complete fusion between the weld and base metal.

Step 7. The broken weld is examined for gas pockets, oxide particles, or slag inclusions exceeding 3/32 inch in the greatest dimension. One point is subtracted for each inch segment (both sides included) with such an occurrence. Six points are given if the weld is free of the above described flaws.

Step 8. The broken weld is examined for gas pockets exceeding 1/16 inch in the greatest dimension and numbering more than 6 per square inch of weld. One point is subtracted for each inch of weld (both sides included) with such an occurrence. Six points are possible if the test weld is sound within the limits set for gas pockets.

APPENDIX E

Cognitive Test

RELATED INFORMATION POST-TEST

PART I - Multiple Choice

Instructions: Place an X in the square in front of the best answer listed to the right of the question.

Sample: The E-6010 electrode is generally limited in the maximum current that can be used with the larger sizes of electrodes due to

- ☐ overheating base metal
- ☐ overheating metal electrode
- ☐ excess spatter

1. The E-6010 electrode is generally classified by its coating as
   - ☐ low hydrogen
   - ☐ high cellulose sodium
   - ☐ low cellulose sodium

2. The E-6010 electrodes work best with which welding current
   - ☐ d-c reverse polarity
   - ☐ a-c reverse polarity
   - ☐ d-c straight polarity

3. The E-6010 electrode is manipulated to reduce
   - ☐ oxidation
   - ☐ spatter & undercut
   - ☐ penetration

4. The E-6010 electrode can be used in what positions?
   - ☐ flat
   - ☐ flat-fillet
   - ☐ all

5. The major application for the E-6010 electrode is on
   - ☐ mild steel
   - ☐ malleable iron
   - ☐ high carbon steel

6. The fillet welds produced with the E-6010 electrode are
   - ☐ relatively flat
   - ☐ course uneven ripples
   - ☐ none of these
   - ☐ all of these

7. Welds produced with the E-6010 electrode which have poor fusion are caused by
   - ☐ low current & improper weld speed
   - ☐ improper manipulation
   - ☐ improper edge preparation
   - ☐ all of these

8. Undercutting is caused by
   - ☐ too much welding current
   - ☐ improper electrode manipulation
   - ☐ electrode not designed for that position
   - ☐ all of these

9. Incomplete penetration is caused by

- ☐ poor edge preparation
- ☐ wrong size electrode
- ☐ weld current too low
- ☐ weld speed too fast

10. The arc welding lens used by many weldors working with 1/8" and 5/32" E-6010 would be shades

- ☐ 5, 6, 7
- ☐ 9, 10, 11
- ☐ 12, 13, 14
- ☐ none of these

11. When running overlapping stringer beads the percentage of lap of each bead is

- ☐ 20 - 30
- ☐ 30 - 40
- ☐ 40 - 50
- ☐ 50 - 60
- ☐ none of these

12. The most important pass of a multiple pass stringer bead is

- ☐ cover pass
- ☐ lower pass
- ☐ root pass
- ☐ none of these

PART II - True or False

Instructions: Place an X in the square in front of the best answer to the right of the question.

Sample: The E-6010 electrode is used for high speed production work which is positioned.

- ☐ True
- ☐ False

1. The ultra violet rays in the electric arc are not harmful to the eyes.

- ☐ True
- ☐ False

2. Reverse polarity is electrode negative.

- ☐ True
- ☐ False

3. A poor ground connection does not effect the welding arc.

- ☐ True
- ☐ False

4. When welding with the E-6010, less amperage is usually used in the overhead and vertical positions as compared to the flat position.

- ☐ True
- ☐ False

5. Sweat shirts are suitable clothing for arc welding if a leather jacket if worn also.

- ☐ True
- ☐ False

6. If your clothing catches fire, you should run for the nearest water source.

- ☐ True
- ☐ False

7. Storage of the E-6010 electrodes is important so they are usually stored in heated rooms to keep them dry.

- ☐ True
- ☐ False

8. The amperage used for the 1/8" E-6010 electrode, horizontal position, is in the range of 75 to 110 amps.
- ☐ True
- ☐ False

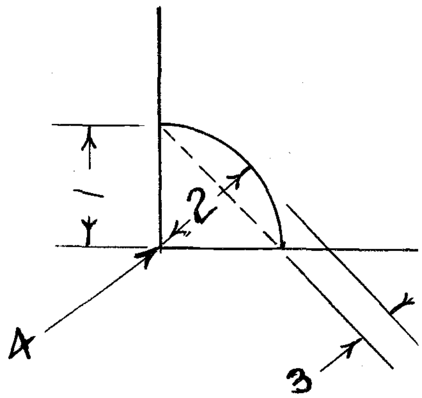
9. When welding in the vertical position with the E-6010, the weldor should use just enough current to arc smoothly.
- ☐ True
- ☐ False

10. The proper arc length for horizontal welding with the E-6010 is the diameter of the electrode.
- ☐ True
- ☐ False

PART III

Instructions: Identify the numbered parts of the fillet weld by placing the number in front of the name of that part.

Sample: In the figure below the weld size is determined by number 1.



- ☑ weld size
- ☐ root
- ☐ throat
- ☐ reinforcement

APPENDIX F

Instructor Information Sheet for Cognitive Material

November 17, 1971

FROM: R. Stemmer

TO: Welding Instructors Involved in Study

RE: Informational Units to be Covered by Final Test

The following outline of related information is being provided for your inspection and use if necessary. I would assume that all welding instructors cover the following items during the quarter. If my assumption is wrong, please be sure to provide learning experiences for your students on items not discussed previously.

At the end of the practice session (either before the students take the weld test, or afterward) each student will be asked to take the related information test. These test scores will be used in the study.

RELATED INFORMATION

A. Objective - The student will demonstrate his knowledge of E-6010 electrodes in the following categories:

1. Type of coating.
2. Type of current used.
3. Type of manipulation.
4. Positions suitable for the electrode.
5. Weld characteristics of E-6010.
6. Causes of defective welds and method of corrective action to be taken with E-6010.
7. Procedures to be followed when welding in the flat, horizontal, vertical, and overhead positions (arc length, amperage, manipulation).
8. Storage procedures for E-6010.
9. Type of Steel suitable for the E-6010 electrode.
10. Quality of the weld produced by E-6010.

B. The student will demonstrate his knowledge of safety precautions necessary to protect the weldor from burns and harmful rays of the electric arc. Specific items to be covered will include:

Memo to Welding Instructors Involved in Study
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1. Suitable clothing, leathers, and gloves.
2. Welding helmet and lens.
3. Harmful rays in the electric arc.
4. Procedure to follow if clothing catches fire.
5. What to do if injured.

C. The student will demonstrate knowledge and ability to prepare welder and lead cables for welding. Items to include:

1. Electric switching procedure.
2. Adjusting welder for proper amperage and polarity.
3. Proper ground connection.
4. Effect of poor lead connections or ground.

D. The student will demonstrate knowledge of how fillet welds are measured, and also identify the following:

1. Throat
2. Root
3. Reinforcement
4. Identify and use fillet weld gauge.

All questions will come from items listed above. If you have non-readers in your class, a verbal test will be allowed.

RS:rc

APPENDIX G

Instructor Information Sheet

INSTRUCTOR INFORMATION SHEET

Purpose of the Study

The major objective of this study is to assess the effects, in terms of time required to partially develop motor skills necessary for proficiency as a manual stick electrode arc welder, by using the whole job approach, practicing all position tasks (horizontal, vertical, and overhead) each welding laboratory session as compared to the traditional part method now used.

Student Involvement

Students should be told that they are subjects of a study, but do not tell them any details concerning the study.

Every effort should be made to encourage students to follow their assigned sequence and record their welding time each laboratory session. Be sure each student understands the instructions on the sequence sheet and follows them.

PHASE I -- 15 hours

Student Selection for Study

Only those students who have had little or no welding experience will participate in the study. This means that if the student can run satisfactory-looking beads in any position other than the flat position, he is not eligible as a study subject.

Initial Practice Period

All students eligible for the study will follow the same practice exercises for the first 15-hour period. The details of the first 15-hour time period follow:

1. Practice striking the arc and running stringer beads - 6 hours. E6010--1/8" electrodes, flat position.

2. Running 40 percent overlapping stringer beads for the next 8 hours. E6010--1/8" electrodes, flat position.

3. The student will make a test plate during the fifteenth hour, using 40 percent overlapping stringer beads, one layer, E6010--1/8" electrodes in the flat position. Student's number goes on the back of the plate.

This marks the end of Phase I.

PHASE II -- 45 hours

Pairing of Students

The test plates will be evaluated and students paired according to their scores. The pairs will be split with one being assigned to Sequence Number I and the other to Sequence Number II.

Sequence sheets will be provided for each student. Instructors will be informed of the student sequence number, but will not know which students comprise a pair or the scores of any student.

Instructor Involvement

The instructor will have to vary his instructional approach slightly to conform to the design of the study. Nothing new will be added, only the sequence will change for some of your students. For example, all Sequence Number II students will be given a demonstration of horizontal, vertical, and overhead position welding during the first welding laboratory session after the sequences have been assigned. Students assigned to Sequence Number I will be given a demonstration in horizontal position welding only. As each Sequence Number I student completes a 15-hour block of practice time, he will need another demonstration of welding in a different position.

At the end of the 45-hour period of Phase II, all students participating in the study shall take the three position fillet weld test. Details and instructions for the test will be provided to each instructor.

APPENDIX H

Student Information Sheet

STUDENT INFORMATION SHEET

Student's Name ______________________________ No. ____________ Seq. ________

Age ____________ Grade Completed ____________________

Student's Status: H.S. ____________ Reg. Day ________________ Part Day ________

Part Night ____________

Objective: ____

____

____

Pretest Score Psychomotor ______________

Posttest Score Psychomotor ______________

Test Score Cognitive ______________

PSYCHOMOTOR POST-TEST

Evaluation

	Horizontal	Vertical	Overhead
CONTOUR			
Uniformity	3 2 1	3 2 1	3 2 1
Undercut & Overlay	6 5 4 3 2 1	6 5 4 3 2 1	6 5 4 3 2 1
FUSION			
Root Penetration	6 5 4 3 2 1	6 5 4 3 2 1	6 5 4 3 2 1
Weld and Base Metal	6 5 4 3 2 1	6 5 4 3 2 1	6 5 4 3 2 1
SOUNDNESS			
"3/32" Inclusions	6 5 4 3 2 1	6 5 4 3 2 1	6 5 4 3 2 1
Sq. Inch Inclusions	6 5 4 3 2 1	6 5 4 3 2 1	6 5 4 3 2 1

1 + Total = ________