A STUDY OF THE TIME REQUIRED BY STUDENTS OF VOCATIONAL AGRICULTURE FOR PRACTICE TO DEVELOP BASIC SKILLS IN ARC WELDING

by

Adolphus James Miller

An Abstract

Submitted to

the School of Advanced Graduate Studies of

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DOCTOR OF EDUCATION

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A STUDY OF THE TIME REQUIRED BY STUDENTS OF VOCATIONAL AGRICULTURE FOR PRACTICE TO DEVELOP BASIC SKILLS IN ARC WELDING

Purpose.- To find answers to the questions, (1) How much time do students of vocational agriculture require for practice to develop these basic skills in arc welding; making a bead, making a fillet weld, making a butt weld, and making a fillet-weld lap joint? (2) Is the time that students require for practice to develop skills in arc welding associated with the age of the students? (3) Is there a difference between the time required for practice to develop the skills by those students who were without knowledge of arc welding and that required by those students who had knowledge of arc welding? (4) Is the time that students require for practice to develop skills in arc welding associated with the time used by teachers to demonstrate the skills? (5) Is there a difference between the time required for practice to develop skills in arc welding by those students who began practicing the same day the demonstration was given and that required by students who did not begin practicing the same day the demonstration was given?

Method.- The author developed an instrument for gathering data to determine the practice-time required to develop four skills in arc welding. In 1953, forty-three teachers used the instrument

with one hundred ninety-five students in the States of Illinois, Michigan, North Carolina, Ohio and Virginia. The teachers used the instrument as a guide to demonstrate the skills and the pupils used it as a guide while practicing. The practice-time in minutes required by students to develop each skill constituted the major part of the data.

Findings and interpretations.- It was found that: (1) The mean practice-times in minutes required to develop the skills were; 50.32 ± 5.49 for making a bead, 48.37 ± 5.47 for making a fillet weld, 40.48 ± 3.92 for making a butt weld, and 35.33 ± 3.79 for making a fillet-weld lap joint. (2) There were no significant differences among the means of the practice-time of the five age groups to develop any one of the skills. (3) Students who gained knowledge of arc welding through observation but without practice did not, on an average, develop the basic skills with any less practice than students who had not gained such knowledge. (4) Teachers cannot be sure of reducing the time required by students to develop skills in arc welding by giving longer demonstrations. (5) When the mean number of days between the demonstration and the day the students begin practicing is no greater than four it can be reasonably expected that students will develop skills in arc welding as quickly as those who began practicing the day the demonstration was given.

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It is recommended that: (1) Class schedules be arranged and welding facilities and supplies provided that will allow each student approximately 175 minutes for practice and permit him to begin practicing each skill within four days after it has been demonstrated. (2) Arc welding skills be taught to any age group enrolled in high-school or young farmer classes. (3) The method of collecting data be used to further determine the time required to develop skills in arc welding and other areas of farm mechanics.

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CHAPTER I

INTRODUCTION

Statement of the problem. The major problem of this study was to find an answer to the question, How much time do students of vocational agriculture require for practice to develop four basic skills in arc welding?

Subsidiary problems of the study were:

1. Is the time that students require for practice to develop the skills in arc welding associated with the age of the students?
2. Is there a difference between the time required for practice to develop the skills by those students who were without knowledge of arc welding and that required by those students who had knowledge of arc welding?
3. Is the time that the students required for practice to develop the skills in arc welding associated with the time used by the teachers to demonstrate the skills?
4. Is there a difference between the time required for practice to develop the skills in arc welding by those students who began practicing the same day the demonstration was given and that required by those who did not begin practicing the same day the demonstration was given?
5. Is the method that was used to collect data for the study reliable and valid?

Background for the study. There is need for a better estimate of the time required by students of vocational agriculture for practice to develop the basic skills in arc welding and other farm mechanics jobs. This need has been intensified by the rapid advancement in mechanized farming and the use of arc welders by farmers and prospective farmers to construct labor-saving equipment, and maintain and repair machinery on their farms. Also, some farm mechanics classes are operated in schools that have schedules organized on the sixty-minute period basis. The problem of finding sufficient time to teach manipulative skills is encountered in such schools. This is true because much of the students' time must be used to get their tools and materials ready before they can begin their jobs and they must return the tools and unused materials to their proper places before the class period ends, hence, little time is left for demonstrations and practice of new skills.

Farm mechanics instruction is available for prospective farmers and farmers of ages above fourteen years. Some authorities feel that there is probably a manipulative skill readiness stage in the development of an individual. If this is true, there is a stage at which arc welding skills can be developed more readily by students in farm mechanics. Much time can be saved if arc welding skills are taught to the students after this readiness stage has been reached. With this thought in mind the author attempted to find if the students of different age levels in this study used different amounts of practice-time to develop the arc welding skills.

In many farm mechanics classes before the students have received systematic instruction in arc welding they have had an opportunity to observe and study the welding operations and jobs that other individuals are performing. Through such media some knowledge is gained. One might form the hypothesis that individuals who have gotten knowledge from such sources would develop arc welding skills with less practice-time than those persons who have not had these or similar experiences. It was decided that one of the purposes of this study should be to provide some factual information with regards to this hypothesis.

The demonstration is considered the most effective method of teaching manipulative jobs by many authorities in farm mechanics instruction. In many departments of vocational agriculture where arc welding is taught there is only one welder, therefore, only one student can practice at a time. When arc welding demonstrations are given to a class or to a group within a class several days usually will have passed before all members have had an opportunity to practice the skill that was demonstrated. This situation has created interest in this question: Do the students who begin their practice periods immediately after the demonstration is given develop the ability to perform the skills in less time than those who do not begin practicing immediately after the demonstration? It seemed appropriate that another of the purposes of this study should be to provide some factual information to help answer this question.

The primary aim of vocational education in agriculture is, "to train present and prospective farmers for proficiency in farming."[1] Arc welding and other farm mechanics activities must be taught in a highly efficient manner if they are to develop the student's proficiency. To have teaching programs that attain the aim of vocational education in agriculture, administrators and teachers must plan schedules and provide equipment that are adequate. The teacher or administrator who wishes to plan an adequate schedule may ask, "How many and what length periods are needed for students to practice in order to develop the farm mechanics skills included in the courses for this department?" The teacher or administrator who wishes to make plans that provide adequate equipment in the school shop may ask, "How many welding units are needed in the department?" To answer these questions one must resort to personal opinion. Most educators would agree that personal opinion varies so widely that its use in this situation is acceptable only because there are no better means available for estimating the time the equipment would be used for giving instruction and for practice.

The fact that personal opinion varies widely was established by Schafer,[2] who used the opinions of nine teachers of vocational agriculture to assist him in the development of selected units to be taught in farm mechanics. These teachers were in agreement on the content of the units but there were wide variations in opinions as

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[1]Educational Objectives in Vocational Agriculture, U. S. Office of Education, Vocational Division Monograph No. 21, Revised 1955, p. 3.

[2]Wallace A Schafer, "Teaching Units in Farm Mechanics for Courses of Study in Arizona Departments of Vocational Agriculture," (unpublished Master's thesis, University of Arizona, Tucson, 1951), p. 24.

to the time needed for teaching each unit. Their estimates of the time needed to teach the unit on arc welding ranged from 3.25 hours to fifty-four hours.

A wide variation of estimates which dealt with the time needed to teach areas in farm mechanics was also exhibited in a survey made by Young.[3] This was a survey of the instruction offered in farm mechanics by forty teachers of vocational agriculture in Illinois. It showed that from one to sixty hours were used by different teachers to teach the area of cold metal work. Variations in teaching time for some other areas were almost as wide.

The rising cost of equipment needed in farm mechanics instruction has increased the concern of administrators regarding the number of students who can be expected to develop the skills needed to operate each piece of equipment during a school term. In recent years, there has been a trend toward depending less upon hunches and opinions and more upon results of research when making decisions that will affect the development and training of students. To decide on the number of arc welding units to install in a school shop a school administrator needs results of research.

There is a need for an estimate, based on research findings, of the time required by students for practice in order to develop the basic skills in arc welding. There is also a great need for a method

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[3] Orville L. Young, "What Are They Teaching in Farm Mechanics?" <u>Agricultural Education Magazine</u>, 23:208, March, 1951.

of determining the time that must be allocated to students for practice to develop the basic skills in other farm mechanics activities. It is believed that this study should make available to teachers of vocational agriculture and to administrators information that can be used to (1) increase their efficiency in planning schedules for arc welding instruction, and (2) determine more adequately the amount of equipment needed to teach arc welding effectively to farm mechanics classes. Also, the method employed in making this study may be used as a guide for individuals who may wish to find the amount of time required for practice by students to develop skills in other farm mechanic activities.

Scope of the study. The nature of the study made it necessary that the teachers who cooperated in it be limited to those who had proved that they possessed abilities to teach arc welding in a manner acceptable to authorities in vocational education. The decision to make this limitation was based on the belief that a teacher must know how to perform the arc welding jobs that he is to demonstrate to a class in farm mechanics.

Nineteen supervisors of vocational agriculture in five states and one teacher trainer sent to the writer the names and addresses of one hundred two teachers who had demonstrated to them that they were qualified to teach arc welding. The names of twelve additional teachers were received from supervisors too late to be used in this study.

Forty-three teachers participated in the study and returned forms for one hundred twenty-nine trainees during the spring of 1953.

During the fall of the following school term five of the teachers in Virginia who had participated in the study during the spring of 1953 selected sixty-six additional students of vocational agriculture, and each of them practiced until they had developed each of the four skills. Therefore, a total of one hundred ninety-five students of vocational agriculture participated in the study.

Limitations of the study. This study has certain limitations inherent in its pattern. The data were secured under circumstances that prevail in regular farm mechanics classes. An inherent purpose of the study was to secure results that could be used to advance and improve instruction in farm mechanics. Therefore, it seemed logical that farm mechanics classes would provide the best source from which data could be secured for the study.

Many departments of vocational agriculture have only one arc welder. This situation put a limitation upon the number of trainees who could practice in a department without interfering with the regular farm mechanics class schedules.

The number of skills in arc welding to be developed by students of vocational agriculture in this study was limited to four, namely; making a bead, making a fillet weld, making a butt weld, and making a fillet-weld lap joint. These skills were to be performed in the flat position.

It was not feasible for the writer to examine each of the eight specimen welds accepted from each of the one hundred ninety-five students by the teachers. The writer did, however, observe at least one demonstration by 11.6 per cent of the teachers. He also examined specimen welds prepared by the students and accepted by these teachers.

This study did not attempt to support any particular sequence as the most desirable for students to employ in the development of the four basic skills in arc welding.

The study dealt mainly with the time that the trainees devoted to practice before attaining a degree of competency that the teachers would accept in light of the criteria set up in the instrument. It was not the purpose of the study, to evaluate the quality of teaching demonstrated by those who participated.

Even though these limitations exist, the writer believes that if the findings of this study are properly interpreted and used by teachers and administrators, a contribution will have been made to vocational education and to research.

<u>Basic assumptions</u>. In order that this study might progress, the following basic assumptions were necessary. It was assumed;

1. That each of the supervisors of vocational education in agriculture and the teacher trainer who cooperated in the study was capable of choosing teachers of vocational agriculture who had demonstrated their abilities to teach arc welding.

2. That the teachers who cooperated in the study would teach the four basic jobs in arc welding in a manner that was satisfactory to authorities in vocational education in agriculture.

3. That the trainees who participated in the study were representative of the students in vocational agriculture who had not developed the basic skills in arc welding.

4. That the normative-survey procedure and the use of a data-collecting instrument were reliable methods of securing the data used in the study.

5. That the teachers followed the instructions with regard to demonstrating the jobs and reporting the time utilized by the trainees in developing abilities to perform the skills.

Definition of Terms

Farm mechanics. Those unspecialized activities of a mechanical nature that are taught in vocational agriculture and done on the farm with the kinds of tools and equipment that the farmer has accessible.

Farm mechanics activities. This term refers to a broad field of training in the vocational agriculture program and includes such areas as the following:

> Farm Shop Work. Selection, sharpening, care and correct use of shop tools and equipment; woodwork and simple carpentry; sheet metal work; elementary forge work; electric arc and oxyacetylene welding;

pipe fitting; simple plumbing repairs; rope work.

Farm Power and Machinery. Selection, management, adjustment, operation, maintenance, and repairing (excluding major repairs requiring specialized equipment and services) of farm gas engines, tractors, trucks, and the principal farm machines.

Farm Building and Conveniences. Elementary scale drawing and plan reading; farmstead layout; functional requirements of farm houses, shelters, and storages, water systems; septic tanks and sewage disposal; heating.

Soil and Water Management. Elementary leveling, land measurement and farm mapping; farm drainage; farm irrigation; terracing, contour farming, strip cropping. (Emphasis on various phases to be varied in accordance with local or regional needs.)

Rural Electrification. Utilization of electricity in the home and in productive farm enterprises; selection, installation, operation, and maintenance of electrical equipment.[4]

Arc welding. This term refers to a localized progressive melting and flowing together of adjacent edges of metal by means of heat that is produced and sustained by an electric arc between a metallic rod, called an electrode, and the base metal.

Electrode. The metallic rod which conducts current from the electrode holder through the arc to the base metal. The tip end of the electrode melts in the heat of the arc and the molten portion is carried across the arc and deposited in or on the base metal. All

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[4]Report of the Subcommittee on Agricultural Teacher-Training, Committee on Curriculums (College Division), American Society of Agricultural Engineering, in Collaboration with an Advisory Group of Agricultural Education Specialists, submitted June 22, 1944.

electrodes used in this investigation are coated. This means that the metal rod is covered with a substance which stabilizes the arc and improves the fusion of the metals.

Arc. The flow of current across a narrow gap between the electrode and the base metal producing heat and a brilliant light or sparks.

Bead. A longitudinal deposit of weld metal from an electrode.

Young-farmer class. A group of young men, usually between the ages of sixteen and twenty-five years, who are not enrolled in any other school, who are in the process of becoming established in farming, and who are receiving systematic instruction in vocational agriculture.

Job breakdown. An outline of the steps and key points organized in the sequence that they should be performed while doing a specific job, used in the same sense as job operation.

Step. A logical part of an operation when something is done or happens to make the job more nearly complete.[5]

Key point. Anything in a step that might make or break the job, avoid injury to the trainee or make the job easier to perform.[6]

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[5] Obed L. Snowden, Glen C. Cook and Clyde Walker, Practical Methods in Teaching Farm Mechanics (Danville, Illinois: The Interstate, 1952), p. 313.

[6] Loc. cit.

Job. For the purpose of this study, the term refers to a task to be performed in an orderly manner to develop skill.

Skill. This term refers to the ability to perform a mechanical activity with accuracy, ease and precision.

Practice-time. This term refers to the actual time in minutes that the trainee worked on the job before producing a specimen weld that met the criteria set up in the instrument and was satisfactory to his instructor.

Trainees without knowledge of arc welding. This term refers to trainees who have never done any arc welding and do not know how it should be done.

Trainees with knowledge of arc welding. This term refers to trainees who have seen someone do or demonstrate arc welding and trainees who have helped someone do arc welding.

Plan of Organization

In the chapters that follow a concise report of the study is presented.

In Chapter II a review of the literature which has implications for the study is presented.

Chapter III is devoted to the design and the methodology used in the study. It contains a description of the techniques used in constructing the instrument, the method used in selecting the individuals

who participated in the study, and of the procedures used in acquiring and analyzing the data.

In Chapter IV the data are presented, analyzed and interpreted. The presentation deals specifically with the time required by the students to develop the four skills in arc welding used in the investigation. The analyses and interpretations of the data are related to age, previous knowledge of arc welding, length of time devoted to the demonstrations by the teachers, and lapse of time between the demonstration and the beginning of the practice-time, as they are associated with the time required to develop the four skills.

Included in Chapter V are the summary and conclusions.

CHAPTER II

REVIEW OF RELATED LITERATURE

In surveying literature pertaining to time and practice in the development of abilities to perform arc welding jobs, the investigator found very little research that had been done in this area. Not any research on the time required by students to learn welding of any type was found. There were, however, some research findings that were of great value to the investigator in developing the instrument used in the study. Also, some literature was found that helped in formulating a method for conducting the study. Although in some of the publications from which information was secured, scientific methods of investigation were not employed, this information was so closely related to parts of the study that it is included in this chapter.

A discussion of the literature reviewed will be classified under three headings.

1. Instrument for gathering data.
2. Skills and their development.
3. Time used for learning how to weld.

Instrument for Gathering Data

One purpose of the instrument used in the study was to provide directions for the teachers and the trainees. Also, part of the instrument was a criterion for use in determining when the ability to perform the skills had been attained.

One purpose of the study was to determine the time that a selected group of trainees needed for practice to develop the abilities to perform certain basic skills in arc welding. The writer used the normative-survey method of research as described by Good, Barr and Scates[1] because it seemed to be the method best adapted to this study.

One goal of vocational education is the development of manipulative skills. Most authorities are in agreement that practice is essential if an individual is to develop skill in an activity. Crawford[2] is also in agreement with this idea. He is of the opinion that performance is one of the best learning devices. He advises first finding what constitutes good form in a task and then adopting it. It is only logical to expect a higher degree of efficiency to result from continual practice of the act. He is also of the opinion that speed should be acquired as well as accuracy, although in the beginning it is well to sacrifice speed in favor of accuracy. After that process, skill may be improved by repetition. With this thought in mind the writer proceeded with the preparation of the instrument used in the study.

The writer followed the suggestions given by Snowden, Cook and

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[1] Carter V. Good, A. S. Barr and Douglas E. Scates, Methodology of Educational Research (New York: Appleton-Century-Crofts, Incorporated, 1941), p. 286.

[2] Claude C. Crawford, The Technique of Study (New York: Houghton Mifflin Company, 1928), p. 352.

Walker who made this statement:

> In getting ready to teach skilled jobs the teacher must be sufficiently prepared to know how to perform each step correctly in demonstrating the job. He should do the following: 1. Make a job breakdown of each skill to be taught. . . .[3]

Each of the jobs used in this study is a manipulative job, therefore, teachers who had exhibited skills in arc welding had to be used in teaching them. As a guide for the teachers, the author prepared a job breakdown for each of the skills used in the study. He followed the same pattern in preparing these breakdowns that Kugler[4] used for seventeen welding operations in his book, Arc Welding Lessons. Phipps[5] also recommends the use of a job breakdown for teaching manipulative skills. The pattern followed was that of having steps for each operation in the skill listed on the left half of the page and key points for the operations listed on the right half of the page.

The number of trainees that would be permitted to work in the welding booth was another factor that had to be considered while developing the instrument. In an attempt to get the maximum use of

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[3] Obed L. Snowden, G. C. Cook, and Clyde Walker, Practical Methods in Teaching Farm Mechanics (Danville, Illinois: The Interstate Printers and Publishers, 1952), p. 161.

[4] Harold L. Kugler, Arc Welding Lessons for School and Farm Shop (Cleveland: The James F. Lincoln Arc Welding Foundation, 1950).

[5] Lloyd J. Phipps and Glen C. Cook, A Handbook on Teaching Vocational Agriculture (Danville, Illinois: The Interstate Printers and Publishers, 1952), p. 161.

the welding booth and welding facilities, some instructors permit two or more students to use them at the same time. Slater[6] suggests that only one student be permitted to work in an arc welding booth so that he will have maximum use of both time and equipment. This will also prevent them from learning undesirable habits from one another.

Jefferson and Wood had this to say about welding,

> The most important property, insofar as welding is concerned, is strength. The success of a welded joint is based on how it compares in strength with the "parent metal," that is the material that is being welded. If the joint is as strong or stronger than the parent metal, then the joint is considered a success.[7]

The above statement influenced the writer in his development of the instrument. The true test of whether a trainee has developed the skill to make a welded joint is his ability consistently to make that type of joint that would withstand certain tests. Austin tells of three such tests. He says, "There are three general types of weld tests: nondestructive, partially destructive, and destructive. . . . Destructive tests involve testing the weld to failure in order to determine its quality."[8]

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[6]S. J. Slater, "Training Aims at Basic Skills," Welding Journal, 19:637, September, 1940.

[7]Theodore Brewster Jefferson and Gorham Woods, Metals and How to Weld Them (Cleveland: The James F. Lincoln Arc Welding Foundation, 1954), p. 11.

[8]John Benjamin Austin, Electric Arc Welding (Chicago: American Technical Society, 1952), p. 239.

Regarding tests to make on welded joints, Austin states,

> Physical tests give an accurate measure of the true quality of the weld metal, and for this reason they are used more than any other tests for purposes of research, procedure control, and operator qualifications. . . . Destructive tests are very helpful to the operator, when made in conjunction with any training or test program, because they enable the operator to establish his welding procedure on the basis of the weld metal quality. When these factors have been established, the operator will have no further difficulty in adhering to a high standard of workmanship.[9]

The purpose of two tests that were used in the study are discussed by Austin. He says, "The free bend test is designed to show the ductility and general quality of a butt welded joint."[10] Regarding the other test he states, "The fillet weld break test provides a quick check on the quality of a single T-filled joint. The operator can readily judge the density of the weld and the degree of fusion to both plates."[11]

Another test for welds may be thought of as the appearance test. "A good weld looks good." Combined with good judgment in welding this can be used as a criterion in determining if a weld is good or not.

In connection with testing welds Fuller states, in part,

> The best test for welds is to watch carefully while you are welding. . . . After a weld has been completed you can learn something about it by studying the appearance. Of course this does not mean that

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[9] Austin, *op. cit.*, 245. [10] *Ibid.*, 254. [11] *Ibid.*, p. 256.

> you can tell the quality of the weld by its appearance alone. Smooth, even ripples are a good indication that you had the weld metal under control. The correct contour of the weld--a gentle slope from the center of the edge--is good evidence that the weld is sound.[12]

Some additional information regarding testing welds that related to this study was found in the Procedure Handbook of Arc Welding in the statement that follows:

> In the early days of welding there was great fear that the welded joints were not going to be strong and that they would not meet the service requirements for which they were designed. Thus elaborate tests were set up to analyze both the joint and the weld metal itself. In the past fifteen years the high physical properties of weld metal deposited in the normal way and the amazingly successful performance of welded joints and welded structures of all types has resulted in arc welding being used in most cases without testing of the weld metal and joints in any way.[13]

To produce successful welds consistently one must use electrodes that are of good quality and of the proper grade. This is another factor that had to be considered in the preparation of the instrument. Concerning the selection of welding electrodes Morford stated, "Since a large part of the metal of farm machines and equipment is low or medium carbon steel, a good class E-6013 electrode will be found adequate for all general purpose welding."[14]

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[12] R. L. Fuller, "How Good Are Your Welds?" The Welding Journal, 29:774, September, 1950.

[13] Procedure Handbook of Arc Welding Design and Practice, (Cleveland: The Lincoln Electric Company, 1950), p. 974.

[14] V. J. Morford, Farm Arc Welding (Cleveland: The James F. Lincoln Arc Welding Foundation, 1954), p. 16.

The American Welding Society has developed specifications for electrodes and filler metals to cover the welding of carbon steels and most of the other metals. The following statement comes from the standard specifications for the electrodes which the writer selected for use in the study.

> The E-6013 classification of electrode, although very similar to the E-6012, possesses some worthwhile differences. Slag removal is somewhat better and the arc can be established and maintained more readily, particularly in the case of the small diameters (1/16, 5/64, and 3/32 inch) thus permitting satisfactory operation with lower open-circuit voltage.
>
> . . . materials are incorporated in the coating which permits the establishment and maintenance of an arc with alternating current at low currents and low open circuit voltages.[15]

The class E-6013 electrode is designed for welding in all positions. Welds made with this electrode have a minimum of spatter, a minimum tendency to undercut, and the beads tend to be fine rippled when properly made. In light of these facts the writer selected this electrode to be used in the study.

A large portion of the metal used in the construction of farm machines and equipment is made of low or medium carbon steel; therefore, this kind of metal was selected to be used in the welding practice by the trainees. Austin has this to say about welding low carbon or mild steel.

> Practically all low carbon steels offer little difficulty in welding. Those steels that come

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[15]Procedure Handbook of Arc Welding Design and Practice, op. cit., p. 65.

> under low carbon or mild steel classification, are those steels which have carbon below 0.03 per cent. . . . Steels of this type are not hardened appreciably when they are heated to a high temperature and then rapidly cooled, as occurs in the arc welding processes. Furthermore the welds are not subject to cracking, and the structure (the parent metal) is not impaired by the welding heat.[16]

Skills and Their Development

It is an accepted belief among most educators that individuals learn quicker when they are interested in the matter that is to be learned. Concerning the teaching of arc welding to students in farm mechanics, Hollenberg says, "Fortunately, arousing interest in arc welding is seldom a problem. The majority of students in farm mechanics have a natural interest in this process which is a relative newcomer to the farm field."[17]

In 1951 Dougan[18] made a study to determine the farm mechanics skills needed and acquired by beginning teachers of vocational agriculture in Ohio. The welding skills needed to teach farm shop were

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[16] Austin, op. cit., p. 239.

[17] Alvin H. Hollenberg, How To Teach Arc Welding in Farm Mechanics (Cleveland: The James F. Lincoln Arc Welding Foundation, 1952), p. 43.

[18] Riley Shelton Dougan, "Farm Shop Skills and Abilities Needed and Acquired by Beginning Teachers of Vocational Agriculture in Ohio," (unpublished Master's thesis, Ohio State University, Columbus, 1951), p. 139.

ranked in order of importance for beginning teachers. The ranks that Dougan gave the skills were based upon ratings by thirty-four experienced teachers of vocational agriculture in Ohio. The possible ratings were "very important," "important," "average importance," "little importance," and "no importance." The skill of making a lap weld was rated "important" or higher by sixty-one per cent of the teachers; making a fillet weld was rated "important" or higher by eighty per cent of the teachers; and making a butt weld was rated "important" or higher by eighty-two per cent of the teachers.

The three skills named in the above paragraph are generally thought of as being basic skills for welding regardless of the position of the metal.

The factor of "readiness" should certainly be given consideration in a study of this nature. Albrecht says this about "readiness" with regards to the development and application of skills in farm mechanics:

> . . . let us not assume that all farm mechanics skills can be developed in a year or two. . . . We have all probably heard about <u>reading</u> <u>readiness</u>--the point at which the student is able to assimilate and understand what he is able to read. How about manipulative skills readiness--the point at which the student is able to understand what he should do and is physically able to do what he understands should be done. What use is there in trying to help a boy to develop skill in forge work when he is physically incapable of swinging the heavy hammer with one hand while holding the tongs with the other?[19]

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[19] Carl F. Albrecht, "Development and Application of Farm Mechanic Skills and Judgments," Agricultural Education Magazine, 25:68, September, 1952.

When skills as complicated as the welding jobs used in this study are concerned, little if any improvement is expected to occur in the absence of practice. Would older boys in vocational agriculture learn such skills more readily than younger ones? One might expect an affirmative answer for two reasons: First, it seems reasonable to suppose that the older students, having sensory, neural, and muscular systems of greater maturity, should profit more from given amounts of practice than the younger students. In the second place, the older students have usually had wider experiences upon which to draw in acquiring new skills and this might be expected to give them an advantage over the younger students.

The writings of several authors in the field of child development were reviewed to secure additional background information on this particular phase of the study.

The development and application of a manipulative skill are referred to by Huggett and Millard in the statement,

> Beginning to write, on the part of the young child, brings into play the musclature of much of his whole skeletal organization. It is not unusual to see a young child attempt his handwriting lesson with tongue in cheek or projecting out of his mouth, along with a tensing of arm and leg muscles as well. As the response becomes automatic, less muscular cooperation is demanded.[20]

In this study arc welding required coordination of movements and control of movements in a horizontal direction and vertical direction

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[20] Albert J. Huggett and Cecil V. Millard, Growth and Learning in The Elementary School (Boston: D. C. Heath and Company, 1946), p. 398.

at the same time. After the weld has been started the electrode must be moved in a horizontal direction at a relatively slow but uniform speed to melt the parent metal and deposit molten metal from the electrode along the joint. At the same time, the end of the electrode must be lowered uniformly to compensate for the metal that has been deposited and must become a part of the weld. A uniform distance between the lower end of the electrode and the parent metal must be held in order that the arc will be maintained. A hand-eye coordination is necessary to control these movements. According to Millard[21] a certain degree of maturation must have been attained before certain controlled coordination and performance should be expected of an individual. This author states that,

> Physical size and proportion are essential in the framework through which motor ability is to function. Organic capacities limit the potentiality of performance, and psychological factors provide motivation and direction.[22]

In referring to learning of sensorimotor skills as a function of age, Munn has this to say;

> . . . if the learning of such motor skills improves with age, the results of studies fail to show clear evidence of it. Although children of increasing age usually evidence an increasingly high initial level of performance, which may be accounted for on the basis of greater maturity, greater experience, or both. The gross amount and percentage of improvement

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[21] Cecil V. Millard, Child Growth and Development in The Elementary School Years (Boston: D. C. Heath and Company, 1951), p. 511.

[22] Ibid., p. 100.

resulting from given amounts of practice do not appear to change in any consistent way as a function of age.[23]

Time Used for Learning How to Weld

In only one case did the writer find any literature on research that had been done to determine the amount of time needed for individuals to develop skills in arc welding. The literature examined that gave information on welding schools indicated that one standard practice of the schools is to provide a certain number of hours or weeks of instruction for a course. After completion of the course one is supposed to be able to perform the operations set up in the aims and objectives of the course.

Burt[24] discussed a 1000-hour training program for welders that was operated at Santa Monica Technical School. Upon completion of the course the students are expected to be able to weld in the four positions--flat, vertical, horizontal, and overhead--on the five basic types of joints--butt, tee, lap, corner, and edge--on ferrous and non-ferrous metals. The students are also expected to be able to do pipe welding, repair welding and hard-facing.

Burt also tells of a specialized six-week course in which the Southern Counties Gas Company in California trains its welders. The

[23] Norman L. Munn, "Learning in Children," Manual of Child Psychology (Edited by Leonard Carmichael, New York: John Wiley and Sons, 1946), p. 389.

[24] Fred M. Burt, "Gas Company Trains Its Own Welders," Welding Engineer, 36:40, June, 1951.

author makes the following statement regarding this course:

> Before applicants are accepted for the schooling, the personnel department gives them a preliminary test to determine aptitudes for this type of work. The test is to show up adaptability rather than developed skill. The percentage of men eliminated is not large. . . . In this specialized course, little attention is paid to the study of theory. The objective is to impart a good competence in arc and oxyacetylene pipe welding.[25]

In his textbook, Chaffee[26] gives forty-one exercises that are used at the Hobart Trade School in the arc-welding courses. These exercises are designed to help in developing the abilities of the students to do certain arc welding operations. The "average practice" time is given at the beginning of each exercise. The "average practice" time ranges from one hour for the exercise, cutting with coated electrodes, to eighteen hours for the exercise, making straight beads in the vertical position. For the three exercises--starting the arc, laying long beads, and controlling the width of beads--a total of fourteen hours is listed as the "average practice" time. All of these exercises are performed on work in the flat position. The average practice time is three hours for the exercise lap joints in the flat position; two hours for the exercise butt joints in the flat position; and two hours for the exercise corner welds in the flat position.

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[25] Burt, op. cit., 36:40.

[26] Wilbur Johnson Chaffee, Practical Arc Welding (Troy, Ohio: Hobart Trade School, Incorporated, 1942), p. 516.

The most outstanding piece of literature related to this study is an article that appeared in a bi-monthly issue of a publication by the Chicago Bridge and Iron Company. The author, Horton, makes this statement:

> During the past few months many of the girls and young men from the office have been making welds for us. Not one of them had ever done so before--few had only the vaguest idea of what a weld might even be. Some forty-five minutes of practice and instruction was given, only sufficient to make it possible for them to complete their task. They all made a butt weld of a ½-inch plate, 8 inches long. These welds were radiographed,--many showing poor fusion, slag inclusions, gas pockets, and some undercutting. Up to the present we have completed tests on 52 of these welds to find that in tension 17 broke outside of the weld, 16 more showed practically the same strength as the parent metal, and of the remaining 19, only four were below 50,000 lbs. per sq. in. (the lowest being at 43,000 lbs. per sq. in.). Nick breaks and bend tests were comparatively as good.[27]

With respect to the time to be used in teaching arc welding to all-day students of vocational agriculture Hollenberg says:

> Welding skills can be mastered in a relatively short time. If time is available only to teach the basic welding skills, the shorter teaching period of Junior and Senior years should be used rather than stretching a basic course over four years.[28]

Relative to the time needed to learn welding, Phipps makes the following statement:

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[27]George T. Horton, "How Good Is a Poor Weld?" _The Water Tower_, 26:2, January 1940.

[28]Hollenberg, _op. cit._, p. 43

> Only a relatively short time is required to train a farmer to do the welding he needs to do on a farm. Complex welding jobs on a farm, of course, should be done by an expert.[29]

Summary

No literature was found that dealt with research to determine the time required by students to learn any type of welding.

The related literature reviewed for this study points toward facts in three main categories.

The first category is on the point of developing skill. Educators seem to be in agreement that for an individual to develop skill in performing a manipulative operation he must learn what to do and how to do it properly, then he must practice. When manipulative operations are broken down into simple steps, learning them is made less difficult. The job breakdown is recommended by several of the leading farm mechanics authors to attain this objective.

Tests can be used to pinpoint the need for additional instruction in a specific area and they may be used to determine how successful one has been in the acquisition of a skill. The writers who prepared literature that dealt with the testing of welds were in agreement on the fact that joints should always be strong and well fused. The manner of testing weld joints to ascertain their

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[29]Lloyd J. Phipps, et al., Farm Mechanics Text and Handbook (Danville, Illinois: The Interstate Printers and Publishers, 1954), p. 243.

strength and degree of fusion may vary since there are several reliable tests. One author believes that the best time to begin examining a weld is while it is being made. Several authors believe that during a training course, the inside of completed welded joints made by trainees should be examined. In other words, the welded joints should be given destructive tests. This will enable one to determine the faults and corrections that should be made. One can learn much about a weld from its outside appearance.

A welding electrode, E-6013, that will weld low carbon or mild steel was recommended in the literature for general use in farm mechanics because much of the farm machinery and farm equipment are fabricated from metals of this class.

Several authors provided evidence that the maturity and the degree of development of an individual should be considered when instruction is given to develop manipulative skills.

The third category is on the matter of time needed for learning how to weld. According to the literature, farmers and members of all-day classes in vocational agriculture can learn to do arc welding. The attempts to learn how well one can weld after having a little instruction and practice provided evidence that the ability to do arc welding can be developed within a reasonable length of time.

CHAPTER III

METHOD OF INVESTIGATION

The particular type of normative-survey procedure employed in the study consisted of using a data-collecting instrument, analyzing the data, making interpretations of the data, summarization of the data, and drawing conclusions. An explanation is given in this chapter of how the instrument was prepared and used in collecting data for the study. Explanations of the methods used in analyzing the data are also given.

Preliminary Activities

One of the first steps in the investigation was to develop criteria which were used as a guide in selecting preliminary farm mechanics jobs for the study. After the criteria were developed, twelve jobs in the area of farm mechanics were selected for preliminary evaluation. After evaluating the jobs, the chairman and members of the author's guidance committee approved the use of four jobs in arc welding.

The author made an exhaustive search for literature dealing with the time required to develop farm mechanics skills before attempting to construct the instrument. The kinds of literature reviewed included unpublished theses, periodicals, bulletins, textbooks, pamphlets and leaflets. Letters were written to several manufacturing companies that have carried on time and motion studies

in connection with the production of their commodities. It was found that a few studies had been made of certain phases of vocational agriculture in which the time used to develop skills in farm mechanics activities were expressed as opinions of teachers. Actually, very little information was found that applied specifically to the development of any type of mechanical skills. Some results of research on learning that have implications for this study are reported in the review of literature. The author did not find any methods that had been tested that would be used as a guide for making the study. In view of this it seems highly probable that the procedure developed and used in this study might well provide a method by which the time required to develop other skills in farm mechanics might be studied. It was apparent that a data-collecting instrument had to be prepared and used to solve the problem of this study, therefore, the next step was that of preparing the instrument.

Preparation of the Instrument

The instrument[1] developed is largely a teaching device which consists of the following parts: (1) instructions to the teacher on the use of the instrument, (2) a job breakdown for use in demonstrating each of the four skills in arc welding, (3) a sheet for use in classifying the trainees and recording the time devoted to practice, and (4) a sheet of instructions for the trainees to use after making

[1]See Appendix A.

a bead with the arc welder.

Instructions to the teacher. The author recognized the fact that the instructors would not have identical teaching facilities and equipment. Also it was improbable that all the instructors would teach the same job in exactly the same manner. Therefore, by providing them with a set of instructions it was thought that a more nearly uniform procedure might be followed in giving the demonstration, recording the results and reporting the results.

Job breakdown. After reviewing literature related to the four basic skills in arc welding a job breakdown was prepared for each skill. The job breakdowns follow very much the same pattern as the operation breakdowns used by Kugler[2] in his welding operation exercises. This plan was used because it is one of the most effective methods for teaching manipulative jobs. It contains the steps needed for the demonstration, and it can serve as a guide for the trainee while practicing to develop each of the skills. A job breakdown was prepared for each of the jobs and they were arranged in the instrument in the following order:

No. 1. Striking an arc and running a bead.

No. 2. Making a fillet weld.

No. 3. Making a butt weld.

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[2]Harold L. Kugler, Arc Welding Lessons for School and Farm Shop (Cleveland: The James F. Lincoln Arc Welding Foundation, 1950), pp. 129-308.

No. 4. Making a fillet-weld lap joint.

Classification of trainees and record of time. It was decided in the early stages of the study that members of vocational agriculture classes would be used as trainees. The situation in which the trainees practice to develop the skills will be the natural setting of a farm mechanics class. To secure a more nearly accurate measure of the time used by the trainees to develop each skill, it was decided that individuals would be selected who were without experience in arc welding and if the individuals had knowledge of arc welding, that knowledge was indicated by placing a mark before the second or third statement in Part I.[3] The form that was developed to be used in selecting and classifying the trainees had features somewhat similar to the device prepared by Clanin[4] for determining the farm-job experiences of students of vocational agriculture. The form that was used in this study contained three classifications. The classifications were based upon the trainees' experience and knowledge of arc welding.

The form on which the amount of practice-time was recorded constituted another part of the instrument.[5] On this form spaces

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[3]See Appendix A, Form 1, Part I.

[4]Edgar Clanin, "The Development of A Device for Determining the Farm-Job Experiences of Students of Vocational Agriculture," (unpublished Doctor's dissertation, Purdue University, West Lafayette, Indiana, 1951), 133 pp.

[5]See Appendix A, Form 1, Part II.

were provided for answers to four specific questions for each of the four skills. The first three questions were directed to the trainee. The fourth question was to be answered by the teacher. The questions were as follows:

1. Did you begin practicing immediately after the demonstration? One of the two possible answers, "yes" or "no," was to be checked in the space provided under the skill.

2. If the answer to item 1 is "no," how long was it before you did begin practicing? The answer was limited to a number of days or hours and it was to be written in the space under the skill.

3. How much time did you spend practicing before doing the job twice successfully? The answer to this question was limited to minutes and it was to be written in the space provided below each skill.

4. How much time was used to demonstrate the job? The answers were limited to minutes. Space was provided under each skill for the teacher to record the time.

An effort was put forth to make it convenient and easy for the instructors and trainees who participated in the study to record and return the data. The parts of the instrument that dealt with classification of the trainees and record of time were on one sheet and identified as Form 1. A separate Form 1 was provided each trainee who participated in the study. The teachers were given directions in the instructions for returning the forms to the investigator.

Instructions for trainees. The teachers were asked to give the instructions and directions in their usual manner of teaching while demonstrating the arc welding jobs. The author constructed Form 2, for two purposes; (1) to assist the trainees in diagnosing the troubles that might cause the more common types of poor beads and poor welds and, (2) to help the trainees decide when a good bead and a good weld had been produced. To assist in the accomplishment of these purposes directions were provided at the top of the page. Immediately below the directions a photograph, $1\frac{1}{4}$ inches by 2 inches, of each commonly made type of bead was shown on the right side of the page. To the left of each photograph there was a verbal description of four characteristics of that particular type of bead. A photograph of a good bead was located at the top of the page and below it five of the most common poor beads were located. By following the directions, the trainee compared the bead he had made with the photographs and the written characteristics on Form 2. This constituted the surface appearance test which was a part of the inspection given to each weld.

Pilot studies of the instrument. The first draft of the instrument was prepared and a member of the staff in the Agricultural Engineering Department at Michigan State University used it with a selected group of students in a farm mechanics short course. He analyzed it in a critical manner and offered suggestions for its improvement. The second draft was prepared in light of these suggestions. The second draft was duplicated and copies were mailed to four teachers of vocational agriculture in Michigan and to the farm mechanics instructor at Virginia State College. In all cases a personal letter was sent to the teachers and they were asked to try out the instrument with at least two of their students and to offer suggestions for its improvement. Three teachers cooperated in this pilot study. The suggestions given by these teachers resulted in several changes in the instrument. A critical evaluation and analysis of the instrument by the chairman and each member of the guidance committee resulted in further changes. In its final form, the instrument consisted of seven parts. A complete copy is included in the Appendices.

Collecting the Data

Inasmuch as this was a study to determine the practice-time required by students of vocational agriculture to develop basic skills in arc welding, it was decided that the data should be secured from individuals in farm-mechanics classes.

Selection of the states. The two main criteria used to select the states in which teachers and students would be asked to participate were (1) that more than ninety per cent of the farms in the state have electrical service, and (2) that the state is located in the Southern Region or the North Central Region as defined by the Division of Vocational Education, United States Office of Education.

The states selected were as follows: Illinois, Indiana, North Carolina, Ohio, Michigan and Virginia.

Selection of the teachers. A personal letter was sent to the District and/or Area Supervisors of Vocational Agriculture in each of the states selected for the study. In this letter they were asked to recommend six teachers who had demonstrated their abilities to do a good job of teaching arc welding. This was requested in order that only teachers who were competent to do the job might be selected. A self-addressed and stamped envelope was included with each letter. Each supervisor responded by recommending at least five teachers. The names and addresses of five teachers in Michigan were given to the author by a member of the teacher-training staff in Agricultural Education at Michigan State University.

Mailing the instrument. The instrument of this study was mailed on March 20, 1953, to eighty-nine teachers who had been selected. Four copies of Form 1 were included with each instrument. A letter stating the purpose of the study, giving the reason for including that teacher's name on the selected list and a request for his cooperation was also included with each instrument. A self-addressed, stamped envelope was included to help encourage the participants to return the forms.

As the "returns" came in they were tabulated and checked against the original mailing list. A follow-up letter was sent to each teacher from whom a reply had not been received by the tenth of May.

By May twenty-first, forty-three teachers had returned forms for one hundred twenty-nine trainees. Four teachers in Michigan and two teachers in Ohio sent letters to the writer stating that their classes in vocational agriculture had already completed the instruction in arc welding that had been planned for that school term.

Recording the data. The forms that were returned gave the following information for each trainee: (1) name, (2) age in years, (3) indication whether a member of an all-day class or young farmer class, (4) indication of his experience and knowledge of arc welding, (5) when he began practicing after the demonstration was given, (6) the amount of time in minutes devoted to practice before developing each skill, and (7) the amount of time in minutes the teacher used to give each demonstration.

As the "returns" came in the data were recorded on a form that the writer prepared for this purpose.

Second sample. It was felt that the value of this investigation would be enhanced by comparing the results of the performance of a second sample of trainees who used the instrument of this study with the results of the first sample. With this thought in mind the writer selected five teachers of vocational agriculture in Virginia who had participated in the initial part of the study to assist him in securing data for this phase of the investigation. Each of the teachers who were selected worked in a department that was located near enough to the writer so that he could work with the teachers and the trainees personally. The writer visited and observed each teacher give a demonstration to his portion of the sixty-six trainees who participated in the second sample. The writer observed the trainees inspect their welds and he saw at least one welded specimen that was prepared by each trainee and accepted by his teacher.

The data collected in the second sample were analyzed and treated in the same manner as those of the original sample. Appropriate statistical methods were used to compare the findings of the two samples. The methods used in making the analyses and comparisons are described in the section that follows.

Methods Used In Analyzing the Data

To help answer the questions asked in the problems of the study the following procedure was used:

1. Hypotheses based on the questions asked in the problems were formulated regarding each skill. A statement of the hypothesis is given at the beginning of each section that pertains to the skills.
2. The hypotheses were tested and accepted or rejected on the basis of the value of the probability that a value as unusual as that of the sample statistic would have been observed from the sampling distribution.
3. The results of the tests were interpreted.

It was felt that an explanation should be given of the null hypotheses as used in making certain analysis in the study. On the basis supplied by observation of a sample we are not able to say that this or that is absolutely certain or not certain about the universe from which the sample was drawn. Hagood and Price[6] point out that by statistical methods we can come nearer to proving that something is not true about a universe than that something is true. In light of this, a negativistic approach is often used in securing information about a statistic. This method is explained in an appropriate manner by Hagood and Price in the following statement regarding the null hypothesis:

> If we want to establish one hypothesis, we shall not test it directly but shall formulate the opposite hypothesis, which we shall call the null hypothesis, and test it on the basis of the evidence from our sample. If the evidence is such as to cause us to reject or discard the null hypothesis and if the hypothesis we wanted to establish is the only alternative hypothesis, then the rejection of the null hypothesis is the equivalent of the confirmation of the original hypothesis.[7]

The above statement served as a basis for the formation of the hypotheses used in the study. The three statistical methods used to secure evidence that would enable the writer to accept or reject the hypotheses set forth in the study were as follows:

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[6] Margaret Jarman Hagood and Daniel O. Price, Statistics for Sociologists (New York: Henry Holt and Company, 1952), p. 237.

[7] Ibid., p. 237-8.

1. Analysis of variance.

2. The t-test of significance of a difference between the means.

3. Coefficient of correlation.

The five per cent level of significance was employed as the point beyond which an observed deviation of the statistic from the mean would be considered great enough to be classed as "significant" in this study. The selection of the five per cent level of significance by the writer conforms with the practice recommended by Walker who stated, "Each experimenter may properly set up his own definition of significance, so long as he informs his readers as to what it is."[8]

Analysis of variance. It was suggested by Croxton and Cowden[9] that analysis of variance is an appropriate method to use when seeking statistical evidence that may be used as a basis for accepting or rejecting a hypothesis in which several groups are compared simultaneously.

The procedures which follow are for convenient calculation of of the sums of squares and degrees of freedom involved in the analysis of variance of N observations, distributed among k groups

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[8]Helen M. Walker, Elementary Statistical Methods (New York: Henry Holt and Company, 1943), p. 292.

[9]Frederick E. Croxton and Dudley J. Cowden, Applied General Statistics (New York: Prentice-Hall, Inc., 1946), p. 351.

of m_j individuals each. For the purposes of setting forth the computational procedures used in this investigation let

X_{ij} be the practice time of the ith group

k be the number of groups

m_j be the number of individuals in jth group

N be the number of observations in all k groups; i.e.,

$$N = \sum_{j=1}^{k} m_j$$

t_j be the total of the observations of the jth group

T be the total of the observations in all k groups; i.e.,

$$T = \sum_{j=1}^{k} t_i$$

The total sum of squares, x_T^2, may be calculated from

$$\sum x_T^2 = \sum_{j=1}^{k} \sum_{i=1}^{m} X_{ij}^2 - \frac{T^2}{N}$$

The groups sum of squares, x_G^2, may be calculated from

$$\sum x_G^2 = \frac{t_1^2}{m_1} + \frac{t_2^2}{m_2} = \frac{t_3^2}{m_3} + \cdots + \frac{t_k^2}{m_k} - \frac{T^2}{N}$$

The within-groups sum of squares, x_W^2, may be calculated from

$$\sum x_W^2 = \sum x_T^2 - \sum x_G^2$$

The number of degrees of freedom corresponding to the total sum of squares, $d.f._t$, may be obtained from

$$d.f._T = k-1$$

The number of degrees of freedom corresponding to the within groups sum of squares, d.f.W, may be calculated from

$$d.f._W = d.f._T - d.f._G$$

The t-test. The t-test of significance was used in the study whenever the means of two groups were compared. Hagood and Price state,

> Frequently we are interested in testing the significance of the difference between the mean of one distribution and the mean of the other. To test the significance of the difference between two means, we test the null hypothesis that the two means were observed from samples which may have been drawn from the same universe. If the probability of observing two means differing as widely as those actually observed is small enough, we reject the hypothesis and declare the difference between the two means to be significant. . .[10]

A procedure given by Snedecor[11] was used throughout the study when testing the significance of the difference between the means of two groups. This procedure of testing was used because the sizes of the various pairs of groups were not equal. When the groups are not equal in size, in order to obtain maximum accuracy the population variance of both groups must be weighed by their

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[10] Hagood and Price, *op. cit.*, p. 314.

[11] George Snedecor, *Statistical Methods* (Ames, Iowa: The Iowa College Press, Fourth edition, 1946), p. 82.

respective degrees of freedom. These factors are included in the formula given below.

$$t = \bar{x}\sqrt{\frac{n_1 n_2 (n_1 + n_2 - 2)}{(n_1 + n_2)\, S_x^2}}$$

Where: $\bar{x}$ = the difference between the group means

n_1 = the number of trainees in the group that was without knowledge of arc welding

n_2 = the number of trainees in the group that had knowledge of arc welding

S_x^2 = the pooled sum of squares of the two groups

For this part of the study the test of significance was made by using the Student's t-distribution Table[12] and comparing the value of t, as calculated by use of the formula stated above, with the value of t as found in the Table at the five per cent level of significance for one hundred twenty-seven degrees of freedom for the first sample and sixty-four degrees of freedom for the second sample.

Coefficient of Correlation. The writer assigned the letter "X" to the distribution of values for the practice-time in minutes required by the trainees to develop the ability to perform a skill. The letter "Y" was assigned to the distribution of values for the time in minutes used by the teachers to demonstrate a skill. The

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[12] Snedecor, *op. cit.*, p. 65.

next step was to calculate the summation of the X-values for the skill and calculate the summation of the Y-values for the skill; to calculate the summation of the square of each X-value and the square of each Y-value; and to calculate the summation of each XY-value.

A formula was selected to compute the correlation coefficient that utilized the original summation values of the practice-time required by the trainees and the demonstration time used by the teachers. This formula was given by Hagood and Price.[13]

$$r = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{\left[N\Sigma X^2 - (\Sigma X)^2\right]\left[N\Sigma Y^2 - (\Sigma Y)^2\right]}}$$

r = correlation coefficient

N = number of pairs of variables

X = practice-time in minutes used by trainees to develop ability to perform each skill

Y = time in minutes used by teachers to demonstrate each skill

The final step was to make the F-test of significance. This test was made by calculating the value of F from a formula and procedure as given by Hagood and Price.[14]

The formula is as follows:

$$F = \frac{r^2 (N - 2)}{1 - r^2}$$

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[13]Hagood and Price, op. cit., p. 413.

[14]*Ibid.*, p. 431.

r^2 = value of coefficient correlation squared

N = number of pairs of variables (one hundred twenty-nine in the first sample and sixty-six in the second sample).

The degrees of freedom for the F-test are one and one hundred twenty-seven for the first sample and one and sixty-four in the second sample,

n_1 = 1 degree of freedom and

n_2 = N - 2.

By referring to the Table of F,[15] which shows the five per cent points for the distribution of F, it was found that a calculated value of F with one and one hundred twenty-seven degrees of freedom must exceed 3.92 to be of significant value at the five per cent level. Therefore, unless the calculated value of F for the skill is greater than 3.92, the hypothesis pertaining to that skill may be accepted.

The formula used to calculate the fiducial limits is as follows:

Lower limit = $\bar{X}$ - 1.960 $\bar{X}$

Upper limit = $\bar{X}$ + 1.960 $\bar{X}$

When:

$\bar{X}$ = the mean

$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{N}}$ = standard error of the mean.

The data are presented and analyzed in the next chapter.

[15] Herbert Arkin and Raymond R. Colton, Tables for Statisticians (New York: Barnes and Noble, Incorporated, 1950), p. 120.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

The purpose of this chapter is to present and analyze the data used in the study. In this chapter the trainees who participated in the study have been described in terms of their ages, the size of group with which they practiced to develop the four skills and in terms of the practice-time required to develop the ability to perform each of the four basic arc welding skills. The trainees were divided into groups on the basis of (1) the age of the trainees, (2) whether or not the trainees had knowledge of arc welding before participating in the study, and (3) whether or not the trainees began practicing the day the skill was demonstrated, afterwhich the practice-time required by each of the groups to develop each of the four skills was analyzed. Also, the time used by the teachers to demonstrate the skills was correlated with the practice-time required by the trainees to develop the skills.

Distribution of Trainees

It is shown in Table I that one hundred twenty-nine trainees and forty-three teachers of vocational agriculture participated in the first sample used in the study. They were from five states, two of which are located in the Southern Region and the other three are located in the North Central Region. Sixty-six trainees and five teachers participated in the second sample all of whom were located in the State of Virginia.

TABLE I

TRAINEES AND TEACHERS WHO PARTICIPATED
IN THE STUDY BY STATES

States	Number of Trainees	Number of Teachers
First Sample		
Virginia	76	25
Ohio	28	10
North Carolina	14	4
Illinois	9	3
Michigan	2	1
Total	129	43
Second Sample		
Virginia	66	5*
Grand Total	195	48

*These teachers also participated in the first sample.

Table II shows the number of trainees that each teacher worked with in the study. In the first sample, four teachers worked with one trainee each, six teachers worked with two trainees each, twenty-two teachers worked with three trainees each, eight teachers worked with four trainees each and three teachers worked with five trainees each. The mean number of trainees per teacher was 3.0 in the first sample.

In the second sample, three teachers worked with twelve trainees each, one teacher worked with fourteen trainees and one teacher worked with sixteen trainees. The mean number of trainees per teacher was 13.2, in the second sample. No teacher demonstrated to more than six trainees at any one time.

TABLE II

TRAINEES GROUPED IN TERMS OF THE NUMBER TAUGHT BY THE SAME TEACHER

Number of trainees in each group who were taught by the same teacher (1)	Number of teachers who taught trainees in group sizes as shown in column (1) (2)	Total number of trainees taught in groups of the sizes shown in column (1) (3)
First Sample		
1	4	4
2	6	12
3	22	66
4	8	32
5	3	15
Total	43	129
Mean number of trainees per teacher 3.0		
Second Sample		
12	3	36
14	1	14
16	1	16
Total	5	66
Mean number of trainees per teacher 13.2		

Table III shows the distribution of the trainees by ages in years. The description of performances is presented for groups as a whole, the groups being differentiated on the basis of the age of the trainees. The ages of the trainees ranged from fourteen to thirty-six years.

TABLE III

AGES OF TRAINEES IN YEARS

Age in Years	First sample Frequencies	Second sample Frequencies
14	14	6
15	20	15
16	47	19
17	32	10
18 and over	16	16
Total	129	66
Grand Total	195	

For this particular description, the trainees will be referred to in terms of age groups hereafter. For example, all trainees who were fourteen years of age will be referred to as the fourteen-year-old-trainees group. In both samples, the smallest number of trainees was in the fourteen-year-old-trainees group and the largest number of trainees was in the sixteen-year-old-trainees group. Of the trainees in the first sample who were in the eighteen-year-old-and over-trainees group, twelve were in all-day classes and four were members of young farmer classes. In the second sample, thirteen of the trainees in the eighteen-year-old-and-over age group were members of young-farmer classes. There were no members of young-farmer classes less than eighteen years of age in either sample. Almost eighty-four per cent of the trainees were between fourteen and eighteen years of age. The five age groups will be further described by means of the average practice-time in minutes and measures of variability as required for the development of the ability to perform four basic arc welding skills.

It seems justifiable to explain at this point how certain analyses that will follow were made. Observation of differences between or among means naturally raises the question of whether or not the differences are so large that the samples in which they were computed are from the same normal population. Stated otherwise, whenever differences between or among means are observed the question of whether or not the differences could have arisen as the result of vagaries of sampling from the same normal population naturally comes to mind. If the probability of a difference or several differences in sampling from the same normal population is small, say five per cent or less, it is reasonable to conclude that the sample means are estimating different population parameters. The procedure for answering the question of whether or not differences are too large to be accounted for by the sampling variation of statistics is a null hypothesis to the effect that the differences among population means is zero, is stated. Then its creditability is tested by use of an appropriate test criterion. Where two groups are involved Student's t test is utilized. Where more than two groups are involved the analysis of variance technique leading to an F test is utilized. The null hypothesis is rejected if the value of F is as large as or larger than the value which will not be observed more than five per cent of the times in sampling. If it is smaller than such a value the null hypothesis is not rejected. The level of significance adopted for this study is the five per cent level. Hence, the probability of rejecting the null hypothesis when it is true will not exceed five per cent.

The analyses of the practice-time required by the trainees to develop the four skills follow.

Age of Trainees and Practice-Time

Making a bead. Shown in Table IV are values for the practice-time in minutes required by five age groups to develop skill in making a bead with the arc welder. In the first sample the seventeen-year-old trainees required the smallest mean practice-time, 48.5 minutes. For this group the standard deviation was 36.3 and the range was ten to one hundred sixty minutes. The fourteen-year-old trainees had the largest mean practice-time, 54.9 minutes. The standard deviation for this group was 32.4 and the range was eighteen to one hundred twenty minutes.

TABLE IV

PRACTICE-TIME IN MINUTES REQUIRED BY FIVE AGE GROUPS TO DEVELOP THE ABILITY TO MAKE A BEAD WITH THE ARC WELDER

Groups		Number	Mean	Range	SD
Fourteen-year-old	(1)	14	59.4	18-120	32.4
trainees	(2)	6	58.3	25-97	21.6
Fifteen-year-old	(1)	20	52.1	3-183	44.9
trainees	(2)	15	59.3	7-90	22.2
Sixteen-year-old	(1)	47	49.1	4-180	48.6
trainees	(2)	19	41.8	5-95	27.0
Seventeen-year-old	(1)	32	48.5	10-160	36.3
trainees	(2)	10	36.6	6-89	26.9
Eighteen-year-old-	(1)	16	54.3	16-180	41.4
and-over trainees	(2)	16	50.8	15-120	28.7

Note: Rows (1) contain values from the first sample and rows (2) contain values from the second sample.

In the second sample, as in the first, the seventeen-year-old trainees had the smallest mean practice-time, 36.6 minutes. For this group the standard deviation was 26.9 and the range was six to eighty-nine minutes. The fifteen-year-old trainees had the largest mean practice-time, 59.3 minutes. The standard deviation for this group was 22.2 and the range was seven to ninety minutes.

After observing the differences among the means the question arises as to whether or not the differences among the means of practice-time for the five age groups were statistically significant.

To help answer this question it is in order to test the hypothesis that the samples from which the means of each of the five age groups were calculated were from the same normal population. For this purpose the analysis of variance technique, leading to the F-test of significance, is appropriate. The null hypothesis tested was stated as follows: The differences among the means of the practice-time required to develop the ability to make a bead with the arc welder are in the population of which the sample is representative equal for the fourteen-year-old trainees, fifteen-year-old trainees, sixteen-year-old trainees, seventeen-year-old trainees, and the eighteen-year-old-and-over trainees. Since the null hypothesis tested for each of the four skills would be stated so much alike, only the first one is stated.

It is shown in Table V, which relates to the skill of making a bead, that for the first sample the ratio of the between-group variance to the within-group variance produced .213 as the value of F. Since the value of F is considerably smaller than the value of F which would be observed in five per cent of all random samples from the same normal population, the null hypothesis was not rejected.

In the second sample the ratio of the between-group variance to the within-group variance produced 1.606 as the value of F. Since the value of F is smaller than the value of F which would be observed in five per cent of all random samples from the same normal population, the null hypothesis is not rejected for the second sample.

TABLE V

ANALYSIS OF VARIANCE OF PRACTICE-TIME IN MINUTES USED BY TRAINEES IN FIVE AGE GROUPS TO DEVELOP THE ABILITY TO MAKE A BEAD WITH THE ARC WELDER

Source of Variation	Sum of Squares	Degrees of Freedom	Mean square Variance	F
First Sample				
Total	229,032.25	128		
Between-group	1,567.95	4	391.98	.213*
Within-group	227,464.30	124	1,834.39	
Second Sample				
Total	49,054.667	65		
Between-group	4,674.401	4	1,168.600	1.606**
Within-group	44,380.266	61	727.545	

*The value of F in the first sample must equal to or exceed 2.44 to be significant at the five per cent level with 4 and 124 degrees of freedom.

**The value of F in the second sample must equal to or exceed 2.52 to be significant at the five per cent level with 4 and 61 degrees of freedom.

Making a fillet weld. In Table VI the values for the practice-time in minutes required by five age groups while developing the skill of making a fillet weld with the arc welder are shown. In the first sample the sixteen-year-old trainees had the smallest mean practice-time, 44.4 minutes. For this group the standard deviation was 43.9 and the range was five to 170 minutes. The eighteen-year-old and-over trainees had the largest mean practice-time, 60.3 minutes.

For this group the standard deviation was 50.0 and the range was ten and one hundred sixty minutes.

TABLE VI

PRACTICE-TIME IN MINUTES REQUIRED BY FIVE AGE GROUPS TO DEVELOP THE SKILL MAKING A FILLET WELD WITH THE ARC WELDER

Groups		Number	Mean	Range	SD
Fourteen-year-old	(1)	14	46.1	8-140	41.0
trainees	(2)	6	47.8	45-54	3.1
Fifteen-year-old	(1)	20	53.2	4-180	50.4
trainees	(2)	15	52.8	25-75	14.9
Sixteen-year-old	(1)	47	44.4	5-170	43.9
trainees	(2)	19	42.0	15-87	18.0
Seventeen-year-old	(1)	32	46.9	9-180	45.5
trainees	(2)	10	46.2	20-90	22.0
Eighteen-year-old-and	(1)	16	60.3	10-160	50.0
over trainees	(2)	16	50.4	15-115	22.5

Note: Rows (1) contain values from the first sample and rows (2) contain values from the second sample.

In the second sample as in the first the sixteen-year-old trainees had the smallest mean practice-time, 42.0 minutes. For this group the standard deviation was 18.0 and the range was fifteen to eighty-seven minutes. The largest mean practice-time, 52.8 minutes, was in the fifteen-year-old trainees group. The standard deviation and range for this group were 14.9 and twenty-five to seventy-five minutes, respectively.

In Table VI differences are observed among the means of the age groups for the practice-time required to develop the skill of making a fillet weld with the arc welder. The null hypothesis regarding the skill, making a fillet weld, was formulated and tested.

It is shown in Table VII that when the F-test was applied in the first sample, for testing this null hypothesis, the ratio of the between group variance to the within-group variance produced .430 as the value of F. The value of F is considerably smaller than the value of F which would be observed in five per cent of all random samples from the same normal population, therefore the null hypothesis is not rejected for the first sample.

In the second sample the ratio of the between-group variance to the within-group variance produced .673 as the value of F. Since the value of F is smaller than the value of F which would be observed in five per cent of all random samples from the same normal population, the null hypothesis is not rejected for the second sample.

Making a butt weld. It is shown in Table VIII that the smallest mean practice-time, 33.4 minutes, required by a group in the first sample to develop the ability to make a butt weld with the arc welder was obtained by the fourteen-year-old trainees. For this group the standard deviation and the range for this group was 33.4 and fifteen to one hundred thirty minutes, respectively.

In the second sample, as in the first, the fourteen-year-old trainees had the smallest mean practice-time, 40.3 minutes. For

TABLE VII

ANALYSIS OF VARIANCE OF PRACTICE-TIME IN MINUTES USED BY TRAINEES IN FIVE AGE GROUPS TO DEVELOP THE ABILITY TO MAKE A FILLET WELD WITH THE ARC WELDER

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square Variance	F
First Sample				
Total	263,909.69	128		
Between-group	3,611.85	4	902.96	.430*
Within-group	260,297.84	124	2099.18	
Second Sample				
Total	26,812.666	65		
Between-group	1,133.138	4	283.284	.673**
Within-group	25,679.528	61	420.975	

*The value of F in the first sample must equal to or exceed 2.44 to be significant at the five per cent level with 4 and 124 degrees of freedom.

**The value of F in the second sample must equal or exceed 2.52 to be significant at the five per cent level with 4 and 61 degrees of freedom.

this group the standard deviation was 10.7 and the range was twenty-nine and fifty-five minutes. The largest mean practice-time, 50.7 minutes, was in the eighteen-year-old-and-over trainees group as in the first sample. The standard deviation and range for this group were 26.6 and fifteen to one hundred five minutes, respectively.

TABLE VIII

PRACTICE-TIME IN MINUTES REQUIRED BY FIVE AGE GROUPS TO DEVELOP THE SKILL MAKING A BUTT WELD WITH THE ARC WELDER

Groups		Number	Mean	Range	SD
Fourteen-year-old	(1)	14	33.4	3-70	16.8
trainees	(2)	6	40.3	29-55	10.7
Fifteen-year-old	(1)	20	40.1	3-150	34.2
trainees	(2)	15	48.1	32-95	14.9
Sixteen-year-old	(1)	47	37.5	3-170	36.7
trainees	(2)	19	42.3	25-73	14.4
Seventeen-year-old	(1)	32	35.2	10-109	25.6
trainees	(2)	10	46.6	26-68	13.4
Eighteen-year-old-	(1)	16	43.2	15-130	33.4
and-over trainees	(2)	16	50.7	15-105	26.6

Note: Rows (1) contain values from the first sample and rows (2) contain values from the second sample.

Do the differences among the means of the five age groups for the skill, making a butt weld, represent differences that should be expected in a sample of this size if, in fact, the means are from the same normal population? An answer to this question was found

by using the analysis of variance shown in Table IX to test the null hypothesis regarding the skill making a butt weld.

When the F-test was applied to the first sample the ratio of the between-group variance to the within-group variance, as shown in Table IX, produced .633 as the value of F. The value of F is considerably smaller than the value of F which would be observed in five per cent of all random samples from the same normal population therefore, the hypothesis is not rejected.

TABLE IX

ANALYSIS OF VARIANCE OF PRACTICE-TIME IN MINUTES USED BY TRAINEES IN FIVE AGE GROUPS TO DEVELOP THE ABILITY TO MAKE A BUTT WELD WITH THE ARC WELDER

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square Variance	F
First Sample				
Total	127,532.93	128		
Between-group	2,554.72	4	638.68	.633*
Within-group	124,978.21	124	1007.89	
Second Sample				
Total	21,887.931	65		
Between-group	880.449	4	220.112	.639**
Within-group	21,007.482	61	344.384	

*The value of F must equal to or exceed 2.44 to be significant at the five per cent level with 4 and 124 degrees of freedom.

**The value of F must equal or exceed 2.52 to be significant at the five per cent level with 4 and 61 degrees of freedom.

Table IX shows for the second sample the analysis of variance of the practice-time in minutes used by sixty-six trainees in five age groups to develop the ability to make a butt weld with the arc welder. It is shown in the table that the ratio of the between-group variance to the within-group variance produced .639 as the value of F. Since the calculated value of F does not equal to or exceed the value, 2.52, the value of F, which would be observed in five per cent of all random samples from the same normal population, the hypothesis as applied to the skill of making a butt weld was not rejected.

Making a fillet-weld lap joint. Shown in Table X are the means of the practice-time, in minutes, required by five age groups to develop the skill of making a fillet-weld lap joint with the arc welder. In the first sample the fourteen-year-old trainees had the smallest mean practice-time, 26.1 minutes. For this group the standard deviation was 13.6 and the range extended from six to fifty-four minutes. The seventeen-year-old trainees had the largest mean practice-time, 36.2 minutes. The standard deviation for this group was thirty-four and the range extended from five minutes to one hundred thirty-four minutes.

In the second sample the seventeen-year-old trainees had the smallest mean practice-time, 35.0 minutes. The standard deviation for this group was twenty-six and the range was five to one hundred thirty minutes, respectively. The sixteen-year-old trainees group

had the largest mean practice-time, 40.5 minutes. The standard deviation for this group was 16.3, and the range was fifteen to seventy-one minutes.

TABLE X

THE PRACTICE-TIME IN MINUTES REQUIRED BY FIVE AGE GROUPS TO DEVELOP THE SKILL MAKING A FILLET-WELD LAP JOINT

Groups		Number	Mean	Range	SD
Fourteen-year-old	(1)	14	26.1	6-54	13.6
trainees	(2)	6	36.8	17-75	19.9
Fifteen-year-old	(1)	20	31.4	4-100	23.8
trainees	(2)	15	36.9	11-90	19.5
Sixteen-year-old	(1)	47	35.6	4-125	33.0
trainees	(2)	19	40.5	15-71	16.3
Seventeen-year-old	(1)	32	36.2	5-134	34.0
trainees	(2)	10	35.0	9-95	26.0
Eighteen-year-old and-	(1)	16	35.8	5-116	30.6
over trainees	(2)	16	37.2	7-85	21.8

Note: Rows (1) contain values from the first sample and rows (2) contain values from the second sample.

The question to be answered for both samples is, "Are the differences among the means of the practice-time for the five age groups significant differences?"

In Table XI is shown the analysis of variance, leading to a test of the hypothesis regarding the skill of making a fillet-weld lap joint. It can be observed in Table XI that for the first sample, the ratio of the between-group variance to the within-group variance produced .368 as the value of F. Since the value of F is considerably less than the value of F which would be observed in five per cent of all random samples from the same normal population, the hypothesis was not rejected.

TABLE XI

ANALYSIS OF VARIANCE OF PRACTICE-TIME IN MINUTES USED BY TRAINEES IN FIVE AGE GROUPS TO DEVELOP THE ABILITY OF MAKING A FILLET-WELD LAP JOINT WITH THE ARC WELDER

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square Variance	F
First Sample				
Total	114,577.26	128		
Between-group	1,345.83	4	336.46	.368*
Within-group	113,231.43	124	913.16	
Second Sample				
Total	27,767.531	65		
Between-group	243.797	4	60.649	.111**
Within-group	27,523.734	61	451.208	

*The value of F for the first sample must exceed or equal to 2.44 to be significant at the five per cent level with 4 and 124 degrees of freedom.

**The value of F for the second sample must equal or exceed 2.52 to be significant at the five per cent level with 4 and 61 degrees of freedom.

Table XI shows, for the second sample, the analysis of variance of the practice-time in minutes used by sixty-six trainees in five groups to develop the ability to make a fillet-weld lap joint with the arc welder. It is shown in the table that the ratio of the between-group variance to the within-group variance produced .111 as the value of F. Since the value of F does not equal to or exceed the value of 2.52, the value of F which would be observed in five per cent of the random samples from the same normal population, the hypothesis as applied to the skill, making a fillet-weld lap joint was not rejected.

Discussion and interpretation. It will be observed that in the tables setting forth the analyses of variance the within-group mean squares were larger than the between-group mean squares for each skill in the first sample and for three skills in the second sample. The question naturally arises as to whether the estimates of population variance based upon means, were significantly smaller than the estimates of population variance based upon the pooled variation within-groups. A test of significance is provided by calculating F as the ratio of the within-group mean square to the between-group mean square, and entering the Table of F with the degrees of freedom reversed, that is, by determining the rejection region by the value F for which the degrees of freedom for the within-group is taken for the larger mean square. The reciprocals of F, for the first sample, were found to be 4.679, 2.325, 1.583, and 2.714 for Tables V, VII, IX, and XI, respectively. To have been significant at the five per cent level, the values of F would have been equal to or exceeded 5.66.

For the second sample the within-group mean squares were larger than the between-group mean squares in Tables VII, IX, and XI, and the reciprocals of F were found to be 1.486, 1.564 and 7.439, respectively. To be significant at the five per cent level for the degrees of freedom here available the value of F must equal to or exceed 5.70. Only the reciprocal of F for Table XI was significant at the five per cent level. The reason for the restriction from group to group is not apparent. Certainly nothing was consciously done that should produce this result. There is the possibility that the sample chosen was actually an unusual one in a probability sense. Probably, under circumstances similar to those prevailing in these observations, and with this particular skill, it is natural for individuals within groups to vary more than the means of the groups vary around the mean of all the age groups. Investigation of this hypothesis is suggested as a subject of further inquiry. The large standard deviations of the groups in both samples for most of the skills are indications that the groups were quite variable.

The investigator interpreted the results that have been presented regarding the means of the five age groups to mean that the evidence that their means are different is not convincing. Nor is there convincing evidence that there were circumstances present which tended to restrict the variation from one age group to another age group.

Trainees' Knowledge of Arc Welding and Practice-Time

The investigator wanted to know if the practice-time required by the trainees who had knowledge of arc welding before participating in the study was significantly different from that of the trainees who did not have knowledge of arc welding before participating in the study. To help answer this question the trainees were divided into two groups. One group was composed of trainees who had knowledge of arc welding before participating in the study. There were seventy-four trainees in this group in the first sample and thirty-seven trainees were in this group in the second sample. The other group was composed of trainees who were without knowledge of arc welding before participating in the study. There were fifty-five trainees in this group in the first sample and twenty-nine trainees were in this group in the second sample.

It can be seen in Tables XII and XIII that the group of trainees with a knowledge of arc welding required a smaller mean practice-time than the group of trainees that was without knowledge of arc welding for all but one skill in each sample. The group that was without knowledge of arc welding had a smaller mean practice-time than the group with knowledge of arc welding for the skill, making a fillet-weld lap joint in the first sample--shown in Table XII--and for the skill, making a fillet weld in the second sample--shown in Table XIII.

There were differences between the means of the two groups for each skill in both samples. To determine whether these differences were significant, a null hypothesis regarding each of the four skills was formulated and the standard error of the difference between the means was used to test each null hypothesis. For the degrees of freedom available, the values of t which would be exceeded not more than five per cent of the times in sampling from the same normal population, are 1.979 and 2.000 for the first and second samples, respectively.

It can be seen in Table XII that the differences between the means of the two groups ranged from 8.0 minutes for making a bead to .6 minutes for making a fillet-weld lap joint. In Table XIII, for the second sample, the differences between the means of the two groups ranged from 19.4 minutes to .1 minute for the four skills. In both samples the differences between the means of the two groups decreased in the order that the skills were performed. For the last skill that was developed, making a fillet-weld lap joint, the difference between the means of the two groups was less than one minute in both samples. The decrease in difference between the means indicates that the two groups of trainees probably became more alike as they practiced to develop each preceeding skill. Some of the decrease in the differences between the means can probably be attributed to the fact that most of the manipulations of the electrodes and electrode holder required to perform each skill had been utilized in the previous skill or skills. The mean practice-time of the groups that had knowledge of arc welding was consistently less for most skills than that of the groups that did not have knowledge of arc welding. This fact would probably lead one to think that these differences between the means of the two groups cannot be unimportant even though they are not significantly different statistically.

Making a bead. The hypothesis that was tested regarding making a bead was stated as follows: The difference between the mean practice-time required to develop the ability to make a bead by the trainees who were without knowledge of arc welding and the mean practice-time required to develop the ability to make a bead by the trainees who had knowledge of arc welding is not significantly different.

For the first sample, it is shown in Table XII that the trainees who were without knowledge of arc welding required a mean practice-time of 55.4 minutes to develop this skill. The trainees who had a knowledge of arc welding required a mean practice-time of only 47.4 minutes to develop the skill. The difference between the mean practice-time of the two groups is eight minutes and the calculated value of t is .675. Since the calculated value of t is

TABLE XII

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF THE PRACTICE-TIME USED TO DEVELOP FOUR SKILLS IN ARC WELDING BY FIFTY-FIVE TRAINEES WHO WERE WITHOUT KNOWLEDGE OF ARC WELDING AND SEVENTY-FOUR TRAINEES WHO HAD KNOWLEDGE OF ARC WELDING - FIRST SAMPLE

Skills	Trainees without knowledge of arc welding		Trainees with knowledge of arc welding		Difference between the means	t*
	Means	Sum of squares	Means	Sum of squares		
Making a bead	55.4	273,812	47.4	288,913	8.0	.675
Making a fillet weld	52.8	289,954	45.4	278,253	7.4	.619
Making a butt weld	41.5	152,716	33.6	155,729	7.9	.910
Making a fillet-weld lap joint	33.6	127,784	34.2	136,510	0.6	.081

Degrees of freedom = 127

*Value of t must equal to or exceed 1.979 to be significant at the five per cent level.

less than 1.979, the hypothesis was not rejected for this skill.

For the second sample, it is shown in Table XIII that the trainees who were without knowledge of arc welding required a mean practice-time of 61.4 minutes to develop the skill of making a bead. The trainees who had a knowledge of arc welding required a mean practice-time of only forty-two minutes to develop the skill. The difference between the mean practice-time of the two groups is 19.4 minutes and the calculated value of t is 1.334. Since the calculated value of t is less than 2.000, the hypothesis for this skill was not rejected.

Making a fillet weld. The hypothesis was tested regarding the skill of making a fillet weld. It is shown in Table XII for the first sample that the trainees who were without knowledge of arc welding required a mean practice-time of 52.8 minutes to develop the skill. The trainees who had a knowledge of arc welding required a mean practice-time of only 45.4 minutes to develop the skill. The difference between the mean practice-time of the two groups of trainees is 7.4 minutes and the calculated value of t is .619. Since the calculated value of t is less than 1.979, the hypothesis was not rejected.

It is shown in Table XIII for the second sample that the trainees who were without knowledge of arc welding required a mean practice-time of 39.6 minutes to develop the skill of making a fillet weld. A mean practice-time of 43.1 minutes were required to develop this skill by the trainees who had knowledge of arc welding. The difference between the means of the two groups of trainees is 3.5 minutes and the calculated value of t is .243. The calculated value of t is less than 2.000 therefore, the hypothesis regarding this skill was not rejected.

Making a butt weld. The hypothesis was tested regarding the skill of making a butt weld. For the first sample, it is shown in Table XII that the trainees who were without knowledge of arc welding required a mean practice-time of 41.5 minutes to develop this skill. The trainees who had a knowledge of arc welding required a mean practice-time of only 33.6 minutes to develop the skill. The difference between the mean practice-time of the two groups is 7.9 minutes and the calculated value of t is .910. Since the calculated value of t is less than 1.979, the hypothesis was not rejected for this skill.

For the second sample, it is shown in Table XIII that the trainees who were without knowledge of arc welding required a mean practice-time of forty-seven minutes to develop the skill of making a butt weld. The trainees who had a knowledge of arc welding required a mean practice-time of 44.8 minutes to develop this skill. The difference between the mean practice-time of the two groups is 2.2 minutes and the calculated value of t is .175. Since the calculated value of t is less than 2.000, the hypothesis regarding this skill was not rejected.

TABLE XIII

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF THE PRACTICE-TIME USED TO DEVELOP FOUR SKILLS IN ARC WELDING BY TWENTY-NINE TRAINEES WHO WERE WITHOUT KNOWLEDGE OF ARC WELDING AND THIRTY-SEVEN TRAINEES WHO HAD KNOWLEDGE OF ARC WELDING - SECOND SAMPLE

Skills	Trainees without knowledge of arc welding		Trainees with knowledge of arc welding		Difference between the Means	t*
	Means	Sum of squares	Means	Sum of squares		
Making a bead	61.4	126,021	42.0	94,214	19.4	1.334
Making a fillet weld	39.6	94,750	43.1	80,403	3.5	0.243
Making a butt weld	47.0	73,804	44.8	88,476	2.2	0.175
Making a fillet-weld lap joint	44.1	69,211	44.0	85,944	0.1	0.008

Degrees of freedom = 64

*Value of t must equal to or exceed 2.000 to be significant at the five per cent level.

Making a fillet-weld lap joint. The hypothesis was tested regarding the skill of making a fillet-weld lap joint. It is shown in Table XII for the first sample that the trainees who were without knowledge of arc welding required a mean practice-time of 33.6 minutes to develop the skill. The trainees who had a knowledge of arc welding required a mean practice-time of 34.2 minutes to develop the skill. The difference between the mean practice-time of the two groups of trainees is .6 minutes and the calculated value of t is .081. Since the calculated value of t is considerably less than 1.979, the hypothesis was not rejected.

It is shown in Table XIII for the second sample that the trainees who were without knowledge of arc welding required a mean practice-time of 44.1 minutes to develop the skill of making a fillet-weld lap joint. A mean practice-time of forty-four minutes was required to develop this skill by the trainees who had knowledge of arc welding. The difference between the means of the two groups of trainees is .1 minute and the calculated value of t is .008. The calculated value of t is much less than 2.000, therefore, the hypothesis regarding this skill was not rejected.

The Day the Trainees Began Practicing and the Practice-Time

In many farm mechanics classes, after a demonstration has been given, several days pass before some of the students begin practicing to develop the skill that was demonstrated. In view of this situation it seems appropriate to ask the question, "Do students who begin practicing immediately after the demonstration require less time to develop the skills in arc welding than the students who do not begin practicing immediately after the demonstration?" In an attempt to answer this question the trainees who participated in the study were divided into two groups and an analysis was made of the practice-time required to develop each of the skills by the groups. One group was composed of trainees who began practicing the day the demonstration was given. The other group was composed of trainees who did not begin practicing the day the demonstration was given.

For each skill, in each of the two samples, a mean practice-time is calculated for the group of trainees who began practicing the day a demonstration was given and a group who did not begin practice the day a demonstration was given. Whether the difference between means of two groups is so large that it is not reasonable to believe that the two sample means estimate the same population mean is one which logically arises. In order to answer this question, in each sample and for each skill, a statistical hypothesis stating that the difference between the population mean of the group beginning practice the day of the demonstration and the population mean of the group which did not begin practice the day of the demonstration is zero, was set up. If the probability of a difference arising as the result of chance in sampling from the same population is so small as five per cent or less, the hypothesis of no difference is rejected.

For each skill, numerical values involved in tests of significance of difference between the means of practice-time required by trainees beginning practice the day a demonstration was given and those trainees who did not begin practice the day a demonstration was given, are shown in Tables XIV and XV for the first and second samples, respectively. It can be seen in the tables that the t-test of significance provided a value of t that was less than one for each skill in both samples. For each skill, the difference between the mean practice-time of the two groups of trainees was larger than the standard error of the difference. This meant that the difference between the means of practice-time required by trainees beginning practice the day a demonstration was given and those trainees who did not begin practice the day a demonstration was given, was not significant at the five per cent level for any of the skills in either sample. Hence, the hypothesis of no difference between the means is not rejected for any of the skills.

Statements of some points that were revealed regarding each of the skills follow.

Making a bead. In the first sample, as shown in Table XIV, fifty-seven trainees began practicing the day the demonstration was given. This group of trainees required a mean practice-time of 49.6 minutes to develop the ability to make a bead. There were seventy-two trainees in the group who did not begin practicing the day the demonstration was given and the mean practice-time required to develop the ability to make a bead was 52.4 minutes. The number of days between the demonstration and the beginning of the practice-time for this group of trainees ranged from one to twenty-six and the mean number of days between the demonstration and beginning practice was 4.6. The difference between the means of practice-time of the two groups of trainees was 2.8 minutes.

In the second sample, shown in Table XV, thirty-two trainees began practicing the day the demonstration was given. This group of trainees required a mean practice-time of 40.6 minutes to develop the ability to make a bead. There were thirty-four trainees in the group who did not begin practicing the day the demonstration was given. This group required a mean practice-time of 50.7 minutes to develop the ability to make a bead. The number of days between the demonstration and the beginning of the practice-time ranged from one to thirteen days and the mean number of days between the demonstration and beginning practice was 2.5. The difference between the means of the practice-time for the two groups of trainees was 10.1 minutes.

Making a fillet weld. It is shown in Table XIV, for the first sample, that seventy-eight trainees began practicing the day the demonstration was given. This group required a mean practice-time of 46.8 minutes to develop the ability to make a fillet weld. There were fifty-one trainees in the group that did not begin practicing the day the demonstration was given. This group required a mean

TABLE XIV

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF THE PRACTICE-TIME REQUIRED TO DEVELOP FOUR SKILLS IN ARC WELDING BY TRAINEES WHO BEGAN PRACTICING THE DAY THE DEMONSTRATION WAS GIVEN AND TRAINEES WHO DID NOT BEGIN PRACTICING THE DAY THE DEMONSTRATION WAS GIVEN - FIRST SAMPLE

Skills	Trainees who began practicing the day the demonstration was given			Trainees who did not begin practicing the day the demonstration was given			Difference between the means in minutes	t*
	N	Means in minutes	Sum of squares	N	Means in minutes	Sum of squares		
Making a bead	57	49.6	225,899	72	52.4	343,279	2.8	.237
Making a fillet weld	78	46.8	307,089	51	51.3	261,109	4.5	.377
Making a butt weld	69	37.2	144,933	60	38.4	159,500	1.2	.139
Making a fillet-weld lap joint	70	37.7	174,427	59	30.1	89,806	7.6	.954

Degrees of freedom = 127

*Value of t must equal or exceed 1.979 to be significant at the five per cent level.

practice-time of 51.3 minutes to develop the ability to make a fillet weld. The number of days between the demonstration and the beginning of the practice-time for this group ranged from one to twenty days and the mean number of days between the demonstration and beginning practice was 4.4. The difference between the mean practice-time of the two groups was 4.5 minutes.

In the second sample, as shown in Table XV, thirty trainees began practicing the day the demonstration was given. This group of trainees required a mean practice-time of 41.8 minutes to develop the ability to make a fillet weld. There were thirty-six trainees in the group that did not begin practicing the day the demonstration was given. This group required a mean practice-time of 52.5 minutes to develop the ability to make a bead. The number of days between the demonstration and the beginning of the practice-time ranged from one to ten and the mean number of days between the demonstration and beginning practice-time was 2.7. The difference between the means of the practice-time for the two groups of trainees was 10.7 minutes.

Making a butt weld. In the first sample, which is shown in Table XIV, sixty-nine trainees began practicing the day the demonstration was given. A mean practice-time of 37.2 minutes was required by this group to develop the ability to make a butt weld. There were sixty trainees in the group that did not begin practicing the day the demonstration was given. A mean practice-time of

TABLE XV

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF THE PRACTICE-TIME USED TO DEVELOP FOUR SKILLS IN ARC WELDING BY TRAINEES WHO BEGAN PRACTICING THE DAY THE DEMONSTRATION WAS GIVEN AND TRAINEES WHO DID NOT BEGIN PRACTICING THE DAY THE DEMONSTRATION WAS GIVEN - SECOND SAMPLE

Skills	Trainees who began practicing the day the demonstration was given			Trainees who did not begin practicing the day the demonstration was given			Difference between the means in minutes	t*
	N	Means in minutes	Sum of squares	N	Means in minutes	Sum of squares		
Making a bead	32	40.6	107,629	34	50.7	110,743	10.1	.589
Making a fillet weld	30	41.8	62,846	36	52.5	113,040	10.7	.829
Making a butt weld	32	40.8	60,281	34	51.0	101,999	10.2	.825
Making a fillet-weld lap joint	34	41.1	70,184	32	47.1	84,971	6.0	.497

Degrees of freedom = 64.

*Value of t must equal or exceed 2.000 to be significant at the five per cent level.

38.4 minutes was required by this group to develop the ability to make a butt weld. The number of days between the demonstration and the beginning of the practice-time for this group ranged from one to fifteen and the mean number of days between the demonstration and beginning practice was 4.4. The difference between the means of the practice-time for the two groups of trainees was 1.2 minutes.

In the second sample, which is shown in Table XV, thirty-two trainees began practicing the day the demonstration was given. A mean practice-time of 40.8 minutes was required by this group to develop the ability to make a butt weld. There were thirty-four trainees in the group that did not begin practicing the day the demonstration was given. A mean practice-time of fifty-one minutes was required by this group to develop the ability to make a butt weld. The number of days between the demonstration and the beginning of the practice-time for this group ranged from one to seven and the mean number of days between the demonstration and beginning practice of days was 2.2. The difference between the means of the practice-time for the two groups of trainees was 10.2 minutes.

Making a fillet-weld lap joint. In the first sample, as shown in Table XIV, seventy trainees began practicing the day the demonstration was given. This group of trainees required a mean practice-time of 37.7 minutes to develop the ability to make a fillet-weld lap joint. There were fifty-nine trainees in the group

that did not begin practicing the day the demonstration was given and a mean practice-time of 30.1 minutes was required to develop the ability to make a fillet-weld lap joint. The number of days between the demonstration and the beginning of the practice-time for this group of trainees ranged from one to fourteen and the mean number of days between the demonstration and beginning practice was four. The difference between the means of the two groups of trainees was 7.6 minutes.

In the second sample, as shown in Table XV, thirty-four trainees began practicing the day the demonstration was given. This group required a mean practice-time of 41.1 minutes to develop the ability to make a fillet-weld lap joint. There were thirty-two trainees in the group that did not begin practicing the day the demonstration was given. This group required a mean practice-time of 47.1 minutes to develop the ability to make a fillet-weld lap joint. The number of days between the demonstration and the beginning of the practice-time for the group ranged from one to six days and the mean number of days between the demonstration and beginning of practice days was 2.6. The difference between the means of the practice-time for the two groups was six minutes.

Discussion and interpretation. The investigator interpreted the results to mean that in this study the differences between the means of the practice-time of the trainees who began practicing the day the demonstration was given and that of the trainees who did not begin practicing the day the demonstration was given were not large enough to be a disturbing factor in teaching the arc welding skills. There was one other observation that seemed very important. In the first sample the trainees who began practicing the day the demonstration was given required a mean practice-time that was less than that required by the trainees who did not begin practicing the day the demonstration was given for each skill except the fourth, making a fillet-weld lap joint. In the second sample, the trainees who began practicing the day the demonstration was given had a mean practice-time that was less than that required by the trainees who did not begin practicing the day the demonstration was given for each of the skills. In view of this observation the writer suggests that further investigation be made to determine the true differences between the practice-time required of students who begin practicing immediately after the demonstration and that of students who do not begin practicing immediately after the demonstration to develop skills in arc welding. This suggestion is made because there seems to be a possibility that those students beginning to practice in less than three or four days might differ, with respect to the time required to develop the skills from those who did not begin practice until after three or four days. The design of this study did not provide for the investigation of this possibility.

Relationship of the Practice-Time Required by Trainees to Develop Skills and the Time Used by Teachers to Demonstrate the Skills

Since the teachers of vocational agriculture who have classes that meet for sixty minutes will not have as much time to give instruction in farm mechanics as the teachers who have classes that meet for ninety minutes or longer, it will be necessary for the teachers with the shorter periods to use less time in giving their demonstrations than the teachers who have longer periods. This prompted the investigator to seek answers to these questions as they relate to each of the skills used in the study. (1) Does a relationship exist between the length of time used by the teachers to demonstrate a skill and the time required by the trainees to develop that skill? (2) If a relationship does exist, what is its direction and to what degree does it exist? To help find answers to these questions the Pearson product-moment coefficient of correlation was calculated for each skill.

Table XVI shows the correlation coefficients and the values of F calculated for testing the hypothesis that the population values estimated by the sample r's are not zero for each of the four skills in the first and in the second samples. The sample values of the coefficients of correlation were positive, and in general they were small. The fact is, the largest, .409, indicates that slightly less than seventeen per cent of the variation in practice-time required by trainees to develop the skill is associated with variation in time used by the teachers to demonstrate

the skill. Within the limits of the observations available here, it is clear that in no case was the association between the practice-time and the demonstration-time sufficiently close to make very satisfactory predictions of values of one variate from values of the other. If the length of time spent demonstrating a skill is considered the independent variate, it is obvious that larger coefficient of correlation would have been obtained if the range of values had been wider. In this connection, however, the question of whether the ranges of values of the independent variable are typical of the ranges of the population is a pertinent one. If the ranges in the sample were much more restricted than the population ranges the question of whether the sample estimates of the parameters would have been sufficiently large to influence the results of the test of significance is of consequence. In any case, regardless of whether the coefficients of correlation were lowered because of restrictions of the variance of the dependent variable, the inference that the ratio of the variation in practice-time associated with variation in demonstration-time to the total variation in practice-time is probably not usefully large, seems to be a safe one.

Inspection of Table XIV shows that the correlation coefficients for the skills, making a fillet weld, making a butt weld, and making a fillet-weld lap joint were significantly different from zero in the first sample. In the second sample the correlation coefficients for making a bead, and making a fillet-weld lap joint were significantly

TABLE XVI

COEFFICIENTS OF CORRELATION BETWEEN THE PRACTICE-TIME IN MINUTES USED BY THE TRAINEES TO DEVELOP THE ABILITY TO PERFORM FOUR SKILLS IN ARC WELDING AND THE TIME USED BY THE TEACHERS TO DEMONSTRATE THE SKILLS AND THE TEST OF SIGNIFICANCE OF r

Skills	First Sample (129 Trainees)		Second Sample (66 Trainees)	
	r	F*	r	F**
Making a bead	.066	.555	.306	6.613
Making a fillet weld	.383	21.832	.049	.153
Making a butt weld	.314	13.891	.166	1.831
Making a fillet-weld lap joint	.319	14.387	.409	12.830

*Value of F in the first sample must equal to or exceed 3.92 to be significant.

**Value of F in the second sample must equal to or exceed 3.99 to be significant.

different from zero at the five per cent level. Although these coefficients of correlation were significant it is clear that in general the association between the demonstration time and the practice-time required to develop a skill is not very close for any of the skills in either of the two samples. If this fact is viewed along with the fact that the estimates of correlation were generally low one might be inclined to say that, in spite of the fact that the tests of significance showed some correlations to be greater than zero, in the population the association between the demonstration-time and the practice-time required to develop a skill is negligible if the lower limits of the demonstration-time are as high as those observed in this investigation. Certainly the results of the observations here, together with the possibility of several conditions influencing the estimate of correlation, suggests further study before inferences considered as conclusive may be drawn about the association of the demonstration-time and the practice-time required to develop a skill.

Practice-Time of the First Sample Compared with that of the Second Sample

Table XVII contains data involved in tests of significance of the differences between the means of the practice-time required to develop each of the four skills in arc welding by trainees in the first sample and that of the second sample. There were one hundred twenty-nine trainees in the first sample and sixty-six trainees in the second sample. The individuals who participated in the second sample did so under close supervision of the investigator.

It can be observed in the table that a difference between the means of the two samples seemed to exist for each of the four skills. The means of the first two skills, making a bead and making a fillet weld, were smaller in the second sample than they were in the first sample. The means of the last two skills, making a butt weld and making a fillet-weld lap joint, were smaller in the first sample than they were in the second sample. The smallest difference

TABLE XVII

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF THE PRACTICE-TIME USED TO DEVELOP FOUR SKILLS IN ARC WELDING BY TRAINEES IN THE FIRST SAMPLE AND TRAINEES IN THE SECOND SAMPLE

Skills	Trainees in the first sample ($N_1 = 129$)		Trainees in the second sample ($N_2 = 66$)		Difference between the means	t*
	Means	Sum of Squares	Means	Sum of Squares		
Making a bead	51.1	566,809	50.2	218,372	0.9	0.032
Making a fillet weld	48.7	576,099	47.5	175,922	1.2	0.039
Making a butt weld	37.4	308,449	46.1	162,280	8.7	1.159
Making a fillet-weld lap joint	34.1	264,723	44.0	154,555	9.9	1.407

Degrees of freedom = 193.

*Value of t must equal to or exceed 1.972 to be significant at the five per cent level.

observed between the means of the practice-time required to develop each of the skills was .9 minutes. This difference was observed for the skill making a bead. The largest difference between the means of the practice-time observed was 9.8 minutes. This difference was for the skill making a fillet-weld lap joint. However, none of the differences recorded in Table XVII were significant at the five per cent level.

In view of the fact that there were no significant differences between the means of any skill for the two samples, it is suggestive that the samples might well have come from the same population therefore they may be combined.

Practice-Time Required to Develop Four Skills

In view of the fact that there were no significant differences between the practice-time means of the groups within the two samples and there were no significant differences between the means of the two samples it is appropriate to combine the data of the samples and calculate a mean for each of the four skills.

The fiducial limits shown in Table XVIII defined a random interval which may be said to enclose the population mean unless the sample is more unusual than five out of every one hundred samples from a normal population. It may be said that the best average estimate of the mean practice-time required to develop the ability to make a bead with the arc welder is 50.32 minutes and

TABLE XVIII

MEAN PRACTICE-TIME IN MINUTES REQUIRED BY 195 TRAINEES TO DEVELOP FOUR SKILLS IN ARC WELDING

Skills	Mean	SD	$SD_{\bar{X}}$	Fiducial Limits Lower	Fiducial Limits Upper
Making a bead	50.32	39.08	2.700	44.84	55.81
Making a fillet weld	48.37	38.97	2.792	42.90	53.84
Making a butt weld	40.38	27.95	2.002	36.46	44.30
Making a fillet-weld lap joint	35.33	26.99	1.933	31.54	39.12

that it is not less than 44.84 minutes nor greater than 55.81 minutes. In general the fiducial limits were relatively narrow, the smallest being 31.54 minutes and 39.12 minutes for the skill making a fillet-weld lap joint, and the largest being 44.84 minutes and 55.81 minutes for the skill making a bead. The two intermediate values, 42.90 minutes and 53.84 minutes, and 36.46 minutes and 44.30 minutes were for the skills making a fillet weld and making a butt weld, respectively. It will be observed that there was tendency for the fiducial limits to be smaller for the smaller means.

It will be recalled that the skills are listed in the tables in the order in which they were performed. Inspection of Table XVIII shows that the mean practice-time decreased as a new skill was

introduced. In this connection, attention is called to the fact that the manner in which the electrode should be manipulated is similar in each of the four skills, therefore, with continued practice one should expect a reduction in the time required to develop each of the succeeding skills. The pattern that prevailed in the study is in accord with the statement made by Barnes[1] regarding the effects of practice. He said, "If a person can perform a manual task at all, he can reduce the time per cycle for performing it with practice."

Reliability and Validity of the Method

One of the problems of the study was to find an answer to the question, Is the method that was used to collect data for the study reliable and valid? The instrument[2] used to collect data was developed by the author and it was used for the first time in this study. Two of the most important considerations in the construction of an instrument of this nature are that it shall have reliability and validity. Evidences found in the study will be used to answer the question, Does the instrument have reliability and validity?

Reliability. The instrument is reliable if it gives the same

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[1] Ralph M. Barnes, Motion and Time Study (New York: John Wiley and Sons, Incorporated, 1950), p. 496.

[2] See Appendix A.

results consistently.

The data of the study do not make it possible to state an estimate of the coefficient of reliability of the instrument. However, it is shown in Table XVII that there is a lack of significant differences between the sample results obtained by teachers who did have and teachers who did not have experience and supervision in the administration of the instrument used in the study. These two groups of teachers used the same instrument but they worked separately, at different times, and with different trainees, yet the results obtained by the two groups were very much alike. Therefore, the claim that the instrument is reliable to a satisfactory degree is not without some justification.

Validity. An instrument is valid if it measures what it is supposed to measure. In this study the instrument was supposed to measure the time required to develop four basic skills in arc welding.

Regarding the validity of tests Nelson and Denny say,

> Validity of tests is frequently discussed under two sub-divisions; namely, curricular validity and statistical validity. If there is agreement between the material found in the test and the material which the pupils were assigned or expected to master, the test has curricular validity. The fact is usually noted by inspection of the materials rather than by statistical procedures, . . .[3]

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[3]M. J. Nelson and E. C. Denny, A Practical Guide and Workbook in Statistics for Teachers (New York: The Dryden Press, Incorporated, 1950), p. 137.

Evidence of curricular validity of the instrument used in the study is inferred in the fact that the steps which constitute a part of the material in the instrument are in complete agreement with and identical to the material which the trainees were expected to master. The basic steps involved in manipulating the electrode in arc welding are repeated in each of the skills used in the study. These basic steps are parts of the job such as, adjusting the amperage setting, striking the arc, establishing the bead, etc.[4] Also, it is logical to expect that as more skills are developed which utilize the same basic steps in the same position there should be a decrease in the time required for practice to develop each of the successive skills. It is shown in Tables XVII and XVIII that there is a decrease in the time required to develop each successive skill. Since there is agreement between the material in the instrument and the material which the trainees were expected to master, and since the results obtained from using the instrument took the form that would logically be expected, this is suggestive that it is not unreasonable to infer that the instrument is valid.

Summary

Forty-three teachers of vocational agriculture and one hundred ninety-five trainees participated in the study. Two samples were

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[4]See Appendix A, Jobs number 1, 2, 3, and 4.

taken. In the first sample there were one hundred twenty-nine trainees. In the second sample there were sixty-six trainees. The individuals in the second sample performed under close supervision of the investigator. The mean practice-time of the trainees was compared for each skill in both samples.

No significant differences between the means of the age groups were found within either sample for any of the four skills, nor were there significant differences between the means of the two samples for any of the skills.

The relationship between the practice-time required by the trainees to develop the skills and the time the teachers used to demonstrate the skills revealed positive but low coefficients of correlation for each skill in both samples.

Estimates of the mean practice-time required to develop each of the four skills; making a bead, making a fillet weld, making a butt weld, and making a fillet-weld lap joint, were observed to be 50.32 minutes, 48.37 minutes, 40.38 minutes, and 35.33 minutes, respectively.

The reliability of the instrument is reflected in the close similiarity of the results obtained in the two samples. Evidence of validity is suggested in the agreement of the material in the instrument with the material that the trainees were expected to master and in the logical results obtained from the use of the instrument.

CHAPTER V

SUMMARY AND CONCLUSIONS

The major problem of the study was to find an answer to the question, How much time do students of vocational agriculture require for practice to develop each of these basic skills in arc welding, (1) making a bead, (2) making a fillet weld, (3) making a butt weld, and (4) making a fillet-weld lap joint? Subsidiary problems of the study were to find answers to the following questions:

1. Is the time that students require for practice to develop the basic skills in arc welding associated with the age of the students?
2. Is there a difference between the time required for practice to develop the basic skills in arc welding by those students who were without knowledge of arc welding and that required by those students who had knowledge of arc welding?
3. Is the time that the students required for practice to develop the skills in arc welding associated with the time used by the teachers to demonstrate the skills?
4. Is there a difference between the time required for practice to develop the basic skills in arc welding by those students who began practicing the same day the demonstration was given and that required by those who

did not begin practicing the same day the demonstration was given?

5. Is the method that was used to collect data for the study reliable and valid?

The purposes of this chapter are (1) to summarize the findings of the study concerning the practice-time required by one hundred ninety-five trainees to develop the ability to perform four basic skills in arc welding, and (2) to set forth the conclusion made in light of the interpretations given to the findings. The trainees in the study were students enrolled in vocational agriculture classes in five states.

Summary. What appeared to be important findings are summarized as follows:

1. The mean practice-time required by the trainees to develop each of the four skills in arc welding were:
   a. For making a bead, 50.32 ± 5.49 minutes.
   b. For making a fillet weld, 48.37 ± 5.47 minutes.
   c. For making a butt weld, 40.48 ± 3.92 minutes.
   d. For making a fillet-weld lap joint, 35.33 ± 3.79 minutes.
2. The variations among trainees in the practice-time required to develop the ability to perform each of the four skills in arc welding were large. The individuals within the age

groups varied more than the means of the groups varied around the mean of all the age groups for the time required to develop most of the basic skills used in the study.

3. The ages of the trainees ranged from fourteen years to forty-one years. The study showed that there were no significant differences among the means of the practice-time required by the trainees of five age groups to develop any one of the four skills.

4. The mean practice-time required to develop each of the four skills by the trainees with a knowledge of arc welding generally was less than that of the trainees who did not have knowledge of arc welding, however, there was no significant difference between the means of the two groups for any one of the four skills.

5. There was a low positive association between the practice-time required by the trainees to develop each of the four skills and the time utilized by the teachers of vocational agriculture to demonstrate each skill.

6. The mean practice-time required to develop each of the four skills by the trainees who began practicing the day the demonstration was given on an average was less than that of the trainees who did not begin practicing

the day the demonstration was given, however the difference between the means of the two groups was not significant for any one of the four skills.

7. The teachers of vocational agriculture and the trainees in the second sample participated under closer supervision of the investigator than those who participated in the first sample. There was, however, no significant difference between the means of the two samples for the practice-time required to develop any one of the four skills.
8. There are evidences in the study that the method used to collect data has reliability and validity.

Conclusions. In light of the findings in the study it seems justifiable to conclude that:

1. For populations of students in farm mechanics of which this sample is representative, approximately one hundred seventy-five minutes should, on an average, be sufficient for developing the four basic skills in arc welding. Two implications that can be drawn from this statement are as follows:
   a. Teachers of farm mechanics planning their schedules so that approximately one hundred seventy-five minutes are provided per pupil for practice-time to develop the abilities to, (1) make a bead, (2) make a

fillet weld, (3) make a butt weld, and (4) make a fillet-weld lap joint, will on an average, have allowed sufficient time for the development of these skills.

b. School administrators who provide welding machines and supplies, so that each pupil can, (1) use them for approximately one hundred seventy-five minutes for practice to develop the four basic skills in arc welding, and (2) begin practicing on each skill within four days after it has been demonstrated, have provided sufficient facilities for arc welding in the farm mechanics classes.

2. On the basis of the evidence available one cannot be disposed to teach the basic skills in arc welding to students of one particular age group in preference to any other age group for the sake of economy of time. In accordance with the inference that can be reasonably drawn from the study it would follow that instruction aimed at developing the basic skills in arc welding may be profitably planned for any group enrolled in all-day or young farmer classes in vocational agriculture.

3. In populations in which the samples of students under study are representative, those students who gain knowledge of arc welding by observation only or by

helping someone weld but without practice will not, on an average, develop the basic skills in arc welding with any less practice than those students who have not gained such knowledge. It logically follows, therefore, that the practice of having students watch others weld seems to have very little value as far as helping them develop the welding skills faster if they have not been given instruction on what to observe during the process.

4. Teachers cannot be sure of reducing the practice-time required by pupils to develop the basic skills in arc welding by giving longer demonstrations. The results of this investigation did not provide convincing evidence that there was any worthwhile association between the practice-time required by the students to develop each of the skills and the time utilized by the teachers to demonstrate each skill. It appears that the portion of the variation in the amounts of time teachers spent in demonstrating each of the skills which is associated with the variation in the amounts of time required by the students to develop the skills is, in a probability sense, too small for practical purposes of prediction.

5. On the basis of the evidence obtained in the study, for populations in which the samples of students under study

are representative, when the mean number of days between the demonstration and the day the students begin practicing is no greater than four it can be reasonably expected that the students will develop the ability to perform each of the basic skills in arc welding on an average as quickly as those students who began practicing on the day the demonstration was given. One implication drawn from this statement is that it would probably be most expedient if the students begin practicing for the development of a skill in arc welding within four days after the skill has been demonstrated. Another implication of the findings of the study is that further investigation should be made to determine the true differences between the practice-time of students who begin practicing immediately after the demonstration and that of those students who do not begin practicing immediately after the demonstration to develop skills in arc welding.

6. Further inquiry should be made to determine if it is natural for individuals within the age groups, as defined in this study, to vary more than the means of the groups vary around the mean of all the age groups for the time required to develop the basic skills in arc welding.

7. Further study should be made to determine the relationship of grade level of students to the practice-time required to develop the basic skills in arc welding.
8. It is recommended that the method used to collect data for this investigation be used to make further inquiry into the time required to develop arc welding skills and skills in other areas of farm mechanics.

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INSTRUCTIONS TO THE TEACHER

Certain uniform procedures for teaching these skills are believed to be necessary, therefore, the teacher is requested to follow the procedure given below in his natural teaching manner.

A. Selection of trainees. Give a copy of Form 1 to persons in the class whom you think have not done any welding and ask them to fill out Part I and return it to you. Select as trainees those who marked "x" in front of items 1, 2, or 3 and agreed to keep a record of the time they will practice.

B. Dress for the demonstration. Wear gloves and dress so that you will protect your body and clothing while giving the demonstration.

C. Preparation before the trainees are assembled. Lay out near the welding machine and table all the tools, materials and equipment that will be needed for the demonstration. Have practice material and a copy of the Job Breakdown ready to give to the trainees after the job has been demonstrated. Some practice alone prior to giving the demonstration may be helpful also.

D. Assembling trainees for demonstration. Have the trainees assemble in a semi-circle about the welding table. Do not disturb other members of the class who may be working in other areas.

E. Recording the time. Note time of beginning and ending of demonstration. Record the amount of time used in the blank space to the right of item 4, Part II on Form 1. Instruct the trainees to keep a record of the time, in minutes, they spend practicing and record it in the space to the right of item 3, Part II on Form 1. Have the trainees fill in the spaces opposite items 1 and 2, Part II on Form 1 and return it to you. (Do not include time spent by trainees in reading, securing information and preparing the metal for welding or inspecting the weld.)

F. Checking and returning the forms. Examine both parts of each form for completeness and accuracy and return them in the stamped envelope.

G. Procedure for demonstrating the jobs. (Use the same basic procedure for demonstrating each job.) After the trainees are assembled, get them interested in learning how to do the job.

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*After a reasonable length of time (to be determined by the teacher), if the trainee has not produced a specimen weld that meets the criteria set up, have one of the other trainees begin practicing.

(This part is extremely important since much of the effectiveness of the lesson depends upon the extent to which this is realized.) The following steps are suggestive of a procedure that may be used to accomplish this for the first job; Striking an arc and running a bead.

1. Use regular teaching manner to make trainees feel at ease.

2. Impress upon the trainees that they are to work for the perfection of good welds rather than for speed. Quality of the work that they produce is of prime importance, however, they should try to learn how to make the bead as quickly as possible for their own benefit.

3. The problem method or any other method that the teacher has used successfully to arouse interest might well be used to introduce the lesson. Some suggested questions are as follows:

   a. In what ways do you know of welders having been used to repair or construct farm equipment? (If no answers are given, the teacher should bring out the point that rejoining broken metal parts, strengthening worn parts by building them up, joining metal parts quickly, etc., are some of the ways that they may be used.) Examples should be given.

   b. If you know how to use this welder what are some of the jobs that you would like to do with it? (Let two or three of them tell about the things they would like to make or repair. The teacher might cite examples of things that others have done to bring out the point that knowing how to weld is an asset to the farmer and that to learn how to weld skillfully is not too difficult.)

   c. How do you think that you can best learn to use this welder successfully and properly? (In securing the answers be sure the point is brought out that good arc welding is the result of several basic operations, some of which are:

      (1) Using the right kind of electrode
      (2) Proper cleaning and preparation of the metal
      (3) Setting the machine properly
      (4) Striking and maintaining the right arc length
      (5) Running the bead at the correct speed

Also bring out the fact that after one learns what to do, one must also learn how to do it best. The best way for one to learn how to weld is to practice welding properly. Show specimen of good welds, point out their characteristics and explain how they were produced.

4. Giving the first demonstration*

   a. Give each trainee a face shield or helmet to observe the demonstration.

   b. Explain to the trainees that you are going to give them a demonstration on how to strike an arc and run a bead, they are to observe each step and ask questions about anything they do not understand.

   c. Tell what is being done as each step is performed. Use key points and explanations to bring out how and why the step is performed in that manner.

Explanations

Usually, thick metal and large electrodes require high amperages while thin metal and small electrodes require low amperages. An amperage setting of 125 is a good one to use on a trial bead for 5/53" electrode and 3/16" mild steel. If too high, it should be decreased. If too low, it should be increased.

Good surface contact of the metal conductors is essential if an adequate and even flow of electricity is to pass between the electrode and the practice plate to produce a good arc. Clamping the plate to table top increases surface contact.

When the bare end of the electrode is placed between the jaws of the holder, metal contact is made that will allow electricity to pass through the electrode freely. This is essential to produce and maintain a good arc.

Turn the welding machine on when you are ready to weld and turn it off when you have stopped. This is for the protection of the people about the welder and the welding equipment.

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*Follow the same basic pattern in giving each of the four demonstrations.

By holding the electrode almost vertically above the plate, it is easier to strike the exact point desired after the helmet is pulled over the face. With the helmet or shield in position over the face the welder cannot see until the arc lights up the work.

Be sure that everyone who is observing has a shield over his face before striking the arc.

Holding a long arc momentarily after it is first started gives it time to heat up the metal and reduce freezing.

By holding the electrode at an angle of about 20 degrees in the direction that the electrode is being moved, one can see the arc, the pool of molten metal and the width of the bead being formed. In this manner one can see when the bead is about the same width as the coated electrode. This helps in judging the correct speed. One can see how fast the electrode is melting and therefore more accurately judge how fast to feed it down to the plate.

APPENDIX A

THE INSTRUMENT USED TO COLLECT DATA

Form 1

PART I. CLASSIFICATION OF TRAINEE

Name______________________________________ Age________ (Years)

All Day Class Member? ________ Young Farmer Class Member?___________

Directions: Put a mark (X) on the line to the left of the statement below that more nearly describes your experience or lack of experience in electric arc welding.

1. ____ I have never done any electric arc welding and do not know how it should be done.

2. ____ I have never done any electric arc welding but I have seen it done or have seen someone demonstrate how to do it, however, I do not know whether it was done according to the best methods or not.

3. ____ I have never done any electric arc welding alone but I have helped someone else frequently, however, I do not know whether the welding was done according to the best methods or not.

Do you agree to keep a record of the amount of time <u>in minutes</u> spent practicing on each arc welding job and write it on the form below?
Yes ________ No ________

PART II. RECORD OF PRACTICE TIME

		Bead	Fillet Weld Joint	Butt Weld Joint	Lap Joint
1. Did you begin practicing immediately after the demonstration?	Yes				
	No				
2. If answer to item 1 is no, how long was it before you did begin practicing?	Days				
3. How much time did you spend practicing before doing the job twice successfully?	Minutes				
4. How much time was used to demonstrate the job?	Minutes				

<u>Return this form to the teacher</u>.

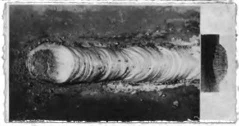
INSTRUCTIONS FOR TRAINEES AFTER MAKING A BEAD

DIRECTIONS: **After cleaning the bead examine it and compare it with the photographs and characteristics below. If the appearance of the bead is not very much like the top photograph, compare it with the others and their characteristics to help determine the cause of the defective condition. Make the necessary adjustments and run another bead. When you** have made two beads consecutively with characteristics and appearance very much like the top photograph and they are approved by the teacher, record on Form 1 the amount of time that you devoted to practice.

COMMON CHARACTERISTICS OF THE BEAD

1. Bright surface with uniform ripples.
2. Edges smoothly joined to the plate.
3. Fairly deep crater at end of bead.
4. Very little spatter.

(Good normal bead)*



1. Metal piled up excessively high.
2. Deposited metal may overlap plate.
3. Lack of penetration along edges.
4. Wide bead.

(Slow speed of travel bead)

1. Elongated ripples on the surface.
2. Bead is small and narrow.
3. Fusion along edges not smooth.
4. Penetration not uniform along edges.

(Fast speed of travel bead)

1. Excessive spatter on the plate.
2. Undercutting along the edges.
3. Deep penetration.
4. Long crater at end of bead.

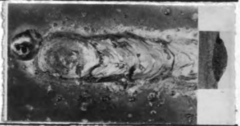
(Hot bead, too much amperage)

1. Poor fusion along edges.
2. Shallow crater at end of bead.
3. Metal may overlap the plate.
4. Metal piled up excessively high.

(Cold bead, amperage too low)

1. Bead irregular in shape and size.
2. Bead is wide and flat.
3. Excessive spatter on the plate.
4. Wide shallow crater at end of bead.

(Arc too long, other conditions may be normal)



*Note: This bead will also be used with Jobs Nos. 2, 3 and 4

Job No. 1

JOB BREAKDOWN*: Striking an arc and running a good flat bead.

Steps	Key Points
1. Adjust the amperage setting on the welding machine.	a. Use 125 or point nearest this for trial setting.
2. Prepare the welding table.	a. Make the ground cable connections secure.
	b. Clamp the plate to the table.
3. Select electrode.	a. Use 5/32" general purpose electrode. (Type E6013)
	b. Put bare end in the holder.
4. Turn welder switch to the "on" position.	a. See that the main cable is plugged in and the current is on at the main switch.
5. Adjust helmet on head.	a. Hold tip of electrode ½" above the place where bead is to begin on practice plate.
	b. Adjust helmet over face before striking the arc.
6. Strike the arc.	a. Use a scratching motion or tapping motion.
	b. After striking arc, hold a long arc momentarily, before beginning to form the bead.
7. Run the bead for a distance of about six inches on the plate	a. Keep tip of electrode above crater a distance equal to diameter of electrode.
	b. Keep electrode almost perpendicular to practice plate but tipped 20 degrees in direction of travel.
	c. Made bead width 1½ times diameter of metal electrode.
	d. Keep bead forming in straight line.

*Some material in the Job Breaddown has been taken from Arc Welding Lessons, Lincoln Welding Foundation.

8.	Turn the switches on the welder to the "off position.	a.	Hang the electrode holder.
9.	Clean the bead. a. Chipping b. Brushing	a.	Chip away the slag formed on the bead.
		b.	Chip after the plate has cooled enough for the dark natural color to return.
		c.	Protect the eyes from flying scale.
		d.	Handle the plate with pliers or tongs while hot.
10.	Examine the bead.*	a.	Follow the direction on Form 2.
		b.	Compare the bead with the pictures and characteristics..
11.	Have a trainee strike an arc and run a bead.	a.	Have trainee tell and show what he is doing on second bead.
		b.	Correct errors that trainee makes.
		c.	Ask questions of trainee about steps and key points to help insure proper understanding.
12.	Have trainees begin practice session.	a.	Pass copy of Job Breakdown to each trainee.
		b.	Each trainee will use same copy of Form 2 when ready to examine bead.
		c.	Instruct trainees to record time on Form 1.

*If the first bead is not a good one, point out the faults and defects to the trainees, explain what caused the imperfections, show them how to remedy it (or them) and make another bead.

Job No. 2

JOB BREAKDOWN: Making a single pass fillet weld in flat position.

Steps	Key Points
1. Adjust the amperage setting on the welding machine.	a. For the trial setting use 135 or the point nearest to this figure.
2. Prepare the welding table.	a. Make ground cable connections secure.
	b. Locate pieces of metal to hold practice plates in place while being welded.
3. Prepare two pieces of metal for use in making the joint.	a. Use 3/16" mild steel, preferably 1 or 2 inches wide, about 6 inches long. Scrap metal may be used.
	b. Clean parts where the bead will be formed. Grind until surface is bright. See Figure 1.

Grind here

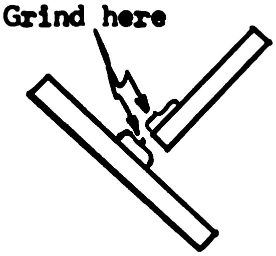
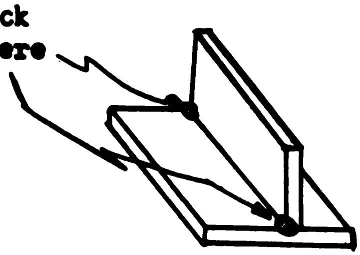


Figure 1. - Surface to be cleaned.

Steps	Key Points
4. Select electrodes.	a. Use 5/32" general purpose electrode. (Type E6013)
5. Tack weld the two pieces of metal together.	a. Position the two pieces of metal as shown in Figure 2.
	b. Strike an arc and run a bead about ¼" long at each end of the joint.
	c. Remove the slag by chipping and brushing well.

Tack here



Fiture 2. - Position for tacking metal plates.

Steps	Key Points
6. Strike arc and establish bead.	a. Strike arc at point within one inch of the corner where weld is to begin.
	b. Bring tip of electrode into position in corner of weld and hold long arc momentarily.

7. Run the fillet weld.

a. Hold electrode at 45 degree angle to plates, (see Figure 3) tipped forward about 20 degrees in direction of travel.

b. Hold electrode so that the coating is about 1/16 or 1/8 inch from plate on either side.

c. Observe action within the pool of molten metal at all times and keep amount of deposited metal equal on both plates.

d. If undercutting begins to appear on the righthand plate shift the point of the electrode slightly toward that plate.

e. Slightly increase speed of electrode to stop piling up of metal, decrease speed if insufficient metal is deposited.

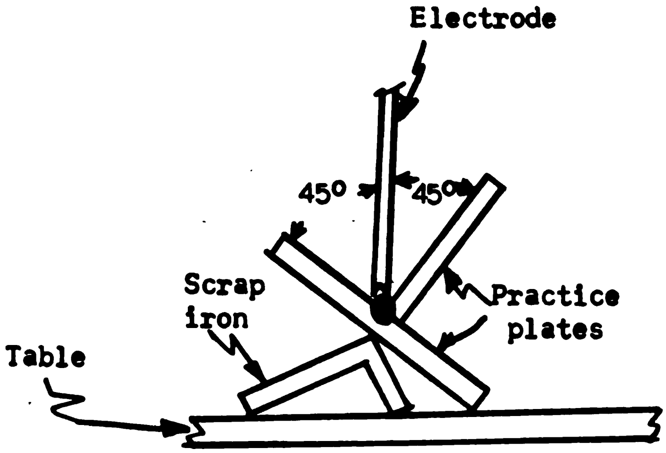


Figure 3. - Position of plates when running fillet weld.

8. Chip and clean the bead.

a. Use chipping hammer and wire brush.

b. Protect the eyes from flying scales.

9. Inspect the weld.
   a. Surface appearance.

a. Examine the bead to see if it has the appearance and characteristics very much like a good bead (see top photograph on Form 2).

   b. Break the weld.

b. Place in a vise and break by striking on opposite side from weld (see Figure 4).

c. Examine broken weld for:
<u>Adequate penetration</u>. Minimum of half the thickness of each metal plate.
<u>Full fusion along the joint</u>. Indicated by clean grey metal all along the edges. Blackened condition indicates poor fusion.
<u>Cleanliness and free of porosity</u>. Indicated by absence of slag and gas pockets on the exposed part of the deposited metal.

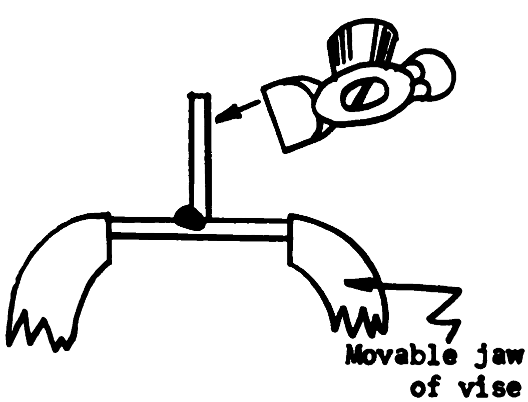


Figure 4. - Breaking fillet weld in vise.

d. If the broken fillet welded joint does not show indications of adequate penetration, full fusion

9. Continued.	along the joint, cleanliness and freedom from porosity, correct the condition that caused the defective weld and make another joint.
10. Repeat steps 1 through 9 until two fillet welds are made in succession that show indications of having the qualifications listed under the key points.	a. Surface appearance of a normal bead. b. Adequate penetration. c. Full fusion along the joint. d. Clean and free from porosity. e. Meets the approval of the teacher.
11. Record the amount of time devoted to practice.	a. Use Form No. 1, Part II. Fill the space for item 3 in the column with the heading "Fillet Weld Joint." b. Return Form 1 to the instructor.

Job No. 3

JOB BREAKDOWN: Making a Vee Joint butt weld in flat position.

Steps / **Key Points**

1. Prepare two pieces of metal using the single vee method.

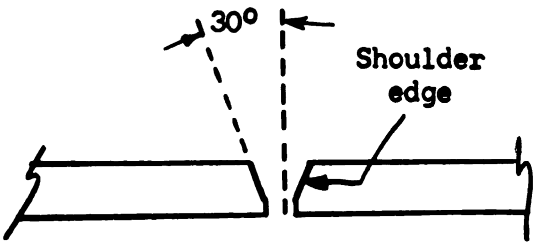


Figure 5. - Angle to grind edges of plates.

a. Use mild steel 3/16" in thickness and preferably 2 or 3" wide, about 6 inches long. (Scrap metal may be used.)

b. Grind metal plates on emery wheel to angle of 30 degrees. (See Figure 5.)

c. Grind edge leaving a shoulder edge on each plate.

d. Use safety goggles while grinding.

2. Adjust amperage setting on the welding machine.

a. Use trial setting of 125 amperes or point nearest this figure. (If bead piles up and penetration is not secured, increase amperage by 10. If excessive burn-through is encountered, reduce amperage by 10 for the next trial.)

3. Prepare the welding table.

a. Make ground connections secure. (Making good connections help insure good electrical circuit which is essential for a continuous and steady arc.)

4. Select the electrodes.

a. Use 5/32" general purpose electrodes. (Type E6013)

b. Choose partially used electrodes about 8" or 9" long. (These are easier to manipulate.)

5. Clamp the two pieces of metal in welding position.

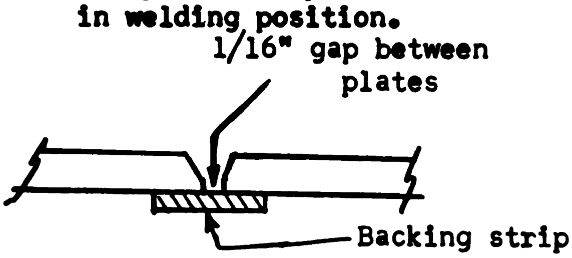


Figure 6. - Space between plates and backing strip.

a. Place a piece of scrap metal about 1/8" thick directly under the joint. (This serves as a backing strip.)

b. Leave 1/16" gap between the pieces of metal as shown in Figure 6.

6. Tack weld the two pieces of practice plates together.

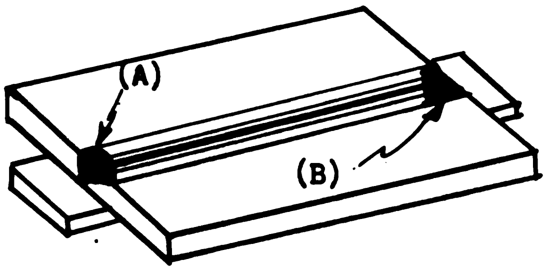


Figure 7. - Position for tacking practice plates.

   a. Make sure that practice plates are clamped so that good contact is made with metal top of welding table.

   b. Strike arc and weld bead about $\frac{1}{4}$ inch long in bottom of vee at both ends of the joint as shown at A and B in Figure 7.

   c. Remove the slag from the tack beads by chipping and brushing well.

7. Strike the arc and establish the bead.

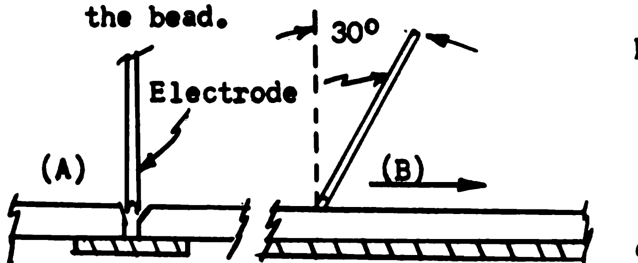


Figure 8. - Position of electrode for striking arc.

   a. Use scratching motion.

   b. Strike arc in bottom of vee and within one inch of the end where weld is to begin, tilting electrode 30 degrees in the direction of travel. (Figure 8.)

   c. Hold long arc momentarily and bring electrode about 15 degrees in direction of travel.

8. Run the bead.

   a. Hold electrode so that coating is about 1/16 or 1/8 inch from either plate. (See A, Figure 8.)

   b. Maintain good arc and uniform speed of travel.

   c. Observe the action of molten metal in pool at tip of electrode at all times. Deposit metal so that it is slightly higher than surface of plates.

9. Fill crater and break arc at end of bead.

   a. Gently move electrode tip into molten pool momentarily at the end of bead, lean electrode backward 15 degrees opposite the direction of travel and slowly draw tip of electrode over the crater, raising the electrode until arc is broken.

10. Chip and clean the bead.

   a. Use chipping hammer and wire brush.

   b. Protect the eyes from scale.

   c. Remove backing strip.

11. Inspect the weld.

a. Examine side of plates opposite the bead to see if weld penetrated completely. (Plates should be fused at bottom.)

   a. Surface appearance.

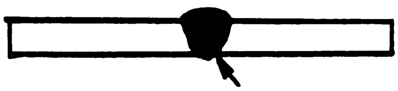


Figure 9. - Complete penetration of bead.

b. See if bead has the appearance and characteristics very much like a good bead. (Compare with photograph at top of Form 2.)

   b. Break the weld.

a. Place in vise and break by striking on opposite side from the weld as shown in Figure 10.

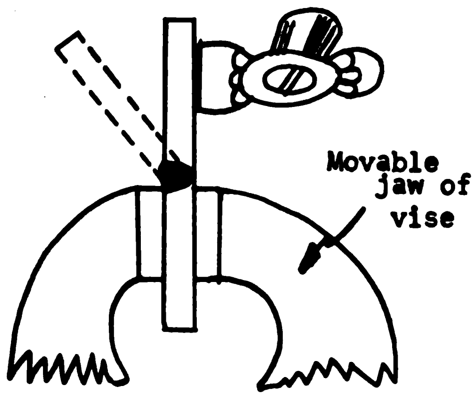


Figure 10. - Breaking the butt weld in vise.

b. Examine the broken weld for: Adequate penetration. Indicated by appearance of deposited metal between plates on back side. (Figure 9) Full fusion along the joint. Indicated by clean grey metal all along the break on both plates. (Blackened condition indicates poor fusion.) Cleanliness and freedom from porosity. Indicated by absence of slag and gas pockets on the exposed part of the deposited metal.

c. If broken joint does not show indications of adequate penetration, full fusion, cleanliness and/or freedom from porosity, correct the condition that caused the defective joint and make another vee but weld joint.

12. Repeat steps 1 through 9 until two joints are made in succession that show indications of having the qualifications listed under the key points.

a. Surface appearance of a normal bead.

b. Adequate penetration.

c. Full fusien aleng the joint.

d. Clean and free from poresity.

e. Meets approval ef teacher.

13. Record the amount of time devoted to practice.

a. Use Form No. 1, Part II. Fill the space for item 3 in the column with the heading "Butt Weld Joint."

Job No. 4

JOB BREAKDOWN: Making a single pass fillet weld lap joint in a horizontal position.

Steps	Key Points
1. Adjust the amperage setting on the welding machine.	a. Use 135 or the point nearest this figure for the initial trial setting. (If this proves to be too hot, decrease it. If too cold, increase it.)
2. Prepare the welding table.	a. Make ground connections secure. (Fasten cable well, as a good electrical circuit is essential for a continuous and steady arc.)
3. Prepare the two pieces of metal for use in making the joint.	a. Use mild steel 3/16" in thickness and preferably 1 or 2 inches wide about 6 inches long. (Scrap metal may be used with width and length of various demensions.)
	b. Clean the edge and side where the bead will be formed until the surface is bright, see Figure 13. (Use grinder for this process.)

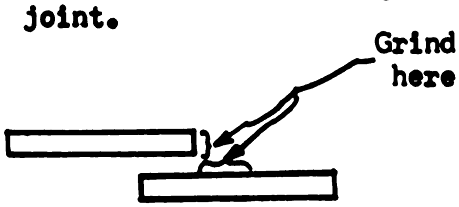


Figure 13. - Surface to be cleaned.

Steps	Key Points
4. Select the electrodes.	a. Use 5/32" general purpose electrodes. (Type E6013)
5. Tack weld the two pieces of metal together.	a. Position the two pieces of metal as shown in Figure 14.
	b. Strike arc and run a bead about ¼" long at the ends of the lap, points A and B.
	c. Remove the slag by chipping and brushing well.

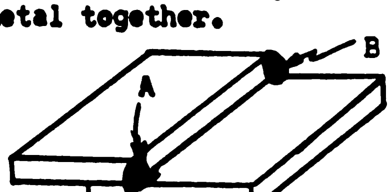


Figure 14. - Position for tacking metal plates.

Steps	Key Points
6. Strike the arc and establish the bead.	a. Strike the arc at a point within one inch of the end where weld is to begin.
	b. Bring tip of electrode into position at point A, Figure 14, and hold a long arc momentarily.

7. Run the fillet weld.

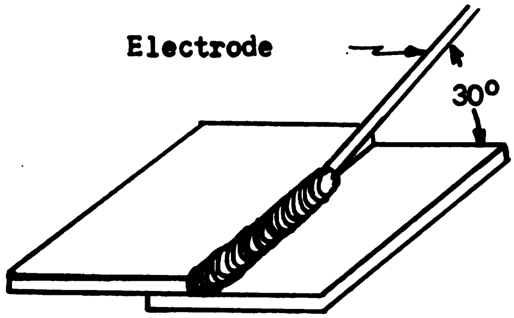


Figure 15 - Position of electrode and plates for running fillet weld.

a. Hold the electrode at an angle of 30 degrees with the bottom plate (Figure 15).

b. Tip the electrode 20 degrees in the direction of travel.

c. Hold electrode so that the coating is about 1/16 or 1/8 inch from the metal plates on either side.

d. Use slow steady movement of the electrode. (Observe the action within the pool of molten metal at all times and keep the amount of deposited metal equal on both plates.)

e. Position the electrode to take care of undercutting. (If undercutting begins to appear on the top plate, shift the point of the electrode slightly toward that plate.)

f. Slightly increase speed of electrode to stop piling up of metal, decrease speed if insufficient metal is deposited.

8. Chip and clean the bead.

a. Use chipping hammer and wire brush.

b. Protect the eyes from scale.

9. Inspect the weld.

   a. Surface appearance

   b. Break the weld.

a. Examine the bead to see if it has the appearance and characteristics very much like a good bead. (See photograph at top of Form 2.)

b. Place in vise and break by striking on opposite side from weld. (Figure 16.)

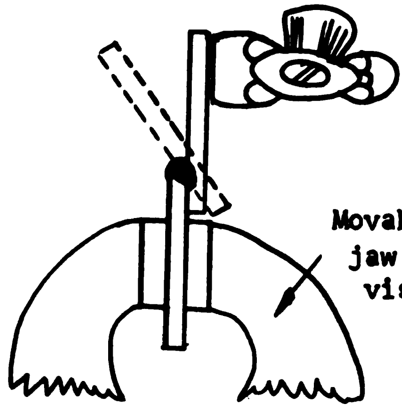


Figure 16. - Breaking lap joint in vise.

c. Examine broken weld for:
<u>Adequate penetration</u>: Minimum depth equivalent to $\frac{1}{4}$ the thickness of the plate.
<u>Full fusion along the joint</u>. Indicated by clean grey metal all along the break on both plates. Blackened condition indicates poor fusion.
<u>Cleanliness and freedom from porosity</u>. Indicated by absence of slag and gas pockets on the exposed part of the deposited metal.

9. Continued.	d. If the broken joint does not show indications of adequate penetration, full fusion along the joint, cleanliness and freedom from porosity, correct the condition that caused the defective joint and make another fillet weld lap joint.
10. Repeat steps 1 through 9 until two single pass fillet welds are made in succession that show indications of having the qualifications listed under the key points.	a. Surface appearance of a normal bead. b. Adequate penetration. c. Full fusion along the joint. d. Clean and free from porosity. e. Meets the approval of the teacher.
11. Record the amount of time devoted to practice.	a. Use Form No. 1, Part II. Fill the space for item 3 in the column with the heading "Lap Joint."

APPENDIX B

TYPES OF LETTERS SENT TO TEACHERS OF VOCATIONAL AGRICULTURE

341 Snyder Hall
Michigan State College
East Lansing, Michigan

January 24, 1953

Mr. Clyde Ray
Charlotte High School
Charlotte, Michigan

Dear Mr. Ray:

I need some help in making a pilot study. Three members of the Michigan State College faculty have told me that you are very capable of providing the assistance that I need. Will you help me?

I am making a study of the time that students in vocational agriculture require to learn each of four basic skills in electric arc welding. Enclosed is a set of the plans that I anticipate asking teachers of vocational agriculture to use in teaching these jobs to four or five members of their classes and keep a record of the time consumed in learning to do each skill.

You probably are already teaching arc welding or plan to teach it to some of your classes. I hope that this can fit in with the instruction that you have planned.

Would you kindly follow the instructions and teach these skills to three or four of your enrollees, then criticize the plan, its contents, its arrangement, make additions and/or deletions, etc., that would make it easier for a teacher of vocational agriculture and/or a trainee to understand and use?

For your convenience I suggest that you write your comments in the margins, between the lines, at the tops and/or bottoms of the sheets in the plan and return it to me in the enclosed envelope. <u>Return only Forms 1 and 2 and the sheets on which comments have been made</u>.

If you cannot have three or four of your all-day or young farmer class members work on the four skills, I would appreciate it if you will have them do as many as they can and send me your comments.

I will be very grateful to you for this assistance.

Very truly yours,

A. J. Miller

341 Snyder Hall
Michigan State College
East Lansing, Michigan

March 20, 1953

Mr. K. V. Clemons
Teacher of Vocational Agriculture
West Unity, Ohio

Dear Mr. Clemons:

I am making a study of the factor of time in learning certain basic skills in arc welding by students of vocational agriculture. Your Supervisor of Vocational Education in Agriculture recommended you as one teacher who is qualified and capable of helping secure the facts I need.

I realize that you are very busy, but most likely you will teach, or have taught, arc welding to some of your classes this school term. If you have not finished teaching it for this term, would you please select four or five students and include in your teaching the four basic jobs listed below and permit each student to practice the job and fill in Form 1 according to the instructions?

If you have already taught arc welding this term and have some students who need additional practice, would you please select four or five of them and have them practice, following the procedures given in the four Job Breakdowns that are attached and fill in the information on Form 1 according to the instructions?

If you have only one or two students that you can use in this study, I would appreciate your using them.

This is part of a doctoral study and as one of the special teachers, if you can assist in securing the data, you will be given credit in the proper part of the dissertation. Also, the results of the study will be available for your use.

Your assistance will be greatly appreciated. If, however, you see that you cannot assist in this study, would you kindly return Forms 1 and 2 in the enclosed envelope at once.

Jobs to be included in the study are as follows:

1. Running a flat bead.
2. Making a fillet weld.
3. Making a v-butt joint.
4. Making a fillet-weld lap joint.

Very truly yours,

A. J. Miller

Enclosures

341 Snyder Hall
Michigan State College
East Lansing, Michigan

May 9, 1953

Mr. K. V. Clemons
Teacher of Vocational Agriculture
West Unity, Ohio

Dear Mr. Clemons:

On or about March 20, I mailed to you job breakdowns for four basic jobs in arc welding and asked if you would assist me with a study of "time" required to develop these skills with students of vocational agriculture.

You were recommended as one of the possible participants from Ohio by your Supervisor of Vocational Agriculture, Mr. J. E. Dougan.

I am now assembling these data and would appreciate your returning the completed forms at once as I would like very much to include in this study information provided by you and your students.

If you have already returned the completed forms, please disregard this letter.

Sincerely yours,

A. J. Miller

Date Due

Jul 2 '57			
Feb 21 '58 FEB 14			
FEB 14 '58			
MAR 1 '58			
[illegible] 2 '58			
19 Mar 59			