Experimental evaluation of prepared lesson plans on instruction in vocational agriculture

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EXPERIMENTAL EVALUATION OF PREPARED LESSON PLANS ON INSTRUCTION IN VOCATIONAL AGRICULTURE

by

Donalj Louis Ahrens

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INTRODUCTION

Instructors are constantly concerned with the instruction provided students enrolled in vocational agriculture at the high school level. This instruction must be of high quality so as to maintain student interest and to cause them to want to learn. With high quality comes support of the vocational agriculture program, both from the administration and from the public.

Teachers of vocational agriculture in Iowa are plagued by "educational shortages". Probably the most serious shortage of the average teacher is time. With more students to teach, with more technology to be taught and with more duties outside the classroom and in the community, the vocational agriculture instructor has difficulty in finding time to plan and complete his work adequately.

In planning his work, the instructor has several alternatives. He may attempt to teach without a plan or use the same plan year after year. Neither of these alternatives satisfies the professional person. It is obvious that an effective vocational agriculture teacher must be a well organized person who is able to budget time wisely, think clearly and act decisively.

Planning is a necessity in every day life. The busy housewife sets up a schedule for the week; the businessman organizes his day at the office; the contractor follows a detailed blue print in building a house; the farmer diversifies and rotates his crop. Success or failure of each enterprise depends upon the adequacy of planning. Some plans are for a day; other are for a week or weeks, months, or years. Some are simple;
others are complex. Planning is as much a necessity for the teacher as for the housewife, the contractor, or the farmer. Neither ingenuity nor experience can serve as a substitute for thorough planning. The teacher in today's school must be better prepared and must plan more effectively than ever before.

The mild hostility with which the term "lesson plan" is greeted by many teachers, beginning and experienced, is evidenced and wholly understandable. It might seem that teachers should accept lesson planning as a necessary and desirable part of their professional work. Yet, because the lesson plan has for beginning teachers, student teachers, and experienced in-service teachers often been made to appear a time consuming task, the term itself is usually greeted with something less than enthusiasm.

Instructors give many reasons for not using lesson plans. Among the reactions expressed: "I know my field of work, and therefore do not need lesson plans"; "time does not permit my working detailed lesson plans"; "I used to use lesson plans, but have been teaching X number of years"; "I cannot use lesson plans because there are wide differences in my group"; "I teach six classes a day"; "I can't type"; "lesson plans are no good" and the like.

Actually, lesson planning is nothing more than outlining one's plan for doing his job as a teacher. It is in many ways the core or the heart of effective teaching. Lesson planning is work, just as any kind of planning is work. Yet, it is potentially the most rewarding phase of
professional work the teacher can do. In this planning, the teacher
has the opportunity to use every bit of his skill, intelligence, ability,
and personality—in short, every opportunity to become a really fine
teacher.

To take a class as he finds it, to study it, to provide helpful
learning experiences, and to direct the growth of the students are tasks
of the teacher. As never before, society is clamoring for quality teach­
ing. In many quarters, schools are under attack and high school cur­
riculums are constantly being subjected to careful analysis. Hand in
hand with curriculum reorganization must go changes in classroom teach­
ing practices. What the individual does as a teacher and how he does it
greatly influences student attitude and behavior. The students react
favorably or unfavorably as the teacher teaches well or poorly.

Since the beginning of time, man has sought ways of communicating
the accumulated knowledge and skills of one generation to another.
The teacher of today can call upon a great variety of methods to assist
in guiding the learning of students. Some of these are traditional and
some are modern; others are still in the experimental stage. Some methods
have outlived their usefulness and have been or should be discarded. It
is through constant experimenting that quality instruction emerges.

Rockets are built to orbit the earth, but they are the result of
many years of research, millions of man hours, and billions of dollars.
Unfortunately we have not yet arrived at that state of public thought
which would permit the investment of such funds and time to educational
research. It is obviously absurd to expect near-perfect teaching to be
developed after only a few years of relatively uncoordinated effort and research financed largely by foundations, private businesses and the government.

It is interesting to note that the armed services have a history of being among the first to take advantage of developments in education methodology. This has been due to the fact that training and education in the military establishment has always required specific results. Inefficient education in training technology has been a luxury that the military could ill afford. If a specified number of qualified radar technicians, pilots, or mechanics were needed by certain dates, then successful instruction was an absolute necessity. It is not surprising therefore that the armed services have looked very hopefully and with intensive anticipation to those developments which imply the emergence of educational technology. The armed forces have spearheaded the movements in instructional training, audio-visual devices and closed circuit TV, to mention only a few of the areas.

A number of the teachers, school personnel, and businessmen have developed instructional materials that include lesson plans in one form or another. Little research has been done to evaluate the effectiveness of lesson plans as compared with other instructional techniques.

The purpose of this study was to experimentally determine the value of prepared lesson plans on instruction in vocational agriculture. The objectives of the study were:
1. To determine factors related to student attainment when using prepared lesson plans.

2. To determine the effectiveness of the prepared lesson plan technique of instruction on student achievement at each of the four high school grade levels: ninth grade, tenth grade, eleventh grade, and twelfth grade.

3. To determine the effectiveness of the prepared lesson plan technique of instruction on student achievement of specific units in each of the four curriculum areas in the vocational agriculture program: animal science, agronomic science, agricultural mechanics, and farm management.

4. To compare the effectiveness of the prepared lesson plan technique of instruction with a control or conventional method of instruction in teaching vocational agriculture.

This study was a part of a larger overall project entitled "An Experimental Evaluation of the Effectiveness of Selected Techniques and Resources on Instruction in Vocational Agriculture". The selected techniques were: 1) audio-tutorial, 2) single concept films, 3) field trips, 4) demonstrations, 5) video tapes, 6) transparencies, and 7) prepared lesson plans.

The project was conducted cooperatively by the Department of Agricultural Education and the Iowa Agriculture and Home Economics Experiment Station of Iowa State University; The Iowa Department of Public
Instruction, Vocational Agriculture Section, and the Iowa Research Coordinating Unit. It was financed through the Iowa Agriculture and Home Economics Experiment Station and through a grant (Ancillary funds—Vocational Education Act of 1963) from the Division of Vocational Education, Iowa Department of Public Instruction.
REVIEW OF LITERATURE

It did not take this researcher long to realize when he began the review of literature that little work had been done in the area of prepared lesson plans. There has been little research completed on lesson plans and their importance in teaching. Information and research is available in related areas such as teaching units, teaching aids and devices, etc.

This review was divided into three parts: 1) lesson plans, teaching units and aids, 2) experimental use of selected techniques and resources, and 3) individualized and programmed learning.

Lesson Plans, Teaching Units and Aids

Delaney (13) stated that lesson plans, theoretically at least, existed to serve two fundamental purposes. From the teacher's standpoint, lesson plans are a course upon which he can steer his classroom activities, his unit goals, and his instructional methods to daily fulfillment. Delaney indicated that the teacher knows that a plan of some type can spell the difference between success or failure for any one period. According to him the teacher is also well aware that the most important item an observer or supervisor should look for, in addition to classroom control, is some form of plan.

The lesson plan takes somewhat a different perspective when seen from the administrator's point of view. Delaney related that the administrator hopes the plan will achieve the goals the teacher desires,
but in addition, the administrator views the lesson plan as a means to evaluate the teacher's personal performance and as a guide for substitute teachers in emergencies.

It was pointed out by Besvenick (6, p. 431) that lesson plans should be simply stated, clearly written, and flexible. He indicated that the following rules would form a good set of criteria to be used in judging a lesson plan.

1) The teacher should be able to teach from it.
2) Someone who is qualified in that subject area should be able to teach from it.
3) It should be useful as a basis for planning the lesson if it is taught again sometime in the future.

In an early study, Randall (26) prepared some study sheets to be used as a teaching device. He had 120 students enrolled in his courses evaluate the study sheets. When the device was evaluated in the light of 14 selected criteria for evaluating good teaching, Randall concluded the sheets were defensible.

In another older study, Davis (11) attempted to determine the teaching aids that should be prepared and supplied to vocational agriculture teachers of Texas. He mailed a questionnaire and letter to 100 vocational agriculture teachers in order to determine the teaching aids they desired. The questionnaires returned were classified according to type of farming followed in the community. They were then summarized and a list of teaching aids was made. He concluded that: 1) additional up-to-date subject matter is needed for relating fields of agriculture, 2) present sources of information are not sufficient to keep the teacher well
informed, and 3) that teachers would be more valuable to the communities they serve if they were supplied with new information regularly.

Smith's (27) intent was to provide agricultural teachers with a cohesive, logical arrangement of farm electrification units together with some suggested teaching plans for each unit. His study resulted in the development of a series of lesson plans for teaching selected electrical units in agricultural education. The units stressed the managerial aspects of farm electrification and included lists of materials needed and explanations for the teacher.

It was Cordes's (10) purpose to: 1) survey the occupational opportunities in the broad field of agriculture, 2) to prepare a resource unit with a list of aids for use by an instructor in vocational agriculture in preparing teaching units on the topic "Choosing a Career in Modern Agriculture", and 3) to prepare teaching units of instruction based on the resource unit. He did an extensive study on the number of people employed in agriculture, including those in distributive occupations, those producing or servicing farmers, and those in actual farming. He estimated the replacement needs in all of these areas and concluded that promising opportunities exist for farm boys trained through high school vocational agriculture courses. Cordes felt that the instructor in vocational agriculture has an excellent opportunity and responsibility to integrate classroom teaching with vocational preparation, and to provide counsel and guidance to students about existing opportunities within their agricultural vocation.
Teaching units and a set of 53 colored 35 mm slides in crop improvement and seed certification in Minnesota were developed by Benson (5). He carried on research for information on the development, increasing, certification, and marketing of certificated seeds. These data were organized into seven teaching units with stated objectives, related information, references, and visual aids. Benson indicated that many teaching opportunities could be developed by carrying out the suggested activities to give a greater understanding and appreciation of certified seeds.

In a study by Barker (2) an attempt was made to measure the relative effectiveness of instructional units designed to enhance student understanding of profit maximizing principles when used in classes of vocational agriculture. Two hundred and sixty-two juniors and seniors in 22 Ohio high schools offering vocational agriculture performed the trial function and assisted in evaluating the farm management instructional unit. Six schools were designated as control schools and farm management was taught in the traditional manner. Seven schools were assigned to a pilot-block in which the units were taught in an uninterrupted sequence. Nine schools were designated as pilot-integrated schools and used the same materials by integrating them with other subject matter. Barker found that the pilot-block group of students had the highest score on the post test. This group was followed in sequence by the pilot-integrated and control groups. Student understanding of profit maximizing principles was significantly associated with four independent
variables: 1) the student's year in vocational agriculture, 2) student's years of farm experience, 3) the student's IQ, and 4) the number of teachers in the vocational agriculture department. The teachers' objective appraisals of the units revealed that the principal's approach to the farm management instruction strengthened the vocational agriculture curriculum. They found the units to be challenging, time consuming, and to require extra study. Yet, the extra preparation and greater teaching effort tended to resolve in greater student interest and achievement.

A study at the University of Minnesota that was completed by Marvin (24) attempted to develop course content and methods of procedure for teaching farm machinery by the unit operation concept, and to evaluate practical application of the method in an experimental situation. The outcome of one comparison in teaching farm machinery by units operations, as opposed to the conventional method, indicated that presently accepted objectives could be achieved as well by teaching operational units as by teaching according to the individual machine method. The experimental group did not show an advantage in respect to gains in terms of mean scores of the test. Variance of the difference from pretest to posttest scores proved to be significant in the experimental group but not in the control group, which implied that the unit operations method more adequately provided for individual differences within the group.

The use being made of resource units and how they could be improved as an aid to teachers of vocational agriculture were the main concerns of the study done by Burt (7). Questionnaires were used to obtain data
from vocational agriculture teachers in the state of Ohio. Data indicated that resource units were used extensively as a guide in preparing lessons, as a general reference, and as a source of related information. The units were used to a limited extent as a student reference and as a complete lesson plan. A summary of the teachers' responses indicated that "teaching aids", "approved practices and skills", "related information", and "items to consider" should be included in most revised units. The teachers also recommended having units color coded to correspond with AGDEX, revising most units every five years, and publishing inserts frequently. "Teacher and staff members" in combination were most commonly mentioned as the proper persons to develop resource units.

Wright's (34) purpose in his study was to present a number of teaching plans to be used by vocational agriculture instructors in teaching improved land use policies in the Montgomery School District. He used a survey to determine the factors affecting the present land use policies. Although no research was done on the actual lesson plans themselves, Wright concluded that hopefully through lesson plans the vocational agriculture instructor could bring about a change in present land use policies in the district.

In a paper presented at the International Counsel on Exceptional Children meeting in New York, Lance (21) talked about the development of instructional materials for the "trainable mentally retarded" (TMR) children. He discussed: 1) the teacher's awareness of people's needs, 2) the applicability of materials to teaching style and learning style, 3) the teacher's enthusiasm in trying out materials, 4) the need for
more specific materials for the TMR child, 5) the evaluation and modification of materials developed, and 6) the opportunities for pupil involvement. Lance stated that materials: 1) should be developed in sequence, 2) should include the theories and the principles of learning, 3) should fit the teacher's teaching style and the child's learning style, and 4) should relate to the social level at which the TMR is functioning.

A random sample of 20 Illinois schools offering vocational agriculture provided data for a study by Ehresman (15) to ascertain the relative effectiveness of structured and unstructured printed material on agricultural cooperatives. Pre- and posttests were administered to the students in the schools; half of the schools were randomly designated as experimental and half as control schools. The experimental variable was a structured source unit. The difference in mean posttest scores did not differ at the .05 level when tested with the "t" test. The reaction of the teachers using the structured units was favorable. Ehresman stated he believed that the structured unit would be beneficial in saving teacher time and encouraged adoption of new units if adequate assistance in utilizing material was provided.

A staff study in which teachers of agriculture in Kentucky evaluated selected teaching materials was headed by Luster (22). A five-page survey was sent to 265 high school teachers of agriculture asking for suggestions to improve the teaching materials program. One hundred and fifty-five surveys were returned with the subject matter content sections of units receiving the highest score. These sections included content
material, supplementary information to support content (tables, charts, drawings, etc.), major and minor teaching objectives, and references. The suggestions on techniques of teaching (introduction of the unit, class instruction, and evaluation) were rated lower. Teachers felt that calendars, lists of improved practices, colored slides, teaching materials, and newsletters were helpful and their provision should be continued.

The purpose of the study by Whitman (32) was to determine the need for printed technical subject matter information that might be supplied by a subject matter specialist. Data were gathered through questionnaires sent to one-half of the teachers in the state of New York. Sixty-four percent (100) of them were returned. He found that the teachers' greatest needs for subject matter information were in the following three enterprises: 1) dairy, 2) farm mechanics, and 3) farm management. Major units were identified in each enterprise, for which teachers needed technical subject matter information. Whitman concluded that since the information was obtained from the teachers themselves through questionnaires, said information could be of value to anyone preparing subject matter units for distribution to the teachers.

A teacher's manual and a student's handbook on gasoline engines were developed in a Pennsylvania study. A student information sheet and a 40 question-multiple choice test was used to collect data for Ayers' (1) study. Twelve teachers and 137 vocational agriculture students in grades 10 through 12 participated in the research project. Ayers reported the unit of instruction on small gasoline engines was found to be an effective tool in teaching small gasoline engines to vocational
agriculture students. The mean total difference of 8.28 percent was found between pretest and posttest scores. This difference was significant at the 1 percent level when analyzed by a "t" test. Student achievement in the unit was not significantly affected by age, place of residence, experience level with small gasoline engines, or IQ as measured by pre- and posttest scores.

Elstrom's (16) purposes were: 1) to evaluate source material, 2) to develop a weed control source unit, and 3) to prepare lesson plans that might be used by vocational agriculture teachers in preparing and teaching lesson plans on weed control. The usefulness of the material in the source unit was evaluated by a comparison of pre- and posttest scores taken in connection with the teaching of lessons from the unit to the Jewell High School (Kansas) vocational agriculture students. These students were divided into two groups. Freshmen and seniors were in the control group and sophomores and juniors were the treatment group. The pretest was given to all students. The source unit was taught to the treatment group, and then all the students took the test again. The results of the pre- and posttests were analyzed. The findings revealed that those students who had received instruction from the source unit increased their scores from the pretest to the posttest by 90.9 percent. Those students who did not receive instruction through the use of the source unit increased their scores 2.1 percent. There was a difference of 88.8 percent between the experimental and the control group.

The third volume of the *Image of the World of Work* (8) put out by the Rocky Mountain Educational Laboratory, Inc., Greeley, Colorado,
presents representative lesson plans on seventh grade language, arts, and social studies. The components of these lesson plans were to include cognitive objectives, occupational information, attitudinal objectives, student tasks, and evaluation of lesson effectiveness.

A publication entitled "Consumer Education: Elementary, Intermediate Junior, Junior High Schools" (9) was prepared by a committee of teachers and administrators in New York. It was designed for teacher use in developing programs and activities to aid students in grades K-8 and their families to become intelligent consumers. The suggested plans were provided for a representative number of topics, grouped for grades K-2, 3-4, 5-8, with each plan including: 1) unit and grade, 2) topic, 3) aim, 4) materials needed, 5) motivation, and 6) procedure. A listing of all the visual aids, including title, length, level and resource unit and sources of information were also provided.

Lesson plans were developed by Mason (25) that were designed to increase the observation skills of intermediate elementary students and to provide them with a variety of sensory experiences. He included in his lesson plan objectives, outlines for both indoor and outdoor learning experiences, materials and equipment needed, and evaluation procedures. Suggested activities with instructions and forms to be used were given.

Data were collected from various sources by Stump (29) to be used in the development of a course of study about agricultural cooperatives. This "body" of information was broken down into three forms so that
attention could be given to the relative importance of the material as well as its teachability. The three forms were: 1) a visual form, 2) a lesson plan form, and 3) an activities procedure. Fifty schools and 460 students participated in the testing program. Three groups of 10 schools tested the above three forms of learning materials. Two groups of 10 schools served as controls. Stump reported that lesson plans and visual materials were found to be superior methods in the overall pattern for presenting material related to agricultural cooperatives. The activity procedure, while less effective in the overall pattern, still retains some effectiveness in bringing about an understanding of the principles and operation of farmer cooperatives. The results of this study indicated that an attempt should be made to produce and to provide teaching media which can be used by teachers and students of vocational agriculture.

Experimental Use of Selected Techniques and Resources

A number of studies have been conducted and completed under a larger project entitled "An Experimental Evaluation of the Effectiveness of Selected Techniques and Resources on Instruction in Vocational Agriculture". The study done by this researcher was under this project. The following general procedures apply toward all the studies in the overall project. A random selection was made to obtain six approved Iowa high schools offering four-year vocational agriculture programs to act as control schools and six schools each for seven treatment groups:
1) audio-tutorial, 2) demonstration, 3) field trip, 4) prepared lesson plans, 5) single concept films, 6) transparency, and 7) video tape media. Uniform teaching outlines and reference materials were provided to each instructor in the study for the four specific subject matter units of animal health, commercial fertilizer, small gasoline engines, and farm credit. A pretest and a posttest after 14 days of instruction were given to all students, to determine student achievement. Additional information in the form of tests and questionnaires was gathered from the students and instructors.

A study completed by Klit (20) studied the effectiveness of single concept films in the teaching of vocational agriculture. He reported, with the exception of animal health, statistical analysis did not reveal any difference in magnitude of change of knowledge from the pretest to the posttest. There was no difference in achievement of the vocational agriculture classes taught with the aid of single concept films to those taught in a traditional manner as measured by the posttest scores. The students who performed the best in both the treatment and control groups seemed to be those with the highest pretest, intelligence quotient, Differential Aptitude (verbal section), and the Agricultural Achievement test scores.

Bendixen (4) attempted to evaluate the use of transparencies in the high school vocational agriculture classes. His results indicate that the Nebraska Agricultural Achievement Test, DAT-Verbal, and IQ scores were the more reliable predictors of the student's academic achievement.
on posttest scores in the four subject matter areas selected for the study. Although no statistical positive significance was found between the transparency media and control groups of schools, Bendixen presented evidence to indicate that a vocational agriculture student using prepared overhead transparencies generally achieved as well, or better, than did the students in the control groups.

It was Beane's (3) purpose to determine the relationship between the instructor's knowledge of subject matter and the student's level of achievement. His procedure was similar to that used by Klit (20), Bendixen (4) and Tindall (30) with the addition of a 45 item pre- and posttest for instructors over each of the subject matter units. Beane found that there were significant differences at the .05 level of confidence among the mean posttest scores of students grouped according to their instructor's knowledge of subject matter. Highly significant (at the .01 level of confidence) t-values derived from the tests of difference between pre- and posttest scores indicated that instructors did change in their knowledge of the subject matter while teaching. He concluded that there were small differences among the mean scores of students grouped according to their instructor's knowledge of the subject matter and the instructional media used by the instructors in teaching the units.

A study to determine the relationship of class size and department enrollment to the achievement of students in high school vocational agriculture in Iowa and certain selected instructional media used was
conducted by Tindall (30). He grouped the vocational agriculture classes into two class sizes: 5 to 14, and 15 to 25 students per class. The 42 schools using treatment media were grouped into enrollments of 35 to 53 and 54 to 79. He found that the mean gain of the students in the smaller departments was higher when demonstration, field trips, prepared lesson plans and transparency media were used. The audio-tutorial, single concept films, and video tape media produced the higher mean gain in the larger departments. Tindall concluded that there was no evidence in his study to verify that differences in achievement of students in large and small classes or in large and small departments were significantly different.

Individualized and Programmed Learning

The best way to organize instruction, plan, and to distribute the time of both pupils and teacher in implementing a plan for more individual instruction was investigated by MacDonald (23). He reported that: 1) as individual instruction and planning increases in a system, the demand on the teacher time increases, 2) there seems to be more actual learning on the part of pupils in a system of individual instruction and planning than in a system of all group instruction, and 3) a system of individual instruction in planning and group instruction presents a more formidable challenge to the teacher than all group instruction.

The primary purpose of a study by Dayger (12) was to determine the educational effectiveness of the programmed instructional unit on
figuring board feet as compared with the conventional teaching method. The programmed unit was an effective unit of instruction based on the increase in means between the pre- and the posttest scores. The programmed unit proved to be as effective as the control method. The programmed unit was also more effective in the use of classroom time than the control method. Dayger reported the majority of the students had a favorable attitude toward programmed instruction and felt that it should be used more frequently.

Hull and McClay (19) reported that in comparing programmed learning versus lecture-discussion method on an unlimited time basis, the lectured discussion method of teaching resulted in significantly greater gain of knowledge. However, some lecture discussion teachers used twice as much class time as did the programmed instruction teachers. When the amount of instruction time was controlled, there was no significant difference between the mean scores for the two methods. The teachers felt that programmed instruction should be integrated with other methods of teaching.

A study was done by Hannemann (17) to test the following hypotheses: 1) use of programmed instruction is an effective method for teaching parliamentary procedure to vocational agriculture students, and 2) there is a positive relationship between the time required by the students to complete the parliamentary procedure and their score on the criterion examination. Through the use of pre- and posttests in experimental control groups, it was concluded that programmed instruction was an effective method of teaching parliamentary procedure.
The library school program was conducted to develop independent study courses for the four beginning core areas of librarianship. The purpose of a study by Walker (31), was to evaluate the first segment of the cataloging course which was used in three library science programs. The experiment involved four classes in cataloging in which the control groups were taught by regular instructors and conventional lecture laboratory methods. The experimental groups used the materials developed for independent study. These materials consisted of a programmed text, an index, a number of dependencies, resumes of materials programmed, and a group of books assembled for use in the final session.

Walker concluded that: 1) the learning achievement of students who used the independent study materials was sufficiently high to justify their use in teaching the same material now taught by the conventional classroom method, 2) students who used the materials reacted favorably to them, and 3) retention of subject matter learned through independent study was not different from retention of those students who had been taught in classroom situations.

The feasibility and effectiveness of using program materials with laboratory exercises in teaching genetics at the secondary level was investigated by Young (35). He found that: 1) there was no significant difference in achievement, but the experimental group attained this level in one-half the time, 2) academic average was a successful predictor of success in the program, 3) there was a positive relationship between reading score and achievement using the programmed materials, 4) there
was a negative correlation between time in the instructional program and achievement for the total group, and 5) there were no unusual administrative problems in presenting basic genetic subject matter with integral laboratory exercises in programmed form.

In summary, the review of literature displayed the already known fact that teachers do need help. The preparation of lesson plans is time consuming and time is a big factor, especially to vocational agriculture teachers. The literature revealed that the teachers were very receptive to prepared lesson plans in hopes of saving time as well as encouraging new ideas and better instruction in the classroom.
METHOD OF PROCEDURE

This study, as indicated in the introduction, was a part of an overall project entitled "An Experimental Evaluation of the Effectiveness of Selected Techniques and Resources on Instruction in Vocational Agriculture". The prepared lesson plan technique was one of seven treatment areas.

Project Design

It was necessary to identify high schools in Iowa offering an approved program of vocational agriculture. The vocational agriculture department had to meet the following criteria to qualify as a participant in this study.

1. An enrollment of at least 35 students in the vocational agriculture program
2. Four day classes
3. Have the following required class enrollments
   a. 9 to 19 students in the junior class
   b. 7 to 22 students in each of the remaining three class
4. An instructor who had taught at least one year in the high school vocational agriculture program.

A random sample of 48 schools was selected from the schools meeting the acceptable standards. A table of random numbers was used. From this random sample of 48 schools, schools were randomly assigned to one of the seven treatment groups or to the control group, thus resulting in six schools per group. The treatments assigned to the seven groups of schools were as follows: 1) audio-tutorial, 2) single concept
films, 3) prepared lesson plans, 4) field trips, 5) demonstrations, 6) video tape, and 7) transparencies.

Material Preparation

It was decided by the project staff that the following subject matter would be used:


10th grade: Commercial fertilizer. Essential plant food elements, crop hunger signs, soil sampling, liming, fertilizer application rates, and selection of fertilizers.

11th grade: Small gasoline engines. Principles of operation of two and four stroke cycle engines, function of the engine parts, measuring devices, and preventive maintenance on small gasoline engines.

12th grade: Farm Credit. Budgeting principles, types of loans, sources of credit, interest rates, collateral, credit instruments, and the use of farm credit.

The units were developed cooperatively by the Department of Agricultural Education staff members in conjunction with project staff members.

The problem areas and objectives were determined for each class for each of the 15 day experimental periods. An outline of these problem areas and objectives were used in both the treatment and control schools to give as uniform instruction as possible. Identical reference materials
were provided to both the treatment and control schools. The only variance in instruction came from the use of the media or technique. Any one treatment group could not use any of the methods used in other treatment groups. The control schools were taught by the "traditional" method excluding the seven treatment methods. Once this information was developed, it was possible for each individual of the project staff to initiate the development of his own treatment comparison.

This researcher was concerned with the prepared lesson plan technique. The prepared lesson plans were developed with the idea of giving the instructor everything that he needed to completely teach the class each day for the three week period. Each day's lesson contained the following: 1) problem area, 2) objectives, 3) references, 4) subject matter, 5) teacher and student activities, and 6) any worksheet and/or assignments that might be needed. The first three, problem area, objectives and references, were provided to all schools. This researcher developed the subject matter area in detailed outlines. Everything the teacher needed to present to the students was contained in the outlines. Activities for the teacher and for the student were included to enhance the learning experience of the students involved. Work sheets were made up for any areas necessitating their use for effective teaching. Assignments were included. The prepared lesson plans were put in a notebook as an aid to the teacher in maintaining them in an orderly fashion. An example of the prepared lesson plans used in this study are included as Appendix B.
The lesson plans were developed in outline rather than essay form. It was the feeling of this researcher that they had to be in outline form in order that the instructor could quickly grasp the steps in the sequence. The plan should be on the desk as a reminder of the way the work of the classroom will be carried out while the class is in progress as well as providing the necessary subject matter. It was necessary to develop lesson plans that would be followed exactly by the instructors involved in the study.

The twelve schools in this study are listed below. One group of schools was used as the control group while the other group was considered the treatment group and tested for the effectiveness of prepared lesson plans. The six treatment schools and instructors using the prepared lesson plans were:

1. Earlham Community Schools--Gerald Lamers
2. Monticello Community Schools--Grover Miehe
3. Northeast Community Schools (Goose Lake)--Edward Faselt
4. Paullina Community Schools--Paul Vincent
5. Villisca Community Schools--Dale Spencer
6. Wilton Community Schools (Wilton Junction)--Derwood Keith

The six control schools and instructors were as follow:

1. Alta Community Schools--Harold Carstens
2. Everly Community Schools--Dale Fisher
3. Hartley Community Schools--Harold Woodard
4. Rock Valley Community Schools—Donald Kaberna

5. Sac Community Schools (Sac City)—Larry Reding

6. West Liberty Community Schools—Richard Wehde

A map showing the geographic locations of the six treatment and six control schools participating in the study is shown in Figure 1.

The number of students in each class and the size of the vocational agriculture departments are presented in Table 1.

Collection of Data

Data on the students were gathered through extensive testing. The testing was carried out according to a precise plan. The scheduled test was administered during the week indicated on a master test program schedule. The test books were put in the mail on the Friday of the week the test was given and sent to the next school. At the end of schedule, the tests and answer sheets were all returned to Iowa State University. The school guidance counselors administered the tests.

The following tests were given:

1. Kuder General Interest Survey
2. Nebraska Agricultural Achievement Test
3. Otis Quick-Scoring Mental Ability Tests
4. Differential Aptitude Test—Abstract
5. Differential Aptitude Test—Mechanical
6. Differential Aptitude Test—Verbal

The guidance counselor also administered a pretest over the specific subject matter to be used in each grade. These tests were prepared by
Figure 1. Geographical location of participating schools

Key: # - Treatment schools
* - Control schools
Table 1. Schools and the number of students participating in the experiment by subject matter area

<table>
<thead>
<tr>
<th>Schools</th>
<th>Animal health</th>
<th>Commercial fertilizer</th>
<th>Small gasoline engines</th>
<th>Farm credit</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treatment:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earlham</td>
<td>17</td>
<td>4</td>
<td>11</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>Monticello</td>
<td>11</td>
<td>12</td>
<td>11</td>
<td>20</td>
<td>54</td>
</tr>
<tr>
<td>Northeast Community (Gooselake)</td>
<td>20</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>56</td>
</tr>
<tr>
<td>Paullina</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>9</td>
<td>51</td>
</tr>
<tr>
<td>Villisca</td>
<td>16</td>
<td>10</td>
<td>17</td>
<td>9</td>
<td>52</td>
</tr>
<tr>
<td>Wilton Junction</td>
<td>14</td>
<td>14</td>
<td>8</td>
<td>11</td>
<td>47</td>
</tr>
<tr>
<td>Total</td>
<td>91</td>
<td>64</td>
<td>74</td>
<td>71</td>
<td>300</td>
</tr>
<tr>
<td><strong>Control:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alta</td>
<td>12</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>35</td>
</tr>
<tr>
<td>Everly</td>
<td>7</td>
<td>9</td>
<td>9</td>
<td>11</td>
<td>35</td>
</tr>
<tr>
<td>Hartley</td>
<td>12</td>
<td>8</td>
<td>10</td>
<td>9</td>
<td>39</td>
</tr>
<tr>
<td>Rock Valley</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>10</td>
<td>37</td>
</tr>
<tr>
<td>Sac City</td>
<td>10</td>
<td>8</td>
<td>14</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>West Liberty</td>
<td>16</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>45</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
<td>51</td>
<td>59</td>
<td>55</td>
<td>232</td>
</tr>
</tbody>
</table>
the project members. The pretest was necessary to determine the student's knowledge of subject matter prior to the use of the treatment. A posttest (same as pretest) was given immediately upon completion of the experiment in order to determine the knowledge possessed at that time.

The posttests in each of the four subject matter areas were item analyzed to determine the reliability of each test. The results were as follows:

1. Animal health---.85
2. Commercial fertilizers---.85
3. Small gasoline engines---.85
4. Farm credit---.87

Information pertaining to the student's social-economic background was collected.

Data were also collected on the teachers. These data included 1) pre-test on subject matter, 2) posttest on subject matter, 3) Minnesota Teacher Attitude Inventory, 4) total years teaching experience, 5) tenure in present school system, and 6) amount of education (Beane, 3; Tindall, 30). The following coefficients of reliability were revealed in an item analysis of the instructor posttest scores:

1. Animal health---.80
2. Commercial fertilizers---.87
3. Small gasoline engines---.85
4. Farm credit---.84.
Training of Instructors

Two meetings of all the teachers involved in the study were held. The first training meetings were held at three selected sites over the state. Members of the project staff worked as teams in these meetings held on a Saturday two months prior to initiating the study. Primary purpose of the first meetings was to familiarize the vocational agriculture instructors and guidance personnel with the project. Other items stressed were the importance of the teacher's role in the experiment, gathering information on the number of students in classes and the testing program to be administered.

A second meeting was held on the Iowa State University campus the Saturday prior to the start of the experiment. At this time, the teachers were trained in the use of the techniques and resources. The notebooks containing the prepared lesson plans and reference material were passed out and discussed. Instructors were informed that they could use any of the following instructional aids and techniques in providing instruction: 1) individual study, 2) out of class assignments, 3) discussion, 4) lecture, 5) chalk board, 6) charts, 7) handouts, 8) pictures, 9) and utilization of small groups such as panels, role playing, etc. They were also told that they could not use any of the following: 1) audio-tutorial, 2) single concept films, 3) field trips, 4) demonstrations, 5) video tape, and 6) transparencies. It was hoped that the teacher meetings would result in uniformity in classroom procedures within the treatment and control groups.
The experiment was conducted in the high schools over a three week period of time beginning March 24, 1969.

This researcher observed the use of the prepared lesson plans in each of the treatment group schools at least once to ascertain that correct use was being made of them and that the instructor was encountering no problems. The six control schools were visited by Beane (3) and Tindall (30).

**Treatment of Data**

The data collected on the individual students in each of the schools as well as test scores, etc. were coded and transferred to 80 column IBM data processing cards. An initial run was made on the computer to obtain class means for each school. The class means were punched on another set of cards. These became the observations and were used in analyzing the data. Analysis of the data was made by the Computational Center at Iowa State University.

The relationship between the control and prepared lesson plan treatment schools was evaluated with a number of statistical procedures, including analysis of variance, a two-factor experiment with repeated measures, stepwise regression and analysis of covariance.

The following single classification analysis of variance model was used in this study:

\[ Y_{ij} = \mu + a_i + \epsilon_{ij} \]

where
\( Y \) = pretest means of class per treatment, per school

\( M \) = overall grand mean of the pretests

\( a \) = contribution of treatment effect

\( \epsilon \) = random error associated with the class pretest means

\( i = 1 \) for prepared lesson plans and \( 2 \) for control

\( j = 1, 2, ..., 6 \) for schools.

The model used for the two-factor experiment with repeated measures was as follows:

\[
Y_{ijk} = \mu + a_i + \epsilon_{ij} + \beta_k + (a\beta)_{ik} + \delta_{ijk}
\]

where

\( Y \) = pretest and posttest means of class per treatment, per school, per repeated measure

\( M \) = overall grand mean of the pretest and posttest means

\( a \) = contribution of treatment effect (prepared lesson plans vs. control)

\( \epsilon \) = error associated with the treatment effect (prepared lesson plan vs. control)

\( \beta \) = effect of the repeated measure (pretest and posttest)

\((a\beta)\) = interaction of the treatment (prepared lesson plan vs. control) and the repeated measure (pretest and posttest)

\( \delta \) = random error associated with the class pretest and posttest means

\( i = 1 \) for prepared lesson plans and \( 2 \) for control

\( j = 1, 2, ..., 6 \) for schools

\( k = 1 \) for pretest and \( 2 \) for posttest.
Variables that could be used to account for the variation in the mean posttest scores were identified through a stepwise regression analysis. The following model was used.

\[ Y_{ij} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon_{ij} \]

where

- \( Y \) = posttest mean of class per treatment, per school
- \( \beta_0 \) = Y intercept or height of regression line at origin
- \( \beta_1, \beta_2, \ldots, \beta_k \) = regression coefficients
- \( X_1, X_2, \ldots, X_k \) = independent variables used to predict posttest class means
- \( \varepsilon \) = random error associated with the class posttest means
- \( i = 1 \) for prepared lesson plans and 2 for control
- \( j = 1, 2, \ldots, 6 \) for schools
- \( k = 1, 2, \ldots, 11 \) variables.

The analysis of covariance model used was as follows:

\[ Y_{ij} = \mu + a + \beta_1 (\bar{X}_{ij} - \bar{X}_{..}) + \varepsilon_{ij} \]

where

- \( Y \) = posttest mean of class per treatment per school
- \( \mu \) = overall grand mean of the posttests
- \( a \) = contribution of treatment effect (prepared lesson plans vs. control)
- \( \beta_1 \) = regression coefficient (slope of common regression line)
- \( \bar{X}_{ij} \) = treatment or control mean
- \( \bar{X}_{..} \) = overall grand mean of combined pretest and posttest scores
- \( \varepsilon \) = random error associated with the class posttest means
$i = 1$ for prepared lesson plans and 2 for control

$j = 1, 2, \ldots, 6$ for schools.

This model was expanded accordingly when more than one covariate was used.
FINDINGS

The results of this study were analyzed in terms of the overall objectives of the subject matter selected by the project staff. Overall objectives were used as the prepared lesson plans were employed for the total class period of each day. Specific subject matter objectives were selected by the project staff on which to concentrate treatment approaches, but they were not used in this study due to the nature of the prepared lesson plans.

The statistical models used in analyzing the data are presented in the Method of Procedure chapter. As the schools were randomly selected, the class means became the experimental units and were the bases for all comparisons. The findings are presented to support the acceptance or rejection of specific null hypotheses. The hypotheses are stated in terms of and used to satisfy the objectives of the study listed in the Introduction.

The findings of this study are grouped and presented under the following four categories:

1. Ninth grade - Animal health
2. Tenth grade - Commercial fertilizer
3. Eleventh grade - Small gasoline engines
4. Twelfth grade - Farm credit

The table values of F at the five and one percent levels were obtained from Snedecor and Cochran (28, p. 560).
Ninth Grade - Animal Health

The class mean scores for the animal health unit in the treatment and control schools are presented in Table 2. The posttest score was the dependent variable in this unit and throughout the study. The scores for the remaining variables were considered as the independent variables.

The mean pretest scores in the animal health unit were 30.98 for the treatment and 34.04 for the control schools. The control schools were still higher than the treatment schools at posttest time, with the mean scores being 50.11 and 57.57 respectfully. Essentially the same scores were observed when looking at the pre- and posttests by objectives. Otis I.Q. scores of 99.43 for treatment schools and 101.96 for control schools indicated intellectual superiority in the later group. Nebraska Agricultural Achievement Test scores of 52.49 and 57.40 for treatment and control schools would support this contention.

The treatment group schools reported a mean of 171.43 crop acres and 204.25 total farm acres. This compares with 228.22 crop acres and 260.55 total crop acres for the control group. The mean animal units were 123.99 and 103.28 in favor of the control group.

The treatment school teachers had a mean score of 30.50 for knowledge of the animal health unit as compared to 33.67 for the control school. Class sizes of 16.17 for treatment and 11.50 for control schools were reported.

Variables such as DAT-Abstract, DAT-Verbal, Kuder-Mechanical,
Table 2. Mean scores for the animal health unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Variable</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
</tr>
<tr>
<td>Pretest score</td>
<td>30.98</td>
</tr>
<tr>
<td>Pretest score by objective</td>
<td>31.05</td>
</tr>
<tr>
<td>Posttest score</td>
<td>50.11</td>
</tr>
<tr>
<td>Posttest score by objective</td>
<td>49.45</td>
</tr>
<tr>
<td>Otis IQ score</td>
<td>99.43</td>
</tr>
<tr>
<td>DAT-Mechanical</td>
<td>58.08</td>
</tr>
<tr>
<td>DAT-Abstract</td>
<td>51.44</td>
</tr>
<tr>
<td>DAT-Verbal</td>
<td>47.12</td>
</tr>
<tr>
<td>Nebraska Agricultural Achievement Test</td>
<td>52.49</td>
</tr>
<tr>
<td>Kuder-Outdoor</td>
<td>70.72</td>
</tr>
<tr>
<td>Kuder-Mechanical</td>
<td>45.81</td>
</tr>
<tr>
<td>Kuder-Computational</td>
<td>51.73</td>
</tr>
<tr>
<td>Kuder-Scientific</td>
<td>34.46</td>
</tr>
<tr>
<td>Kuder-Persuasive</td>
<td>56.05</td>
</tr>
<tr>
<td>Kuder-Artistic</td>
<td>46.99</td>
</tr>
<tr>
<td>Kuder-Literary</td>
<td>51.25</td>
</tr>
<tr>
<td>Kuder-Social Service</td>
<td>37.26</td>
</tr>
<tr>
<td>Kuder-Clerical</td>
<td>51.83</td>
</tr>
<tr>
<td>Student skill sheet</td>
<td>34.81</td>
</tr>
<tr>
<td>Crop acres</td>
<td>171.43</td>
</tr>
<tr>
<td>Noncrop acres</td>
<td>31.17</td>
</tr>
<tr>
<td>Total farm acres</td>
<td>204.25</td>
</tr>
<tr>
<td>Animal units</td>
<td>103.28</td>
</tr>
<tr>
<td>Number of older brothers</td>
<td>0.93</td>
</tr>
<tr>
<td>Number of younger brothers</td>
<td>0.84</td>
</tr>
<tr>
<td>Number of older sisters</td>
<td>0.94</td>
</tr>
<tr>
<td>Number of younger sisters</td>
<td>1.10</td>
</tr>
<tr>
<td>Total number of brothers and sisters</td>
<td>3.81</td>
</tr>
<tr>
<td>Semesters of science</td>
<td>1.79</td>
</tr>
<tr>
<td>Semesters of mathematics</td>
<td>1.90</td>
</tr>
<tr>
<td>Semesters of business</td>
<td>0.13</td>
</tr>
<tr>
<td>Semesters of vocational agriculture</td>
<td>1.88</td>
</tr>
<tr>
<td>Semesters of industrial arts</td>
<td>0.43</td>
</tr>
<tr>
<td>Teacher knowledge</td>
<td>30.50</td>
</tr>
<tr>
<td>Minnesota Teacher Attitude Inventory</td>
<td>21.17</td>
</tr>
<tr>
<td>Class size</td>
<td>15.17</td>
</tr>
<tr>
<td>Department size</td>
<td>49.67</td>
</tr>
<tr>
<td>Teacher tenure</td>
<td>9.00</td>
</tr>
<tr>
<td>Teacher experience</td>
<td>13.17</td>
</tr>
</tbody>
</table>
student skill sheet, semesters of science, and semesters of vocational agriculture were markedly higher in favor of students in the control schools. Kuder-Clerical, Kuder-Artistic, and Kuder-Literary, total number of brothers and sisters, and semesters of industrial arts were the variables with the higher scores for the treatment group.

The following mean scores hold true for all four areas of animal health, commercial fertilizer, small gasoline engines and farm credit, so will not be repeated later. The mean department size was 49.67 students, the mean teacher tenure in the present school was 9.00 years, and the mean teacher experience was 13.17 years for the treatment schools. These data were all higher than data for the control schools when the mean department size was 39.17 students, the mean teacher tenure was 4.83 years, and mean years of teacher experience was 6.83 years.

$H_0$: There were no differences between the mean pretest scores for the animal health unit in the treatment and control schools.

The mean pretest scores in the treatment and control schools for the animal health unit are presented in Table 2, these being 30.98 for treatment and 34.04 for control. A single classification analysis of variance was calculated in order to determine if the six treatment schools were similar to the six control schools from the standpoint of initial knowledge of animal health possessed by the student. Data in Table 3 revealed a $F$ value of 1.26. A value of 4.96 would have been necessary to say there were significant differences between the two tests.
Table 3. Analysis of variance on mean pretest scores for the animal health unit

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>28.15</td>
<td>28.15</td>
<td>1.26</td>
</tr>
<tr>
<td>Error</td>
<td>10</td>
<td>222.84</td>
<td>22.28</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>250.99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

.05 = 4.96  
.01 = 10.04

The null hypothesis was not rejected indicating that there were no differences between the mean pretest scores for the animal health unit in the treatment and control schools.

$H_{02}$: There were no differences between the mean posttest scores for the animal health unit in the treatment and control schools.

Data from Table 2 indicate that the treatment schools had a mean posttest score of 50.11 compared to 57.57 for the control schools. The single classification analysis of variance reported in Table 4 provided a nonsignificant F value of 2.49. Hence, the null hypothesis that there were no differences between the mean posttest scores for the animal health unit in the treatment and control schools was not rejected.
Table 4. Analysis of variance on mean posttest scores for the animal health unit

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>167.03</td>
<td>167.03</td>
<td>2.49</td>
</tr>
<tr>
<td>Error</td>
<td>10</td>
<td>670.71</td>
<td>67.07</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>837.74</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

.05 = 4.96
.01 = 10.04

H03: There were no differences between the combined mean pre- and posttest scores in the treatment and control schools for the animal health unit.

H04: There were no differences between the mean pretest and posttest scores in the treatment and control schools for the animal health unit.

H05: There were no differences in the magnitude of change, from the mean pretest to posttest scores in the treatment and control schools for the animal health unit.

The above three hypotheses were tested with an analysis of a two factor experiment using repeated measures as described by Winer (33). He explained that in testing hypotheses two separate error terms should be used. The effects tested in hypothesis H03 would be confounded with the difference between the pretest and posttest means. The chance for significance would be greatly reduced in that the corresponding error variance would be large. The other two hypotheses, H04 and H05, were
tested with another error term which was not affected by the confounding.

Analysis of the two-factor experiment using the repeated measures of mean pretest and posttest scores in the animal health unit are revealed in Table 5. A nonsignificant F-value of 2.13 was observed in testing $H_{03}$. The null hypothesis was not rejected. There were no differences between the combined mean pre- and posttest scores in the treatment and control schools for the animal health unit.

The 240.62 F-value indicated for $H_{04}$ was highly significant beyond the .01 level. The null hypothesis was rejected. There was a significant gain in knowledge between the time the pretest and posttest were administered. There were differences between the mean pretest and posttest scores in the treatment and control schools for the animal health unit.

Interpretation of the test for $H_{05}$ would not cause rejection of this hypothesis. The nonsignificant 2.56 F-value would indicate that there were no differences in the magnitude of change from the mean pretest to posttest scores in the treatment and control schools for the animal health unit.

Inspection of the data in Table 6 reveal a stepwise regression using class means in the animal health unit. Draper and Smith (14, p. 63) indicated in explaining variation in the data, $R^2$ is often used as a convenient measure of the success of the regression equation. They say:

...we must be sure that an improvement in $R^2$ due to adding a new term to the model has some real significance and is not due to the fact that the number of parameters in the model is getting close to the saturation point—that is, the number of observations.
Table 5. Analysis of a two-factor experiment using the repeated measures of mean pretest and posttest scores for the animal health unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>1</td>
<td>1166.16</td>
<td>166.16</td>
<td>2.13</td>
</tr>
<tr>
<td>Error (a)</td>
<td>10</td>
<td>780.06</td>
<td>78.01</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
<td>2730.87</td>
<td>2730.87</td>
<td>240.62**</td>
</tr>
<tr>
<td>Method x time</td>
<td>1</td>
<td>29.02</td>
<td>29.02</td>
<td>2.56</td>
</tr>
<tr>
<td>Error (b)</td>
<td>10</td>
<td>113.49</td>
<td>11.35</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>3819.60</td>
<td></td>
<td>.05 = 4.96, .01 = 10.04</td>
</tr>
</tbody>
</table>

**Significant beyond the one percent level.

Table 6. Stepwise regression using class means for the animal health unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Step</th>
<th>Process</th>
<th>Variable</th>
<th>R²</th>
<th>F to remove</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Entered</td>
<td>Otis IQ</td>
<td>0.8152</td>
<td>44.13</td>
</tr>
<tr>
<td>2</td>
<td>Entered</td>
<td>DAT-Mechanical</td>
<td>0.9334</td>
<td>15.98</td>
</tr>
<tr>
<td>3</td>
<td>Entered</td>
<td>Semesters of vocational agriculture</td>
<td>0.9711</td>
<td>10.42</td>
</tr>
<tr>
<td>4</td>
<td>Entered</td>
<td>Semesters of business</td>
<td>0.9842</td>
<td>5.77</td>
</tr>
<tr>
<td>5</td>
<td>Entered</td>
<td>Semesters of mathematics</td>
<td>0.9957</td>
<td>15.92</td>
</tr>
<tr>
<td>6</td>
<td>Entered</td>
<td>Noncrop acres</td>
<td>0.9990</td>
<td>16.48</td>
</tr>
<tr>
<td>7</td>
<td>Entered</td>
<td>Total farm acres</td>
<td>0.9997</td>
<td>11.30</td>
</tr>
<tr>
<td>8</td>
<td>Entered</td>
<td>Number of younger brothers</td>
<td>1.0000</td>
<td>99.00</td>
</tr>
</tbody>
</table>
In the stepwise regression analysis three variables accounted for 97 percent of the variation in the data. These variables were Otis IQ, DAT-Mechanical, and semesters of vocational agriculture. Other variables were added to the model but they were of little value because the number of parameters was approaching the saturation point. The $R^2$ did reach 1.00 in the eighth step.

$H_{06}$: There were no differences between the mean posttest scores for the animal health unit for the treatment and control schools when Otis IQ, DAT-Mechanical, and semesters of vocational agriculture were used as covariates.

The analysis of covariance is a statistical technique that accounts for initial group differences, thus resulting in more precise comparisons. An increased accurate analysis should be obtained by adjusting the posttest class means for initial differences in classes due to specific variables in the treatment and control groups.

In this study the schools were randomized and not the students. The class means became the experimental units resulting in only 12 observations for the two groups. With this size number, normality and homogeneity could not be guaranteed. Winer (33, p. 586) stated:

Evidence from the usual analysis of variance indicates that $F$ tests in the analysis of covariance are robust with respect to the violation of the two assumptions, normality and homogeneity of the residual variance.

The number of covariates that could be used in the model at one time was limited in that the number of observations (experimental units were also class means) was 12. The maximum adjustment of posttest means was obtained with no more than three covariates in the model.
The mean pretest scores presented in Table 2 for the animal health unit in the treatment and control schools revealed that the students in the control schools had greater ability than those in the treatment schools. The unadjusted and adjusted posttest means are presented in Table 7. An inspection of these scores indicated an initial difference of 7.46 points in favor of the control schools. After the adjustment was made in the means this difference was reduced to 3.56 points. Table 8 reports an analysis of covariance that was computed on the posttest scores using Otis IQ, DAT-Mechanical and semesters of vocational agriculture as covariates. The F-value was reduced to 0.69. The null hypothesis stating that there were no differences between the mean posttest scores for the animal health unit in the treatment and control schools when Otis IQ, DAT-Mechanical and semesters of vocational agriculture were used as covariates was not rejected.

Table 7. Effect of covariates, Otis IQ, DAT-Mechanical, and semesters of vocational agriculture on mean posttest scores for the animal health unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Method</th>
<th>Posttest</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unadjusted</td>
<td>Adjusted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>means</td>
<td>means</td>
</tr>
<tr>
<td>Treatment</td>
<td>50.11</td>
<td>52.06</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>57.57</td>
<td>55.62</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>-7.46</td>
<td>-3.56</td>
<td></td>
</tr>
</tbody>
</table>

Difference: - = in favor of control  
+ = in favor of treatment
Table 8. Analysis of covariance using Otis IQ, DAT-Mechanical and semesters of vocational agriculture as covariates on mean posttest scores for the animal health unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>17.97</td>
<td>17.97</td>
<td>0.69</td>
</tr>
<tr>
<td>Error</td>
<td>7</td>
<td>183.32</td>
<td>26.19</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>201.29</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

.05 = 5.59
.01 = 12.25

Tenth Grade - Commercial Fertilizer

The means for the treatment and control classes for the commercial fertilizer unit are reported in Table 9. The dependent variable in this unit was the posttest score. The scores for the remaining variables were considered as the independent variables.

Pretest scores for the commercial fertilizer unit indicate the controls schools' mean of 33.62 was 1.96 higher than the mean of 31.66 for the treatment schools. The mean posttest scores were 44.87 for the treatment and 48.26 for the control schools. In comparing the pre- and posttest scores by objectives this same trend was observed. As was the case with the freshman students, the mean Otis I.Q. scores of 104.20 for control was higher than that of 100.36 for the treatment school students.

The Nebraska Agricultural Achievement Test score of 57.94 for the
Table 9. Mean scores for the commercial fertilizer unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest score</td>
<td>31.66</td>
<td>33.62</td>
</tr>
<tr>
<td>Pretest score by objective</td>
<td>33.61</td>
<td>36.38</td>
</tr>
<tr>
<td>Posttest score</td>
<td>44.87</td>
<td>48.26</td>
</tr>
<tr>
<td>Posttest score by objective</td>
<td>48.45</td>
<td>55.31</td>
</tr>
<tr>
<td>Otis IQ score</td>
<td>100.36</td>
<td>104.20</td>
</tr>
<tr>
<td>DAT-Mechanical</td>
<td>52.16</td>
<td>65.84</td>
</tr>
<tr>
<td>DAT-Abstract</td>
<td>59.62</td>
<td>73.44</td>
</tr>
<tr>
<td>DAT-Verbal</td>
<td>51.05</td>
<td>59.15</td>
</tr>
<tr>
<td>Nebraska Agriculture Achievement Test</td>
<td>57.94</td>
<td>62.14</td>
</tr>
<tr>
<td>Kuder-Outdoor</td>
<td>68.00</td>
<td>74.00</td>
</tr>
<tr>
<td>Kuder-Mechanical</td>
<td>40.51</td>
<td>57.12</td>
</tr>
<tr>
<td>Kuder-Computational</td>
<td>59.30</td>
<td>47.68</td>
</tr>
<tr>
<td>Kuder-Scientific</td>
<td>35.34</td>
<td>37.51</td>
</tr>
<tr>
<td>Kuder-Persuasive</td>
<td>50.40</td>
<td>53.67</td>
</tr>
<tr>
<td>Kuder-Artistic</td>
<td>42.73</td>
<td>48.99</td>
</tr>
<tr>
<td>Kuder-Literary</td>
<td>51.68</td>
<td>48.38</td>
</tr>
<tr>
<td>Kuder-Social Service</td>
<td>43.65</td>
<td>40.98</td>
</tr>
<tr>
<td>Kuder-Clerical</td>
<td>60.90</td>
<td>56.01</td>
</tr>
<tr>
<td>Student skill sheet</td>
<td>16.40</td>
<td>13.72</td>
</tr>
<tr>
<td>Crop acres</td>
<td>144.56</td>
<td>236.98</td>
</tr>
<tr>
<td>Noncrop acres</td>
<td>37.55</td>
<td>51.30</td>
</tr>
<tr>
<td>Total farm acres</td>
<td>182.64</td>
<td>289.79</td>
</tr>
<tr>
<td>Animal units</td>
<td>69.29</td>
<td>186.58</td>
</tr>
<tr>
<td>Number of older brothers</td>
<td>0.75</td>
<td>1.14</td>
</tr>
<tr>
<td>Number of younger brothers</td>
<td>0.97</td>
<td>0.67</td>
</tr>
<tr>
<td>Number of older sisters</td>
<td>1.14</td>
<td>0.97</td>
</tr>
<tr>
<td>Number of younger sisters</td>
<td>0.77</td>
<td>0.85</td>
</tr>
<tr>
<td>Total number of brothers and sisters</td>
<td>3.64</td>
<td>3.62</td>
</tr>
<tr>
<td>Semesters of science</td>
<td>2.39</td>
<td>2.75</td>
</tr>
<tr>
<td>Semesters of business</td>
<td>2.48</td>
<td>2.98</td>
</tr>
<tr>
<td>Semesters of mathematics</td>
<td>0.28</td>
<td>0.21</td>
</tr>
<tr>
<td>Semesters of vocational agriculture</td>
<td>3.33</td>
<td>3.62</td>
</tr>
<tr>
<td>Semesters of industrial arts</td>
<td>0.83</td>
<td>0.00</td>
</tr>
<tr>
<td>Teacher knowledge</td>
<td>28.50</td>
<td>33.50</td>
</tr>
<tr>
<td>Minnesota Teacher Attitude Inventory</td>
<td>21.17</td>
<td>52.67</td>
</tr>
<tr>
<td>Class size</td>
<td>10.50</td>
<td>8.83</td>
</tr>
<tr>
<td>Department size</td>
<td>49.67</td>
<td>39.17</td>
</tr>
<tr>
<td>Teacher tenure</td>
<td>9.00</td>
<td>4.83</td>
</tr>
<tr>
<td>Teacher experience</td>
<td>13.17</td>
<td>6.83</td>
</tr>
</tbody>
</table>
treatments schools was low when compared to the control schools score of 62.14. Both the Kuder-Mechanical and DAT-Mechanical scores indicated less mechanical interest possessed by students in the treatment schools.

The treatment group reported a mean farm size of 182.64 acres with 144.56 crop acres. These were much less than the 289.79 acre farm size and 236.98 crop acres reported by the control group.

The teachers in the control schools displayed more knowledge of commercial fertilizer in that they had a mean score of 33.50, whereas the treatment school teachers had a score of 28.50. The mean class size was 10.50 students for the treatment and 8.83 for the control schools.

The treatment group had the higher means for the variables Kuder-Computational, Kuder-Literary, Kuder-Social Service, and Kuder-Clerical, and student skill sheet. Variables DAT-Mechanical, DAT-Abstract, and DAT-Verbal, Kuder-Outdoor, Kuder-Artistic, animal units, and semesters of vocational agriculture strongly favored the control schools.

Hₐₐₐₐ: There were no differences between the mean pretest scores for the commercial fertilizer unit in the treatment and control schools.

Data in Table 9 reveal that the mean pretest score of the control schools exceeded that of the treatment schools by 1.96 points. An analysis of variance in Table 10 compares the mean pretest scores in the commercial fertilizer unit for the two groups of schools. A non-significant F-value of 0.35 supported the null hypothesis. There were no differences between the mean pretest scores for the commercial fertilizer unit in the treatment and control schools.
Table 10. Analysis of variance on mean pretest scores for the commercial fertilizer unit

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>11.51</td>
<td>11.51</td>
<td>0.35</td>
</tr>
<tr>
<td>Error</td>
<td>10</td>
<td>330.30</td>
<td>33.03</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>341.81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ho₀: There were no differences between the mean posttest scores for the commercial fertilizer unit in the treatment and control schools.

The mean posttest scores of the treatment and control schools for the commercial fertilizer unit are reported in Table 9. A single classification analysis of variance was calculated in order to determine if there were any significant differences at the time of the posttest and is presented in Table 11. A nonsignificant F-value of 0.31 was obtained and the null hypothesis was not rejected. There were no differences between the mean posttest scores for the commercial fertilizer unit in the treatment and control schools.

Ho₀: There were no differences between the combined mean pre- and posttest scores in the treatment and control schools for the commercial fertilizer unit.
Table 11. Analysis of variance on mean posttest scores for the commercial fertilizer unit

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>34.58</td>
<td>34.58</td>
<td>0.31</td>
</tr>
<tr>
<td>Error</td>
<td>10</td>
<td>1104.40</td>
<td>110.44</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>1138.98</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ho\textsubscript{10}: There were no differences between the mean pretest and posttest scores in the treatment and control schools for the commercial fertilizer unit.

Ho\textsubscript{11}: There were no differences in the magnitude of change from the mean pretest to posttest scores in the treatment and the control schools for the commercial fertilizer unit.

An inspection of the data in Table 12 reveal an analysis of a two-factor experiment using the repeated measures of mean pretest and posttest scores in the commercial fertilizer unit. The F-value of 0.35 was nonsignificant. Based on this finding the null hypothesis, Ho\textsubscript{9} was not rejected. There were no differences between the combined mean pretest and posttest scores in the treatment and control schools for the commercial fertilizer unit. However, this effect was confounded with the differences between the pre- and posttest means as discussed earlier in the findings.
Ho10 was rejected due to a highly significant F-value of 57.86. An increase of knowledge had taken place between pretest and posttest time. There were differences between the mean pre- and posttest scores in the treatment and control schools in the commercial fertilizer unit.

A nonsignificant F-value of 0.15 was grounds for failing to reject Ho11. There were no differences in the magnitude of change from the mean pretest to posttest scores in the treatment and control schools for the commercial fertilizer unit.

Table 12. Analysis of a two-factor experiment using the repeated measures of mean pretest and posttest scores for the commercial fertilizer unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>1</td>
<td>42.99</td>
<td>42.99</td>
<td>0.35</td>
</tr>
<tr>
<td>Error (a)</td>
<td>10</td>
<td>1233.53</td>
<td>123.35</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
<td>1163.99</td>
<td>1163.99</td>
<td>57.86**</td>
</tr>
<tr>
<td>Method x time</td>
<td>1</td>
<td>3.10</td>
<td>3.10</td>
<td>0.15</td>
</tr>
<tr>
<td>Error (b)</td>
<td>10</td>
<td>201.17</td>
<td>20.12</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>2644.78</td>
<td></td>
<td>.05 = 4.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.01 = 10.04</td>
</tr>
</tbody>
</table>

**Significant beyond the one percent level.
Stepwise regression using class means for the commercial fertilizer unit in the treatment and control schools is presented in Table 13. Only two variables, pretest and noncrop acres entered the regression. They accounted for 86 percent of the variance in the posttest scores.

Table 13. Stepwise regression using class means for the commercial fertilizer unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Step</th>
<th>Process</th>
<th>Variable</th>
<th>R²</th>
<th>F to remove</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Entered</td>
<td>Pretest</td>
<td>0.7383</td>
<td>28.21</td>
</tr>
<tr>
<td>2</td>
<td>Entered</td>
<td>Noncrop acres</td>
<td>0.8605</td>
<td>7.88</td>
</tr>
</tbody>
</table>

Ho₁₂: There were no differences between the mean posttest scores for the commercial fertilizer unit in the treatment and control schools when pretest and noncrop acres were used as covariates.

Data in Table 9 present the mean scores in the pretest and the noncrop acres for the commercial fertilizer unit in the treatment and control schools. The unadjusted and adjusted posttest means for the treatment and control schools may be examined in Table 14. An initial difference of 3.39 points in favor of the control schools was observed in the mean posttest scores. The difference was 2.29 points in favor of the control schools after adjusting the means. An analysis of covariance is reported in Table 15 on the posttest means in the commercial fertilizer unit using pretest and noncrop acres as covariates. The null hypothesis
Table 14. Effect of covariates pretest score and noncrop acres on mean posttest scores for the commercial fertilizer unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Method</th>
<th>Posttest Unadjusted means</th>
<th>Adjusted means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>44.87</td>
<td>45.42</td>
</tr>
<tr>
<td>Control</td>
<td>48.26</td>
<td>47.71</td>
</tr>
<tr>
<td>Difference</td>
<td>-3.39</td>
<td>-2.29</td>
</tr>
</tbody>
</table>

Difference: = in favor of control  
+ = in favor of treatment

Table 15. Analysis of covariance using pretest score and noncrop acres as covariates on mean posttest scores for the commercial fertilizer unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>13.78</td>
<td>13.78</td>
<td>0.62</td>
</tr>
<tr>
<td>Error</td>
<td>8</td>
<td>178.97</td>
<td>22.37</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>192.75</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

.05 = 5.32  
.01 = 11.26
was not rejected as a nonsignificant F-value of 0.62 was obtained. There were no differences between the mean posttest scores for the commercial fertilizer unit in the treatment and control schools when pretest and noncrop acres were used as covariates.

Eleventh Grade - Small Gasoline Engines

The class mean scores for the small gasoline engine unit are presented in Table 16 for the treatment and control schools. The dependent variable was the posttest score, whereas the scores for the remaining variables were the independent variables.

Observation of the pretest scores in the treatment and control schools indicate mean scores of 43.08 and 38.42 respectively. However, the results of the posttest showed scores of 63.84 for the treatment and 68.44 for the control schools for the small gasoline engines unit. The pre- and posttest scores by objectives nearly paralleled the overall pre- and posttest scores. The control group had an edge over the treatment group, 104.73 to 102.32, in Otis I.Q. scores. The treatment school scores of 55.96 for DAT-Mechanical and 55.57 for Kuder-Mechanical were higher than respective scores of 51.14 and 51.58 on the control schools. Scores of 35.31 for the treatment and 21.88 for the control schools were reported for the student skill sheets.

A difference of nearly 100 acres in farm size was indicated when the treatment group's 173.48 crop acres and 199.63 total farm acres was compared to the control group's 267.93 crop acres and 297.07 total farm acres. Mean scores indicated 122.36 animal units for the students in
Table 16. Mean scores for the small gasoline engines unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Variable</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
</tr>
<tr>
<td>Pretest score</td>
<td>43.08</td>
</tr>
<tr>
<td>Pretest score by objective</td>
<td>41.21</td>
</tr>
<tr>
<td>Posttest score</td>
<td>63.84</td>
</tr>
<tr>
<td>Posttest score by objective</td>
<td>63.24</td>
</tr>
<tr>
<td>Otis IQ score</td>
<td>102.32</td>
</tr>
<tr>
<td>DAT-Mechanical</td>
<td>55.96</td>
</tr>
<tr>
<td>DAT-Abstract</td>
<td>48.90</td>
</tr>
<tr>
<td>DAT-Verbal</td>
<td>46.44</td>
</tr>
<tr>
<td>Nebraska Agriculture Achievement Test</td>
<td>62.31</td>
</tr>
<tr>
<td>Kuder-Outdoor</td>
<td>66.59</td>
</tr>
<tr>
<td>Kuder-Mechanical</td>
<td>55.57</td>
</tr>
<tr>
<td>Kuder-Computational</td>
<td>50.26</td>
</tr>
<tr>
<td>Kuder-Scientific</td>
<td>34.55</td>
</tr>
<tr>
<td>Kuder-Persuasive</td>
<td>51.17</td>
</tr>
<tr>
<td>Kuder-Artistic</td>
<td>47.85</td>
</tr>
<tr>
<td>Kuder-Literary</td>
<td>47.03</td>
</tr>
<tr>
<td>Kuder-Social Service</td>
<td>45.20</td>
</tr>
<tr>
<td>Kuder-Clerical</td>
<td>58.39</td>
</tr>
<tr>
<td>Student skill sheet</td>
<td>35.31</td>
</tr>
<tr>
<td>Crop acres</td>
<td>173.48</td>
</tr>
<tr>
<td>Noncrop acres</td>
<td>56.79</td>
</tr>
<tr>
<td>Total farm acres</td>
<td>199.63</td>
</tr>
<tr>
<td>Animal units</td>
<td>122.36</td>
</tr>
<tr>
<td>Number of older brothers</td>
<td>0.76</td>
</tr>
<tr>
<td>Number of younger brothers</td>
<td>0.94</td>
</tr>
<tr>
<td>Number of older sisters</td>
<td>1.09</td>
</tr>
<tr>
<td>Number of younger sisters</td>
<td>0.91</td>
</tr>
<tr>
<td>Total numbers of brothers and sisters</td>
<td>3.70</td>
</tr>
<tr>
<td>Semesters of science</td>
<td>2.75</td>
</tr>
<tr>
<td>Semesters of mathematics</td>
<td>3.27</td>
</tr>
<tr>
<td>Semesters of business</td>
<td>0.73</td>
</tr>
<tr>
<td>Semesters of vocational agriculture</td>
<td>5.30</td>
</tr>
<tr>
<td>Semesters of industrial arts</td>
<td>1.91</td>
</tr>
<tr>
<td>Teacher knowledge</td>
<td>25.33</td>
</tr>
<tr>
<td>Minnesota Teacher Attitude Inventory</td>
<td>21.17</td>
</tr>
<tr>
<td>Class size</td>
<td>12.17</td>
</tr>
<tr>
<td>Department size</td>
<td>49.67</td>
</tr>
<tr>
<td>Teacher tenure</td>
<td>9.00</td>
</tr>
<tr>
<td>Teacher experience</td>
<td>13.17</td>
</tr>
</tbody>
</table>
treatment schools as compared to 249.93 animal units for the control schools.

The students in the control schools had better high school backgrounds in that they had completed 3.57 semesters of science, 3.84 semesters of mathematics and 5.64 semesters of vocational agriculture. Students in the treatment schools had completed 2.75 semesters of science 3.27 semesters of mathematics and 5.30 semesters of vocational agriculture.

The teachers in the treatment schools possessed less knowledge in small gasoline engines than teachers in the control schools with scores of 25.33 and 31.50 respectively. The treatment group teachers also had larger classes, 12.17 students as compared to 9.67 for the control teachers.

Noticeably higher scores were obtained in the treatment schools in the areas of Nebraska Agricultural Achievement Test, Kuder-Scientific, Kuder-Artistic, and Kuder-Clerical, and lower scores in the areas of DAT-Abstract, DAT-Verbal, Kuder-Outdoors, Kuder-Computational, Kuder-Persuasive and Kuder-Social Service.

$H_{013}$: There were no differences between the mean pretest scores for the small gasoline engines unit in the treatment and control schools.

Data in Table 17 report the pretest means for the treatment and control schools in the small gasoline engines unit. When the pretest scores were compared in an analysis of variance test a nonsignificant F-value of 0.99 was obtained as seen in Table 18. The null hypothesis was not rejected. There were no differences between the mean pretest scores for the small gasoline engines unit in the treatment and control schools.
Table 17. Analysis of variance on mean pretest scores for the small gasoline engines unit

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>64.96</td>
<td>64.96</td>
<td>0.99</td>
</tr>
<tr>
<td>Error</td>
<td>10</td>
<td>659.11</td>
<td>65.91</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>724.07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ho\(_{14}\): There were no differences between the mean posttest scores for the small gasoline engines unit in the treatment and control schools.

The mean posttest scores for the small gasoline engines unit in the treatment and control schools are reported in Table 16. A single classification analysis of variance was calculated to determine if there were any significant differences between the treatment and control school posttest mean scores. This analysis of variance is reported in Table 18. The F-value of 2.60 was not significant resulting in failure to reject the null hypothesis. There were no differences between the mean posttest scores for the small gasoline engines unit in the treatment and control schools.

Ho\(_{15}\): There were no differences between the combined mean pre- and posttest scores in the treatment and control schools for the small gasoline engines unit.
Table 18. Analysis of variance on mean posttest scores for the small gasoline engines unit

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>63.53</td>
<td>63.53</td>
<td>2.60</td>
</tr>
<tr>
<td>Error</td>
<td>10</td>
<td>244.65</td>
<td>24.46</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>308.18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(0.05 = 4.96\)
\(0.01 = 10.04\)

\(H_{0_{16}}\): There were no differences between the mean pretest and posttest scores in the treatment and control schools for the small gasoline engines unit.

\(H_{0_{17}}\): There were no differences in the magnitude of change from the mean pretest to posttest scores in the treatment and control schools for the small gasoline engines unit.

The three hypotheses were tested with an analysis of a two-factor experiment using repeated measures. A nonsignificant F-value of 0.00006 was obtained for \(H_{0_{15}}\). The differences between the pre- and posttest mean scores confounded the effects tested. The null hypothesis was not rejected. There were no differences between the combined mean pre- and posttest scores in the treatment and control schools for the small gasoline engines unit.

An F-value of 168.62, highly significant beyond the .01 level, was reported for \(H_{0_{16}}\). This hypothesis was rejected. There were differences
between the mean pretest and posttest scores in the treatment and control schools for the small gasoline engines unit.

$H_0$ was also rejected. The analysis of variance provided a significant $F$-value of 5.60. There were differences in the magnitude of change from the mean pretest to posttest scores in the treatment and control schools for the small gasoline engines unit.

Table 19. Analysis of a two-factor experiment using the repeated measures of mean pretest and posttest scores for the small gasoline engines unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>1</td>
<td>0.004</td>
<td>0.004</td>
<td>0.000 06</td>
</tr>
<tr>
<td>Error (a)</td>
<td>10</td>
<td>674.36</td>
<td>67.44</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
<td>3868.15</td>
<td>3868.15</td>
<td>168.62**</td>
</tr>
<tr>
<td>Method x time</td>
<td>1</td>
<td>128.48</td>
<td>128.48</td>
<td>5.60*</td>
</tr>
<tr>
<td>Error (b)</td>
<td>10</td>
<td>229.40</td>
<td>22.94</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>4900.39</td>
<td></td>
<td>.05 = 4.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.01 = 10.04</td>
</tr>
</tbody>
</table>

*Significant beyond the five percent level.

**Significant beyond the one percent level.

Data in Table 20 present the small gasoline engines unit stepwise regression using class means scores for the treatment and control schools. The first three variables, Nebraska Agricultural Achievement Test, teacher knowledge, and number of younger sisters accounted for
89 percent of the variance in the data. The saturation point in the small gasoline engines unit was reached with the 9th step, causing the $R^2$ to reach 1.00.

Table 20. Stepwise regression using class means for the small gasoline engines unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Step</th>
<th>Process</th>
<th>Variable</th>
<th>$R^2$</th>
<th>$F$ to remove</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Entered</td>
<td>Nebraska Agricultural Achievement Test</td>
<td>0.5105</td>
<td>10.43</td>
</tr>
<tr>
<td>2</td>
<td>Entered</td>
<td>Teacher knowledge</td>
<td>0.7161</td>
<td>6.52</td>
</tr>
<tr>
<td>3</td>
<td>Entered</td>
<td>Number of younger sisters</td>
<td>0.8876</td>
<td>12.21</td>
</tr>
<tr>
<td>4</td>
<td>Entered</td>
<td>Minnesota Teacher Attitude Inventory</td>
<td>0.9636</td>
<td>14.61</td>
</tr>
<tr>
<td>5</td>
<td>Entered</td>
<td>Pretest</td>
<td>0.9947</td>
<td>35.52</td>
</tr>
<tr>
<td>6</td>
<td>Entered</td>
<td>Number of older sisters</td>
<td>0.9976</td>
<td>6.01</td>
</tr>
<tr>
<td>7</td>
<td>Entered</td>
<td>Kuder-Computational</td>
<td>0.9993</td>
<td>8.86</td>
</tr>
<tr>
<td>8</td>
<td>Entered</td>
<td>Semesters of science</td>
<td>0.9999</td>
<td>30.21</td>
</tr>
<tr>
<td>9</td>
<td>Entered</td>
<td>Kuder-Mechanical</td>
<td>1.0000</td>
<td>31.78</td>
</tr>
</tbody>
</table>

$H_0$: There were no differences between the mean posttest scores for the small gasoline engines unit in the treatment and control schools when the Nebraska Agricultural Achievement Test, teacher knowledge and number of younger sisters were used as covariates.
Examination of data in Table 16 reveal the mean pretest scores for the Nebraska Agricultural Achievement Test, teacher knowledge and number of younger sisters variables for the treatment and control schools. Data in Table 21 indicate a difference of 4.60 points in favor of the control schools before the adjustment of the posttest means was made. When the covariates Nebraska Agricultural Achievement Test, teacher knowledge and number of younger sisters were used to adjust the scores, the mean posttest scores for small gasoline engines in the control schools exceeded those of students in the treatment schools by only 1.58 points. An analysis of covariance computation on these posttest scores is reported in Table 22. An F-value of 1.03 was not significant resulting in failure to reject the null hypothesis. There were no differences between the mean posttest scores for the small gasoline engines unit in the treatment and control schools when the Nebraska Agricultural Achievement Test, teacher knowledge and number of younger sisters were used as covariates.

Table 21. Effect of covariates Nebraska Agriculture Achievement Test, teacher knowledge, and number of younger sisters on mean posttest scores for the small gasoline engines unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Method</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted means</td>
</tr>
<tr>
<td>Treatment</td>
<td>63.84</td>
</tr>
<tr>
<td>Control</td>
<td>68.44</td>
</tr>
<tr>
<td>Difference</td>
<td>-4.60</td>
</tr>
</tbody>
</table>

Difference: - = in favor of control  
+ = in favor of treatment
Table 22. Analysis of covariance using Nebraska Agricultural Achievement Test, teacher knowledge, and number of younger sisters as covariates on mean posttest scores for the small gasoline engines unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Residuals</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Degrees of freedom</td>
<td>Sum of squares</td>
</tr>
<tr>
<td>Treatment</td>
<td>1</td>
<td>15.50</td>
</tr>
<tr>
<td>Error</td>
<td>7</td>
<td>105.07</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>120.57</td>
</tr>
</tbody>
</table>

.05 = 5.59
.01 = 12.25

Twelfth Grade - Farm Credit

The class mean scores in the treatment and control schools for the farm credit unit are presented in Table 23. As was the case in all the other units, the posttest score was the dependent variable. The scores for the remaining variables were the independent variables.

The mean pretest score for the animal health unit was 46.00 in the treatment and 48.39 in the control schools. The students in the treatment schools had a mean score of 57.16 as compared to a score of 64.44 for the control schools on the posttest at the completion of the experiment. The Otis I.Q. scores were similar to the other classes in that students in the control schools had a score of 104.77 compared to a score of 101.92 for the treatment students indicating less ability possessed by the students in the latter group. The mean score of 69.11
Table 23. Mean scores for the farm credit unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Variable</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
</tr>
<tr>
<td>Pretest score</td>
<td>46.00</td>
</tr>
<tr>
<td>Pretest score by objective</td>
<td>52.01</td>
</tr>
<tr>
<td>Posttest score</td>
<td>57.16</td>
</tr>
<tr>
<td>Posttest scores by objective</td>
<td>62.80</td>
</tr>
<tr>
<td>Otis IQ score</td>
<td>101.92</td>
</tr>
<tr>
<td>DAT-Mechanical</td>
<td>54.62</td>
</tr>
<tr>
<td>DAT-Abstract</td>
<td>59.35</td>
</tr>
<tr>
<td>DAT-Verbal</td>
<td>47.45</td>
</tr>
<tr>
<td>Nebraska Agricultural Achievement Test</td>
<td>69.11</td>
</tr>
<tr>
<td>Kuder-Outdoor</td>
<td>68.46</td>
</tr>
<tr>
<td>Kuder-Mechanical</td>
<td>58.61</td>
</tr>
<tr>
<td>Kuder-Computational</td>
<td>51.65</td>
</tr>
<tr>
<td>Kuder-Scientific</td>
<td>26.52</td>
</tr>
<tr>
<td>Kuder-Persuasive</td>
<td>53.79</td>
</tr>
<tr>
<td>Kuder-Artistic</td>
<td>44.25</td>
</tr>
<tr>
<td>Kuder-Literary</td>
<td>46.65</td>
</tr>
<tr>
<td>Kuder-Social Service</td>
<td>50.17</td>
</tr>
<tr>
<td>Kuder-Clerical</td>
<td>57.22</td>
</tr>
<tr>
<td>Student skill sheet</td>
<td>22.51</td>
</tr>
<tr>
<td>Crop acres</td>
<td>166.35</td>
</tr>
<tr>
<td>Noncrop acres</td>
<td>51.08</td>
</tr>
<tr>
<td>Total farm acres</td>
<td>218.87</td>
</tr>
<tr>
<td>Animal units</td>
<td>92.76</td>
</tr>
<tr>
<td>Number of older brothers</td>
<td>1.08</td>
</tr>
<tr>
<td>Number of younger brothers</td>
<td>1.01</td>
</tr>
<tr>
<td>Number of older sisters</td>
<td>0.83</td>
</tr>
<tr>
<td>Number of younger sisters</td>
<td>0.95</td>
</tr>
<tr>
<td>Total number of brothers and sisters</td>
<td>3.88</td>
</tr>
<tr>
<td>Semesters of science</td>
<td>3.33</td>
</tr>
<tr>
<td>Semesters of mathematics</td>
<td>3.63</td>
</tr>
<tr>
<td>Semesters of business</td>
<td>1.02</td>
</tr>
<tr>
<td>Semesters of vocational agriculture</td>
<td>6.44</td>
</tr>
<tr>
<td>Semesters of industrial arts</td>
<td>1.43</td>
</tr>
<tr>
<td>Teacher knowledge</td>
<td>27.83</td>
</tr>
<tr>
<td>Minnesota teacher personality inventory</td>
<td>21.17</td>
</tr>
<tr>
<td>Class size</td>
<td>11.83</td>
</tr>
<tr>
<td>Department size</td>
<td>49.67</td>
</tr>
<tr>
<td>Teacher tenure</td>
<td>9.00</td>
</tr>
<tr>
<td>Teacher experience</td>
<td>13.17</td>
</tr>
</tbody>
</table>
for the treatment schools on the Nebraska Agricultural Achievement Test was slightly lower than the 69.36 score for the control group. A Kuder-Clerical score of 59.87 was observed for the control schools as compared to 57.22 for the treatment schools. More skills were possessed by the students in the control schools as indicated by mean scores of 30.73 and 22.51 respectively.

There was a marked difference in farm size, with the treatment group reporting 166.35 crop acres and 218.87 total farm acres compared to control group's reporting 259.49 crop acres and 309.71 total farm acres. The control group had an average of 158.24 animal units as compared to 92.76 animal units for the treatment group.

The control group had completed more semesters of science, 3.64 as compared to 3.33; more semesters of mathematics, 4.55, as compared to 3.63; more semesters of business, 1.64 as compared to 1.02; and more semesters of vocational agriculture, 7.19 as compared to 6.44 than had the treatment group.

The teachers in the treatment group scored 27.83 points, whereas those in the control group scored 29.33 points on the farm credit subject matter test. The mean class size for treatment schools was 11.83 students compared to 9.17 for control group.

The DAT-Mechanical, DAT-Verbal, Kuder-Persuasive, Kuder-Artistic, Kuder-Literary and Kuder-Social Service scores were higher for the treatment group. The control group excelled in the Kuder-Outdoor, Kuder-Mechanical, Kuder-Computational, and Kuder-Scientific areas.
Ho_{19}: There were no differences between the mean pretest scores for the farm credit unit in the treatment and control schools.

The pretest scores for the farm credit unit in the treatment and control schools are presented in Table 23. An initial difference 2.39 points in favor of the control schools was noted. A calculation to determine if there were any significant differences between the treatment and control group is presented in the analysis of variance in Table 24. The null hypothesis was not rejected as a nonsignificant F-value of 0.40 was obtained. There were no differences between the mean pretest scores for the farm credit unit in the treatment and control schools.

Table 24. Analysis of variance on mean pretest scores for the farm credit unit

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>17.21</td>
<td>17.21</td>
<td>0.40</td>
</tr>
<tr>
<td>Error</td>
<td>10</td>
<td>435.31</td>
<td>43.53</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>452.52</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ho_{20}: There were no differences between the mean post-test scores for the farm credit unit in the treatment and control schools.

Data in Table 23 reveal the treatment and control schools' mean posttest scores for the farm credit unit. A single class analysis of variance test on the mean posttest scores produced a nonsignificant
F-value of 2.56 in Table 25. The null hypothesis was not rejected indicating there were no differences between the mean posttest scores for the farm credit unit in the treatment and control schools.

Table 25. Analysis of variance on mean posttest scores for the farm credit unit

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>158.99</td>
<td>158.99</td>
<td>2.56</td>
</tr>
<tr>
<td>Error</td>
<td>10</td>
<td>621.38</td>
<td>62.14</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>78.37</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ F_{0.05} = 4.96 \]
\[ F_{0.01} = 10.04 \]

\( H_{01} \): There were no differences between the combined mean pretest and posttest scores in the treatment and control schools for the farm credit unit.

\( H_{02} \): There were no differences between the mean pretest and posttest scores in the treatment and control schools for the farm credit unit.

\( H_{03} \): There were no differences in the magnitude of change from the mean pretest to posttest scores in the treatment and control schools for the farm credit unit.

Hypotheses 21, 22, and 23 were tested and reported in Table 26 with a two-factor experiment using the repeated measures of mean pretest and posttest scores in farm credit. The test made on \( H_{021} \) involved a
different error term than those used in testing $H_{022}$ and $H_{023}$. A non-
significant F-value of 1.54 was obtained resulting in failure to reject
the null hypothesis. There were no differences between the combined
pre- and posttest scores in the treatment and control schools for the
farm credit unit.

The hypothesis, $H_{022}$, was also rejected due to a highly significant
F-value of 75.84. There were differences between the mean pretest
and posttest scores in the treatment and control schools for the farm
credit unit.

A nonsignificant F-value of 2.44 for the hypothesis, $H_{023}$, was
grounds for failing to reject the null hypothesis. There were no dif­
ferences in the magnitude of change from the mean pretest to posttest
scores in the treatment and control schools for the farm credit unit.

Table 26. Analysis of a two factor experiment using the repeated measures
of mean pretest and posttest scores for the farm credit unit
in the treatment and control schools

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>1</td>
<td>140.41</td>
<td>140.41</td>
<td>1.54</td>
</tr>
<tr>
<td>Error (a)</td>
<td>10</td>
<td>910.20</td>
<td>91.02</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
<td>1110.98</td>
<td>1110.98</td>
<td>75.84**</td>
</tr>
<tr>
<td>Method x time</td>
<td>1</td>
<td>35.79</td>
<td>35.79</td>
<td>2.44</td>
</tr>
<tr>
<td>Error (b)</td>
<td>10</td>
<td>146.49</td>
<td>14.65</td>
<td>.05 = 4.96</td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>2343.87</td>
<td></td>
<td>.01 = 10.04</td>
</tr>
</tbody>
</table>

**Significant beyond the one percent level.
A stepwise regression using class means in the treatment and control schools for the farm credit is presented in Table 27. Eighty-one percent of the variance in the posttest scores was accounted for by the first three variables entered in the stepwise regression. They were the Nebraska Agricultural Achievement Test, DAT-Mechanical and Kuder-Literary tests. Other variables were added with the $R^2$ reaching 1.00 in the 11th step. The Kuder-Persuasive variable was entered in the fourth step but removed in the seventh due to its effect on the regression.

Table 27. Stepwise regression using class means for the farm credit unit in the treatment and control schools

<table>
<thead>
<tr>
<th>Step</th>
<th>Process</th>
<th>Variable</th>
<th>$R^2$</th>
<th>$F$ to remove</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Entered</td>
<td>Nebraska Agricultural Achievement Test</td>
<td>0.5507</td>
<td>12.26</td>
</tr>
<tr>
<td>2</td>
<td>Entered</td>
<td>DAT-Mechanical</td>
<td>0.7056</td>
<td>4.73</td>
</tr>
<tr>
<td>3</td>
<td>Entered</td>
<td>Kuder-Literary</td>
<td>0.8064</td>
<td>4.17</td>
</tr>
<tr>
<td>4</td>
<td>Entered</td>
<td>Kuder-Persuasive</td>
<td>0.8823</td>
<td>4.52</td>
</tr>
<tr>
<td>5</td>
<td>Entered</td>
<td>Student skill sheet</td>
<td>0.9285</td>
<td>3.88</td>
</tr>
<tr>
<td>6</td>
<td>Entered</td>
<td>Semesters of mathematics</td>
<td>0.9601</td>
<td>3.97</td>
</tr>
<tr>
<td>7</td>
<td>Removed</td>
<td>Kuder-Persuasive</td>
<td>0.9381</td>
<td>2.77</td>
</tr>
<tr>
<td>8</td>
<td>Entered</td>
<td>Semesters of industrial arts</td>
<td>0.9922</td>
<td>34.56</td>
</tr>
<tr>
<td>9</td>
<td>Entered</td>
<td>Kuder-Artistic</td>
<td>0.9986</td>
<td>18.67</td>
</tr>
<tr>
<td>10</td>
<td>Entered</td>
<td>Semesters of Vocational Agriculture</td>
<td>0.9998</td>
<td>14.87</td>
</tr>
<tr>
<td>11</td>
<td>Entered</td>
<td>Kuder-Social Science</td>
<td>1.0000</td>
<td>73.79</td>
</tr>
</tbody>
</table>
Ho$_{24}$: There were no differences between the mean posttest scores for the farm credit unit in the treatment and control schools when the Nebraska Agricultural Achievement Test, DAT-Mechanical and Kuder-Literary tests were used as covariates.

Data in Table 23 reports the mean pretest scores for the Nebraska Agricultural Achievement Test, DAT-Mechanical and Kuder-Literary variables for the farm credit unit. The unadjusted and adjusted posttest means for the treatment and control groups are presented in Table 28. It was noted that the unadjusted mean posttest score for the control schools was 7.28 points higher than that of the treatment schools. This score was increased to 9.04 points in favor of the control schools, when the farm credit posttest means for the two groups were adjusted for the effects of covariates Nebraska Agricultural Achievement Test, DAT-Mechanical, and Kuder-Literary tests. An analysis of covariance used to analyze these adjusted means is reported in Table 29. The null hypothesis was not rejected as a nonsignificant F-value of 2.08 was obtained. There were no differences between the mean posttest scores for the farm credit unit in the treatment and control schools when Nebraska Agricultural Achievement Test, DAT-Mechanical, and Kuder-Literary tests were used as covariates.
Table 28. Effect of covariates Nebraska Agricultural Achievement Test, DAT-Mechanical and Kuder-Literary tests on mean posttest scores for the farm credit unit in the treatment and control schools:

<table>
<thead>
<tr>
<th>Method</th>
<th>Posttest Unadjusted means</th>
<th>Adjusted means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>57.16</td>
<td>56.28</td>
</tr>
<tr>
<td>Control</td>
<td>64.44</td>
<td>65.32</td>
</tr>
<tr>
<td>Difference</td>
<td>-7.28</td>
<td>-9.04</td>
</tr>
</tbody>
</table>

Difference: - = in favor of control  
+ = in favor of treatment

Table 29. Analysis of covariance using Nebraska Agricultural Achievement Test, DAT-Mechanical and Kuder-Literary tests as covariates on mean posttest scores for the farm credit unit in the treatment and control schools:

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Residuals</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Degrees of freedom</td>
<td>Sum of squares</td>
</tr>
<tr>
<td>Treatment</td>
<td>1</td>
<td>59.88</td>
</tr>
<tr>
<td>Error</td>
<td>7</td>
<td>102.22</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>261.10</td>
</tr>
</tbody>
</table>

.05 = 5.59  
.01 = 12.25
DISCUSSION

This experimental study was conducted to determine the value of prepared lesson plans in teaching vocational agriculture in high school.

Much data were gathered on the students for analysis. The data were analyzed using the class means as the basic observations since randomization was used to select the schools.

The findings were divided into four categories: 1) animal health; 2) commercial fertilizers; 3) small gasoline engines, and 4) farm credit. No attempt was made to combine the four subject matter areas for a composite analysis. A different pre- and posttest was needed for each of the four subject matter areas.

The means for different variables were observed. It was noted, with the exception of the small gasoline engines unit, that the treatment schools had lower pretest scores in the subject matter units. All of the posttest scores in the animal health, commercial fertilizer, small gasoline engines, and farm credit units were lower for the treatment schools than for the control schools. A higher mean Otis IQ score indicated the students in the control schools were more knowledgeable than their counterpart students in the treatment schools. In general the same statement could be made concerning the Nebraska Agricultural Achievement Test scores. The exception was that the students in the treatment group scored 1.05 mean points more than the control group in the small gasoline engines unit. The students in all four classes in the control schools had completed more semesters of vocational agriculture.
The first analysis to be made on the data was to determine if there were any significant differences between the treatment and control schools at the beginning of the experiment. A single classification analysis of variance produced nonsignificant F-values for the animal health, commercial fertilizer, small gasoline engines and farm credit units indicating that there were no differences between the two groups at pretest time. This led to the assumption that there was homogeneity within the two groups in respect to subject matter knowledge prior to participating in this project. The random selection process used was apparently successful.

Another single class analysis of variance test was made on the post-test scores. Again, the results showed no significant differences between the mean posttest scores of the treatment and control schools.

The analysis of the two-factor experiment using the repeated measures of mean pre- and posttest scores was used to determine if there was any gain in knowledge from the beginning to the end of the three-week experimental period. In each of the subject matter areas it was found that highly significant increases in knowledge had been learned by the students. This would be expected of both the treatment and control groups after they had completed the subject matter units.

This test was also used to see if there was the same magnitude of change in the students' knowledge from pre- to post-test time within the treatment and control groups. The students in the control group for the small gasoline engines unit did show a significant increase over the
treatment group in the subject matter gained. In the animal health, commercial fertilizer and farm credit units there was no significant gain in knowledge by the students in one group over the other. An interesting fact, and one that makes the small gasoline engines unit results more difficult to explain, is that the control group scored lower in both the DAT-Mechanical and Kuder-Mechanical tests than the treatment group. Yet they did significantly better on the posttest.

It has been hoped by this researcher that a significant gain in the favor of the treatment group would have been obtained in the previous analysis. Such was not the case. It should be kept in mind that this test accounted for only the differences due to the students prior knowledge of the subject matter. Other factors related to student achievement were not considered.

There was quite a variation in the mean posttest scores for the treatment and control schools. A stepwise regression identified a number of variables affecting student achievement as they entered the regression. In the animal health unit the Otis IQ, DAT-Mechanical and semesters of vocational agriculture variables accounted for most of the variance. The pretest and noncrop acres were the only variables that entered into the stepwise regression for the commercial fertilizer unit. These two variables did represent 86 percent of the variance in the data. The most variance in the small gasoline engines unit was caused by the variables, Nebraska Agricultural Achievement Test, teacher knowledge, and number of younger sisters. In the farm credit unit, the Nebraska Agricultural Achievement Test, DAT-Mechanical, and Kuder-Literary variables were the
first three variables to enter the stepwise regression.

It was interesting to view the results of the stepwise regression. Variables that the author thought might enter the stepwise regression did not. It was the opinion of the author, after his observation, that perhaps Otis IQ would be one variable that would be prominent in the stepwise regressions. However, this was true only in the animal health unit.

The Nebraska Agricultural Achievement Test did appear in two units (small gasoline engines and farm credit) and it was the first variable both times to enter the regression. It represented 51 percent of the variance in the small gasoline engines unit and 55 percent of the variance in the farm credit unit. The DAT-Mechanical mean score was the only other variable accounting for sizeable amounts of variance that entered the regression for more than one class. It came into the regression in the second step for both the animal health and the farm credit units.

Variables of less importance appearing more than once (each appeared twice) in the equations for the subject matter were: 1) semesters of vocational agriculture, 2) semesters of mathematics, 3) noncrop acres, and 4) pretest.

The fact that so many different variables entered the regression indicates that there are many factors related to student achievement. Anyone planning to enter the field of writing lesson plans should pay particular attention to these variables.
The first three variables to enter the stepwise regression were used as covariates in the analysis of covariance, with exception of the commercial fertilizer unit when only two were available. It should be emphasized that these variables did have an effect on the students' achievement. The analyses of covariance accounted for the initial student differences and then adjusted the posttest scores accordingly.

It was noted that the control schools outscored the treatment schools in most all of the independent variables used as covariates.

The adjustment of the posttest means resulted in decreasing the advantage of the control schools over the treatment schools in three of the four classes. In the farm credit unit the posttest mean was adjusted upward in favor of the control schools.

An analysis of covariance on the adjusted mean posttest scores indicated there were no significant differences between the two groups in any of the subject matter units. The F values were very small, being 0.69 for the animal health unit, 0.62 for the commercial fertilizer unit, 1.03 for the small gasoline engine unit, and 2.08 for the farm credit unit.

A generalization on the effectiveness of the prepared lesson plans might be made at this point. It would be that in all of the analyses conducted comparing the pre- and posttest scores of students in the treatment and control groups there was little difference in achievement of students by use of the two methods.
In addition, other factors such as: 1) teacher differences, 2) school differences, 3) type of class scheduling, 4) class sizes, and 5) school location should be considered as possibly affecting the results of the study.

It is difficult to determine the true value of the teacher in the classroom. This researcher weighed this fact in regard to this study.

The teachers in the treatment schools were somewhat less knowledgeable in all four subject matter areas than those in the control schools. They also scored lower on the Minnesota Teacher Attitude Inventory Test. The teachers in the treatment schools had 9.00 years of tenure in a given school compared to 4.83 years for those in the control schools. The teachers in the treatment group also had more years (13.17) of teaching experience than did the teachers in the control group (6.83).

It is a known fact that there is usually quite a range in teachers in respect to their teaching ability and knowledge of subject matter. Just how important this is to student achievement is open to question. It is possible that teacher differences did enter into this study even though a random sample of teachers was obtained.

It is also known that no two school systems are alike. The learning process may be enhanced or discouraged depending on the administration of the school system and the physical facilities available. If the climate for good learning is lacking, it can hardly be expected that students will make full use of their capabilities.
The type of scheduling could be a factor in the student's attainment. None of the schools in this study were involved in modular scheduling.

The treatment school teachers had larger classes in all four units than did the control school teachers. The mean department sizes for the treatment and control schools were 49.67 and 39.17 respectfully. The teachers in the treatment group may not have had as much time to spend with each student as did the teachers in the control group.

It should be noted that even though the schools were randomly selected for this study, five of the six control schools (Figure 1) were clustered in a small area in Northwest Iowa. This section of Iowa is a highly productive grain and livestock area. Most of the high school boys living in that area would have a strong background in general farming. These comments are sustained in that the mean number of acres farmed by parents of students in the control group was about 100 acres more than for the corresponding treatment group. Also, the mean number of animal units owned was higher in favor of the control schools. A random sample, stratified by economic areas of the state, may have been a better way of selecting the schools for the study.

There were no doubt many other factors that had an effect on the students' achievement in this study. How much effect could not be measured.

Some comments about planning and the prepared lesson plans are in order. A statement was once made that there are three things every teacher must face: death, taxes, and lesson plans. Planning is very important for the teacher.
Every teacher has a plan for his classroom presentation. He may conceive it while running down the hall to beat the bell or he may develop it carefully in advance.

The teachers who participated in treatment schools in this study were quite excited and enthusiastic about the prepared lesson plans. They cherished the idea of having all the subject matter as well as the work sheets, problems, etc., right at hand.

The author feels Hasmanek (18, p. 28) summarized the teachers' comments very well. He states that the following things are accomplished through thorough planning and lesson plans:

1. A continuity in the material being learned is insured.
2. Materials are organized so they are available when the teacher needs them.
3. The teacher gains confidence, and continuity, knowing what is next.
4. An adequate distribution of time during a period is provided.
5. Intelligent pacing of the work, provision for motivation and initiation, development, supervised study time, and evaluation are planned.
6. Worthwhile and appropriate activities, procedures and aids to learning are selected.
7. More effective teaching in harmony with objectives and philosophy is possible.
8. A continuity of learning, in event it is necessary for a teacher to be absent, is possible.
9. One of the commonest invitations to disciplinary difficulties - poor planning or lack of it is avoided.
This researcher feels that even though a random sample was used, the control schools chosen were atypical. Certainly the instruction in them was of a high caliber. There was no doubt that an added incentive existed for both the instructor and students to do well and "look good" in the final results. Other data gathered indicated on students in the control schools that they exceeded students in the treatment schools in ability even though the differences were not significantly different. Though high quality instruction was provided using the prepared lesson plans, the advantage in favor of the control schools was too great to overcome. It was indicated in the Introduction that time is of prime importance for a vocational agriculture instructor. The prepared lesson plans could be of much value to all the teachers. There are no doubt some teachers who are not quite as capable as those included in this study. The prepared lesson plans should be of particular value to them.

It was necessary that the instructors involved in the study follow the lesson plans exactly as they were developed. The prepared lesson plans contained several guidelines and specific suggestions. They perhaps could have been made more effective by further additions. However, there is no one model lesson plan. Even if there was, it would probably be unwise to suggest it. Ideally, a vocational agriculture instructor would use the prepared lesson plans and supplement them with his own knowledge and experience.

In line with the above, it was necessary in this study to restrict the use of certain techniques in the use of the prepared lesson plans.
A suggestion would be that the lesson plan serve as the basis for instruction with an incorporation of many or all of the techniques used by the other researchers in the overall experimental study. Field trips, demonstrations, video tapes, audio-tutorial, transparencies, single concept films, etc. would be excellent supplements to the prepared lesson plans. The subject matter areas of vocational agriculture lend themselves to the use of various media of teaching. Organization as well as variety of method is very important in maintaining student interest.

The field is "wide open" for the development of lesson plans. The opportunity to be of service to teachers is available for individual writers as well as for companies. The author does know of one firm that is entering the field. It is his feeling that what they are doing is going to be of a significant help to the teachers of vocational agriculture. The lesson plans are designed to save the instructor time, to encourage him to plan better teaching programs and to increase efficiency. Each lesson plan 1) develops interest, 2) presents problems, 3) raises questions about problems, 4) provides references, 5) uses instructional media and 6) suggests activities for student application and practice.

Additional research is needed to determine the effectiveness of prepared lesson plans on instruction in vocational agriculture. The first suggestion would be to replicate this study. Improvement of the study design might be to: 1) use a stratified sample based on economic areas of the state, 2) increase the number of schools involved, 3) use different
subject matter, 4) use different instructors and students, 5) use different forms of lesson plans, 6) find some way to eliminate the teacher difference variable, 7) conduct the experiment over a longer period of time, and 8) design study in order to use individual students as observational units rather than schools.

A study to determine to what use and how extensively teachers employ lesson plans would be of interest. Research is needed to determine what items and details should be included in a prepared lesson plan. Studies might also be conducted to coordinate in prepared lesson plans programmed learning and individualized instruction. Studies using the prepared lesson plans with the incorporation of the other media involved in the overall study are needed.

As educators, teachers should be concerned and desirous to adopt any method that shows promise of producing better results than now obtained. Prepared lesson plans may be a valuable aid to teachers because of the time saved during planning and preparation. Teachers of vocational agriculture will include new subject matter content in their courses if instructional materials are available. The supplying of prepared lesson plans may motivate teachers to upgrade their courses and include this new content. Teachers may have to be given assistance in utilizing the materials. They need to be informed of the assistance the material will provide and motivated to make the most effective use of the material.
SUMMARY

The purpose of this study was to experimentally determine the value of prepared lesson plans on instruction in vocational agriculture. This study was conducted as a part of a large overall project entitled "An Experimental Evaluation of the Effectiveness of Selected Techniques and Resources on Instruction in Vocational Agriculture". The project was conducted in cooperation with the Department of Agricultural Education and the Iowa Agriculture and Home Economics Experiment Station of Iowa State University; the Iowa Department of Public Instruction, Vocational Agriculture Section, and the Iowa Research Coordinating Unit.

High schools in Iowa offering an approved vocational agriculture program were identified. Schools were included in the study provided they 1) had an enrollment of 35 students, 2) offered four day classes, 3) had an enrollment of 9 to 19 students in the junior class and 7 to 22 students in each of the remaining three classes, and 4) had a teacher who had been in the high school system for at least one year. A random sample of 48 schools was selected from the schools meeting the acceptable standards. From this random sample, schools were randomly assigned to one of the seven treatment groups, or to the control groups, thus resulting in six schools per group.

It was decided by the project staff that the following subject matter units would be used: 1) animal health for the ninth grade, 2) commercial fertilizer for the tenth grade, 3) small gasoline engines for the eleventh grade, and 4) farm credit for the twelfth grade.
The problem areas and objectives were determined for each class for each of the 15 day experimental periods. An outline of these problem areas and objectives, as well as reference materials, were used in both the treatment and control schools to give as uniform instruction as possible. The only variance in instruction came from the use of the media or technique.

The prepared lesson plans were developed with the idea of giving the instructor everything he needed to completely teach the class each day for the three week period. Each day's lesson plan contained the following: 1) problem area, 2) objectives, 3) references, 4) subject matter, 5) teacher and student activities, and 6) any worksheet and/or assignments that might be needed.

Data on the students were gathered through extensive testing, use of questionnaires and from school records. The school guidance counselor administered the following tests: 1) Kuder General Interest Survey, 2) Nebraska Agricultural Achievement Test, 3) Otis Quick-Scoring Mental Ability Tests, 4) Differential Aptitude Test-Abstract, 5) Differential Aptitude Test-Mechanical, and 6) Differential Aptitude Tests-Verbal. The guidance counselor also administered a pretest over the specific subject matter to be used in each grade. A posttest (same as pretest) was given immediately upon completion of the experiment in order to determine the knowledge possessed at that time. Information pertaining to the student's social-economic background was collected.

Data collected on the teachers included: 1) pretest on subject matter, 2) posttest on subject matter, 3) Minnesota Teacher Attitude
Inventory, 4) total years teaching experience, 5) tenure in present school system, and 6) amount of education.

Two meetings of all the teachers involved in the study were held. The primary purpose of the first meeting was to familiarize the vocational agriculture instructors and guidance personnel with the project. A second meeting was held on the Iowa State University campus, the Saturday prior to the start of the experiment, to train the teachers in the use of the techniques and resources. The experiment was conducted in the high schools over a three-week period of time beginning March 24, 1969.

The data collected were coded and transferred to 80 column IBM data processing cards. The class means were computed and became the observations that were used in analyzing the data. The statistical procedures used in the study included analysis of variance, a two-factor experiment with repeating measures, stepwise regression and analysis of covariance.

The means revealed that the scores for the treatment schools in the animal health, commercial fertilizer, small gasoline engines and farm credit units were lower than those for the control schools. In general, this included the means for the pretest, posttest, Otis IQ score, Nebraska Agricultural Achievement Test, crop acres, total farm acres, animal units, semesters of vocational agriculture, teacher knowledge, and Minnesota Teacher Attitude Inventory. Means in favor of the treatment group were class size, department size, teacher tenure, and teacher experience. A definite categorization of the other means was not possible.
A single classification analysis of variance was computed in order to determine if the six treatment schools were similar to the six control schools from the standpoint of initial knowledge of subject matter possessed by the students. No significant differences were found between the mean pretest scores of the treatment and control schools.

Examination of the posttest scores revealed higher scores for the control schools in all four subject matter areas. However, a single classification analysis of variance reported nonsignificant F-values indicating there were no differences between the mean posttest scores in any of the units.

The analysis of the two-factor experiment with repeated measures of mean pre- and posttest scores provided a test to determine if there was any gain in knowledge from the beginning to the end of the three-week experimental period. Highly significant F-values indicated there was a significant gain in knowledge in both the treatment and control schools between the time the pretests and posttests were administered. A significant difference was observed for the small gasoline engines unit when the magnitude of change from the mean pretest to posttest scores in the two groups of schools was analyzed. No significant differences were found for the other three units of animal health, commercial fertilizer and farm credit.

A stepwise regression using class means was computed for the animal health, commercial fertilizer, small gasoline engines and farm credit units. The first three variables to enter the regression were of the most interest as they were used as covariates in the analyses of
covariance test. They accounted for most of the variance in the data, as the $R^2$ was at least .86 or above in each of the four subject matter areas. The stepwise regression analysis for the animal health unit contained the variables: Otis IQ, DAT-Mechanical, semesters of vocational agriculture, semesters of business, semesters of mathematics, non-crop acres, total farm acres and the number of younger brothers. Only two variables entered the regression for the commercial fertilizer unit. They were: pretest and noncrop acres. In the small gasoline engines unit, the variables included in the stepwise regression analysis were: the Nebraska Agricultural Achievement Test, teacher knowledge, number of younger sisters, Minnesota Teacher Attitude Inventory, pretest, number of older sisters, Kuder-Computational, semesters of science, and Kuder-Mechanical. The variables for the farm credit unit included: The Nebraska Agricultural Achievement Test, DAT-Mechanical, Kuder-Literary, Kuder-Persuasive, student skill sheet, semesters of mathematics, Kuder-Persuasive, semesters of industrial arts, Kuder-Artistic, semesters of vocational agriculture and Kuder-Social Science.

As was indicated previously, the covariates for the analysis of covariance were identified by the stepwise regression. The use of Otis IQ, DAT-Mechanical, and the semesters of vocational agriculture as covariates in the animal health unit resulted in reducing the posttest means from 7.46 to 3.56 points in favor of the control group. In the commercial fertilizer unit, the covariates pretest and noncrop crop acres adjusted the posttest score to 2.29 points in favor of the control schools. The small gasoline engines unit unadjusted score favored the
control schools by 4.60 points. This was reduced to 1.58 points when the Nebraska Agricultural Achievement Test, teacher knowledge, and a number of younger sisters variables were used as covariates. The use of the Nebraska Agriculture Achievement Test, DAT-Mechanical and Kuder-Literary as covariates in the commercial fertilizer unit resulted in an upward adjustment of the posttest mean. It went from 7.28 to 9.04 points in favor of the control schools. An analysis of covariance on these posttest means in the animal health, commercial fertilizer, small gasoline engines, and farm credit unit revealed no significant differences between the means in any of the units when the respective variables were used as covariates.

The findings of this study can be summarized in the following summary statements:

1. The students in the treatment and control schools were essentially equal before the start of the experiment in knowledge of the four subject matter areas.

2. There was a significant gain in knowledge by the students in the treatment and control groups over the three-week experimental period.

3. There were no differences between the treatment and control groups in the magnitude of change in knowledge from the pretest to posttest except in the small gasoline engines unit. The control schools in this unit had a significantly greater magnitude of change.
4. There were many variables that affected student achievement.
   Eight variables affected achievement in animal health, 2 in commercial fertilizer, 9 in small gasoline engines, and 11 affected achievement in farm credit.

5. There were no significant differences in achievement of the students taught with prepared lesson plans compared to those taught without prepared lesson plans.

6. The effectiveness of the use of prepared lesson plans could have been more accurately determined if the experiment had been designed to permit the observation of individual students rather than classes.

The results of this study indicate that prepared lesson plans were as effective as other methods used in the control schools in the teaching of vocational agriculture. Prepared lesson plans as an organizational and teaching tool may become even more important in the future as the demand for the vocational agriculture instructor's time continues to increase.


10. Cordes, Arnold B. A study in the career opportunities in agriculture, the development of a resource unit and a teaching unit on the topic of choosing a career in modern agriculture. Unpublished seminar report presented at University of Wisconsin in Department of Agriculture and Extension Education. Madison, Wisconsin, University of Wisconsin. 1961.


22. Luster - A teacher evaluation of selected teaching materials for programs of vocational agriculture in Kentucky. Staff Study. Lexington, Kentucky, Department of Agricultural Education, University of Kentucky. 1965.


ACKNOWLEDGEMENTS

Appreciation is expressed to Professor Clarence E. Bundy, Chairman of my Graduate Committee, for his encouragement, assistance, guidance and direction during my graduate study.

Acknowledgement is made to Dr. Alan A. Kahler, Dr. Paul D. Doak, Dr. Thomas A. Hoerner, and Professor Vilas J. Morford, members of my graduate committee, for their time and assistance.

Gratitude is expressed to other members of the project staff for their assistance and cooperation throughout the duration of the study.

Appreciation for the cooperation received is extended to the administrators, guidance counselors, vocational agriculture instructors and vocational agriculture students in the twelve schools involved in this study.

Appreciation is expressed to a "special" friend for her assistance, patience, and understanding during the time of this study.
APPENDIX A
ANIMAL HEALTH

Problem Area Outline by Days

Day
1  The Economic Importance of Livestock Diseases and Parasites
2  Factors in Maintaining Animal Health
3 & 4 Causes, Symptoms, Prevention and Control of Major Cattle Diseases
5  Life Cycles, Symptoms, Prevention and Control of Major Cattle Parasites
6 & 7 Causes, Symptoms, Prevention and Control of Major Sheep Diseases
6  Life Cycles, Symptoms, Prevention and Control of Major Sheep Parasites
9 & 10 Causes, Symptoms, Prevention and Control of Major Swine Diseases
11 Life Cycles, Symptoms, Prevention and Control of Major Swine Parasites
12 Planning a General Livestock Health Program
13 Occupational Roles of the Veterinarian, Farmer, and Other Animal Health Workers
14 Summary and Review
15 Post-Test
Behavioral Objectives: (understandings and abilities)

Understanding of:

1) The relation between control of diseases and parasites with efficient production of livestock

2) The types, causes, symptoms, prevention and control of the major diseases and parasites of livestock

3) The occupational roles of the veterinarian, farmer, and other animal health workers

4) The possibilities for employment in occupations requiring a knowledge of animal diseases and parasites

Ability to:

1) Recognize normal and abnormal health conditions prevalent in livestock and livestock production

2) Plan an effective program for controlling livestock diseases and parasites

3) Maintain desirable animal health conditions for livestock
Day 1

1. PROBLEM AREA: The Economic Importance of Livestock Diseases and Parasites

Objectives:

To develop an understanding of:

a. The importance of livestock diseases and parasites upon profitable livestock production
b. The amount of damage done to livestock and livestock products by diseases and parasites
c. The cost of controlling livestock diseases and parasites

References:

a. Animal Health, Ch. 1, pp. 1-6

Day 2

2. PROBLEM AREA: Factors in Maintaining Normal Animal Health

Objectives:

To develop an understanding of:

a. The physical characteristics of the healthy animal
b. Characteristics that indicate abnormal health and behavior of animals
c. Proper management steps in preventing and controlling livestock diseases and parasites
d. Desirable livestock health conditions

To develop an ability to:

a. Recognize normal and abnormal livestock and livestock conditions
b. Determine when an animal needs medical attention

References:

a. Animal Health, Ch. 2, pp. 7-12
ANIMAL HEALTH

Days 3 and 4

3. PROBLEM AREA: Causes, Symptoms, Prevention, and Control of Major Cattle Diseases

Objectives:

To develop an understanding of:

a. The types of cattle diseases
b. Causes, symptoms, treatment, and prevention of the following diseases of cattle:

1. Brucellosis  8. Calf Scours
2. Shipping Fever Complex  9. Warts
3. Foot Rot  10. Pneumonia
4. Pinkeye  11. Milk Fever
5. Ringworm  12. Ketosis
7. Leptospirosis

To develop an ability to recognize conditions of cattle that warrant calling a veterinarian

References:

a. Animal Health, Ch. 3, pp. 13-17; Ch. 4, pp. 18-29

Day 5

4. PROBLEM AREA: Life Cycles, Symptoms, Prevention, and Control of Cattle Parasites

Objectives:

To develop an understanding of:

a. The types of cattle parasites
b. The life cycles, symptoms, prevention, and control of major cattle parasites

1. Screw worms  4. Stomach worms
2. Grubs  5. Lice
3. Flies

To develop an ability to:

a. Recognize parasite infestations in cattle
b. Treat cattle parasites
c. Control cattle parasites
Day 5 (continued)

References:

a. Animal Health, Ch. 7, pp. 49-52; Ch. 8, pp. 53-58

Days 6 and 7

5. PROBLEM AREA: Causes, Symptoms, Prevention, and Control of Major Sheep Diseases

Objectives:

To develop an understanding of:

a. The types of sheep diseases
b. Causes, symptoms, treatment, and prevention of the following diseases of sheep:

1. Foot Rot 
2. Mastitis 
3. Sore Mouth 
4. Overeating Disease 
5. Lambing 
6. Paralysis 
7. Bloat

To develop an ability to recognize disease conditions in sheep that warrant calling a veterinarian

References:

a. Animal Health, Ch. 3, pp. 13-17; Ch. 5, pp. 30-35

Day 6

6. PROBLEM AREA: Life Cycles, Symptoms, Prevention, and Control of Major Sheep Parasites

Objectives:

To develop an understanding of:

a. The types of sheep parasites
b. The life cycles, symptoms, prevention, and control of the following major sheep parasites:

1. Screw Worm 
2. Lice 
3. Ticks 
4. Scabblies 
5. Stomach Worm 
6. Tapeworms 
7. Coccidiosis
Day 8 (continued)

Objectives: (continued)

To develop an ability to:

a. Recognize animal parasite infestations in sheep
b. Treat sheep parasites
c. Control sheep parasites

References:

a. Animal Health, Ch. 7, pp. 49-50; Ch. 9, pp. 59-66

Days 9 and 10

7. PROBLEM AREA: Causes, Symptoms, Prevention, and Control of Major Swine Diseases

Objectives:

To develop an understanding of:

a. The types of swine diseases
b. Causes, symptoms, treatment, and prevention of the following diseases of swine:

1. Cholera
2. Erysipelas
3. Chronic Mycoplasmal Pneumonia
4. Atrophic Rhinitis
5. Brucellosis
6. Flu
7. TGE
8. Leptospirosis
9. MDA

To develop an ability to recognize disease conditions in swine that warrant calling a veterinarian

References:

a. Animal Health, Ch. 3, pp. 13-17; Ch. 6, pp. 36-40
Day 11

8. PROBLEM AREA: Life Cycles, Prevention and Control of Major Swine Parasites

Objectives:

To develop an understanding of:

a. The types of swine parasites
b. The life cycles, symptoms, prevention, and control of the following major swine parasites:
   1. Ascarids   3. Mange
   2. Lungworms   4. Lice

To develop an ability to:

a. Recognize parasite infestations in swine
b. Treat swine parasites
c. Control swine parasites

References:

a. Animal Health, Ch. 7, pp. 49-50; Ch. 10, pp. 67-71

Day 12

9. PROBLEM AREA: Planning a General Livestock Health Program

Objectives:

To develop an understanding of:

a. The role of sanitation in an animal health program
b. The importance of preventive medicine

To develop an ability to:

a. Plan general livestock health programs
b. Evaluate current livestock health programs

References:

a. Animal Health, Ch. 11, pp. 73-80
b. Animal Health Handbook, pp. 6-7
ANIMAL HEALTH

Day 13

10. PROBLEM AREA: Occupational Roles of the Veterinarian, Farmer and Other Animal Health Workers

Objectives:

To develop an understanding of:

a. The occupational roles for veterinarians, farmers, and other animal health workers
b. Opportunities for employment in the field of animal health

To develop an ability to care for sick animals

References:

a. Animal Health, Ch. 12, pp. 81-87
b. Animal Health Handbook, pp. 36-38

Day 14

11. PROBLEM AREA: Summary and review

Objectives:

To review previously covered material and answer student questions

References:

a. All previous assignments
### Problem Area Outline by Days

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<td>Summary and Review</td>
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</tbody>
</table>
Behavioral Objectives: (understandings and abilities)

Understanding of: 1) The influence of fertilizers on farming
2) The essential plant food elements and their function in plant growth
3) The effect of soil acidity on crop production

Ability to: 1) Recognize hunger signs of crops
2) Take a soil sample
3) Correct soil acidity by liming
4) Interpret the soil test report
5) Determine the amount of nutrients available in the soil
6) Determine fertilizer application rates
7) Select fertilizer materials to fulfill nutrient needs
COMMERCIAL FERTILIZERS

Day 1

1. PROBLEM AREA: Influence of Fertilizers on Farming

Objectives:

To develop an understanding of:

a. The benefits to be gained from fertilizing
b. The increase in fertilizer use in Iowa and the local community
c. The need to maintain soil fertility
d. How plant food is lost

References:

a. Our Land and Its Care, pp. 2-21, 62-65, 67-68
b. Fertilizer Use in Iowa Reaches Record Level, Iowa Farm Service
   Publication No. 1231

Days 2 and 3

2. PROBLEM AREA: Essential Plant Food Elements and Their Function in Plant Growth

Objectives:

To develop an understanding of:

a. The essential plant food elements and their function in plant growth

   (1) Primary nutrients and their function in plant growth

      (a) The function of nitrogen in plant growth
      (b) The function of phosphorus in plant growth
      (c) The function of potassium in plant growth

   (2) Secondary plant nutrients and their function in plant growth

      (a) The function of calcium in plant growth
      (b) The function of magnesium in plant growth
      (c) The function of sulfur in plant growth

   (3) Micro plant nutrients and their function in plant growth

References:

a. Our Land and Its Care, pp. 23, 26-34
b. Growth and Nutrient Uptake by Corn, Pamphlet 277
Day 4

3. PROBLEM AREA: Hunger Signs of Crops

Objectives:

To develop an understanding of nutrient requirements of various crops

To develop an ability to:

a. Recognize primary plant food deficiencies
b. Recognize secondary plant food deficiencies
c. Recognize micro plant food deficiencies

References:

a. Our Land and Its Care, pp. 36-39
b. Be Your Own Corn Doctor -- NPK Bulletin

Days 5 and 6

4. PROBLEM AREA: Taking a Soil Sample

Objectives:

To develop an understanding of:

a. The effect of soil types on soil fertility
b. The effect of cropping sequence on soil fertility
c. Where soil samples may be analyzed

To develop an ability to:

a. Take a uniform and representative soil sample
b. Correctly fill out the soil and cropping information sheet

References:

a. How to take a Soil Sample, NPK Leaflet
b. Our Land and Its Care, p. 42
c. Soil and cropping Information Sheet, ST-8
5. PROBLEM AREA: Liming to Correct Soil Acidity

Objectives:

To develop an understanding of:

a. What is soil acidity and how it is measured
b. The optimum pH range for farm crops
c. The effective calcium carbonate equivalent (ECCE) of various liming materials

To develop an ability to:

a. Correct soil acidity
b. Select proper liming materials
c. Determine proper liming rates

References:

a. Our Land and Its Care, pp. 18-19
b. Understanding Your Soil Test Report, Pamphlet 429, p. 5
c. Your Limestone Recommendation, (St-2)

Days 8 and 9

6. PROBLEM AREA: Understanding the Soil Test Report

Objectives:

To develop an understanding of:

a. What a soil test measures
b. How the amount of N, P, and K are determined by a soil test

To develop the ability to:

a. Select the correct soil test nutrient recommendation
b. Adjust soil test recommendations to specific crop yields

References:

a. Understanding Your Soil Test Report, Pamphlet 429, pp. 1-4
b. Soil Test Report, (ST-9)
COMMERCIAL FERTILIZERS

Day 10

7. PROBLEM AREA: Determining the Amount of Nutrients Available in the Soil

Objectives:

To develop the ability to estimate:

a. The nitrogen credits for 1st or 2nd corn following a legume
b. The amount of carryover available from fertilizer applied the previous year
 c. The amount of nutrients supplied from manure that has been applied since soil was sampled

References:

a. Understanding Your Soil Test Report, Pamphlet 429, pp. 1-4
b. Modern Farmers Need to be Accountants in the Cornfield, Iowa Farm Service Publication No. 1049

Day 11

8. PROBLEM AREA: Determining Fertilizer Application Rates

Objectives:

To develop an understanding of the factors that affect fertilizer application rates:

a. Nutrient requirements from soil test report
b. Nutrients available in the soil

To develop the ability to:

a. Calculate proper fertilizer application rates
b. Convert $\text{P}_2\text{O}_5$ to Phosphorous
c. Convert $\text{K}_2\text{O}$ to Potassium

References:

a. Understanding Your Soil Test Report, Pamphlet 429, pp. 2-4
b. Better Names for "Phosphate" and "Potash", Iowa Farm Service Publication No. 1050
9. **PROBLEM AREA**: Selecting Fertilizer Materials to Fill Nutrient Needs

**Objectives:**

To develop an understanding of the major sources of fertilizer materials available in the community

To develop the ability to:

- a. Change nutrient recommendations into amounts of a fertilizer grade
- b. Select fertilizer materials that will fulfill nutrient needs

**References:**

- b. *Our Land and Its Care*, pp. 44-45, 56, 57

**Day 14**

10. **PROBLEM AREA**: Review and Summary

**Objectives:**

To review previous material covered in this partial unit

**References:**

- a. Those cited for each of the problem areas studied
SMALL GASOLINE ENGINES

**Problem Area Outline by Days**

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</tbody>
</table>
Small Gasoline Engines

Behavioral Objectives: (understanding and abilities)

Understanding of: 1) Basic principles of small engine operation

2) Difference between two and four-stroke cycle engines

3) Function of piston, rings, crankshaft, camshaft, and valves as related to compression

4) Function of carburetor and component parts

5) Function of small engine ignition systems and component parts

6) Measuring devices used on small engines

Ability to: 1) Identify basic small engine components

2) Perform general maintenance on a small gasoline engine

3) Trouble shoot a small gasoline engine

4) Use various measuring and testing devices

5) Use a service manual
Day 1

1. PROBLEM AREA: Engine principles - Two and Four-Cycle Engines

Objectives:

To develop an understanding of:

a. The intake stroke, compression stroke, power stroke and exhaust stroke in an engine
b. The principles of operation of a two and four-cycle engine

References:

a. General Theories of Operation, Briggs & Stratton, Corp., pp. 2-3

Day 2

2. PROBLEM AREA: Nomenclature - Compression Factors

Objectives:

To develop an understanding of piston displacement and compression ratio as related to horsepower in a small engine

To develop an ability to:

a. Identify main parts of small engines
b. Calculate piston displacement and compression ratio

References:

a. General Theories of Operation, Briggs & Stratton, Corp., p. 4
b. Small Gasoline Engines Student Handbook, Penn. State Univ. p. 4
SMALL GASOLINE ENGINES

Days 3 and 4

3. PROBLEM AREA: Valves, Valve Timing and Camshafts

Objectives:

To develop an understanding of:

a. Valve operating conditions
b. Valve failures

To develop an ability to:

a. Identify parts of valve train
b. Determine usable valve margin and valve seat tolerances

References:

a. General Theories of Operation, Briggs & Stratton, Corp., pp. 4-7
b. Small Gasoline Engines Student Handbook, Penn. State Univ., pp. 5-7

Day 5

4. PROBLEM AREA: Ring Adjustment

Objectives:

To develop an understanding of:

a. The purpose of rings
b. Ring types and each's function

To develop an ability to:

a. Measure various ring clearances
b. Identify types of rings

References:

Day 6

5. PROBLEM AREA: Measuring Devices

Objectives:

To develop an understanding of various measuring devices
To develop an ability to read micrometer and other measuring devices

References:


Days 7, 8, and 9

6. PROBLEM AREA: Carburetion, Carburetor Types and Adjustment, and Governors

Objectives:

To develop an understanding of:

a. Principles of operation of carburetors
b. How gaseous mixture is controlled within the carburetor
c. Governor types and operation

To develop an ability to:

a. Identify basic parts of the carburetor
b. Explain operation of various types of carburetors
c. Governor types and operation

References:

a. General Theories of Operation, Briggs & Stratton, Corp., pp 8-13, 20-21
Day 10

7. PROBLEM AREA: Air Cleaners

Objectives:

To develop an understanding of:

a. The importance of an air cleaner
b. The different types and principles of operations of air cleaners

to develop an ability to service various types of air cleaners

References:

a. General Theories of Operation, Briggs & Stratton, Corp., p. 14

Days 11 and 12

8. PROBLEM AREA: Ignition and the Magneto Cycle

Objectives:

To develop an understanding of:

a. The purpose of ignition systems
b. Principles of magneto-ignition systems
c. A complete magneto cycle

To develop an ability to:

a. Identify parts of magneto-ignition system

References:

Day 13

9. PROBLEM AREA: Preventative Maintenance

Objectives:

To develop an understanding of:

a. The importance of maintenance on small gasoline engines

b. Why clean, fresh, regular gasoline should be used in small gasoline engines

To develop an ability to:

a. Determine and analyze engine problem by observation of spark plug

b. Properly service engine at proper time (spark plugs, breaker points, air cleaners and oil)

c. Properly prepare small gasoline engine for storage

d. Follow a service and maintenance schedule

Reference:


Day 14

10. PROBLEM AREA: Trouble Shooting and Review

Objectives:

To develop an understanding of procedures used in trouble shooting

To develop an ability to trouble shoot an engine

Reference:

a. Small Gasoline Engines Student Handbook, Penn. State Univ., pp. 64-65
<table>
<thead>
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<td>Credit Instruments - Short Term - Intermediate</td>
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<td>14</td>
<td>Summary and Review</td>
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<td>15</td>
<td>Post-Test</td>
</tr>
</tbody>
</table>
Behavioral Objectives: (understandings and abilities)

Understanding of:
1) The importance of credit in agriculture
2) Types of credit used for specific purposes
3) The sources of credit
4) Interest rates and loan costs
5) Credit instruments
6) The criteria used in granting farm credit
7) The criteria used to evaluate a credit source
8) The career potentials in farm credit

Ability to:
1) Use credit to increase farm income
2) Budget income and expenses to determine credit needs
3) Select correct credit source based on financial position and needs
4) Calculate the cost of various types of loans
5) Use credit instruments
6) Prepare a financial statement
7) Plan a repayment schedule
Days 1 and 2

1. PROBLEM AREA: The Problem

Objectives:

To develop an understanding of the need for credit

To develop an ability to:

a. Analyze a farming situation and determine the financial position of the applicant
b. Prepare a financial statement

References and Materials:

a. Financing Farm & Ranch Activities, pp. 8-11, 15
b. The Problem
c. Financial statement form

Days 3, 4, & 5

2. PROBLEM AREA: Budgeting

Objectives:

To develop an understanding of budgeting principles

To develop an ability to budget a farm credit problem

References and Materials:

a. Financing Farm & Ranch Activities, pp. 34, 36-37
b. The Problem
c. Budget Worksheet
d. Application for loan
3. **PROBLEM AREA:** Types of Loans (based on length of loan in years)

**Objectives:**

To develop an understanding of:

a. The three types of loans normally available
b. Disadvantages and advantages of various types of credit

To develop an ability to classify credit requirements into loan types

**References and Materials:**

a. Financing Farm & Ranch Activities, pp. 12-13

---

4. **PROBLEM AREA:** Sources of Credit

**Objectives:**

To develop an understanding of:

a. The sources of credit
b. An understanding of the criteria used to evaluate a credit source

To develop an ability to determine the type of credit source to use

**References and Materials:**

a. Financing Farm & Ranch Activities, pp. 32-41, 50-66
Day 9

5. PROBLEM AREA: Interest Rates and Loan Costs

Objectives:

To develop an ability to calculate the costs of various types of loans

References and Materials:

a. Financing Farm & Ranch Activities, pp. 18-19, 47-50

Days 10 & 11

6. PROBLEM AREA: Collateral

Objectives:

To develop an understanding of the criteria used in granting farm credit

To develop an ability to determine loan value of different types of collateral

References and Materials:

a. Financing Farm & Ranch Activities, pp. 14-17, 44-47
FARM CREDIT

Days 12 and 13

7. PROBLEM AREA: Credit Instruments

Objectives:

To develop an understanding of the types of credit instruments

To develop an ability to use credit instruments

References and Materials:

a. Financing Farm & Ranch Activities, pp. 19-29, 35-39
b. Blank credit instrument forms

Day 14

8. PROBLEM AREA: Summary

Objectives:

To develop an understanding of the career potentials in farm credit work

To review previous problem area objectives

References and Materials:

a. Financing Farm & Ranch Activities
b. The Problem
c. Budget Worksheet
d. Application for loan
e. Credit instruments
APPENDIX B
Problem Area Outline by Days

Day | Topic
--- | ---
1 | Engine Principles - Two and Four cycle Engines
2 | Nomenclature - Compression Factors
3 | Valves
4 | Valve timing - Camshafts
5 | Rings
6 | Measuring devices
7 | Carburetion
8 | Carburetor Types
9 | Carburetor Adjustment - Governors
10 | Air Cleaners
11 | Ignition Systems
12 | Magneto Cycle
13 | Preventative Maintenance
14 | Trouble Shooting - Review
15 | Post-Test
SMALL GASOLINE ENGINES

Behavioral Objectives: (understanding and abilities)

Understanding of: 1) Basic principles of small engines operation

2) Difference between two and four-stroke cycle engines

3) Function of piston, rings, crankshaft, camshaft, and valves as related to compression

4) Function of carburetor and component parts

5) Function of small engine ignition systems and component parts

6) Measuring devices used on small engines

Ability to: 1) Identify basic small engine components

2) Perform general maintenance on a small gasoline engine

3) Trouble shoot a small gasoline engine

4) Use various measuring and testing devices

5) Use a service manual
Day 1

1. PROBLEM AREA: Engine principles - Two and Four-Cycle Engines.

Objectives:

To develop and understanding of:

a. The history of small gasoline engines
b. The intake stroke, compression stroke, power stroke and exhaust stroke in an engine.
c. The principles of operation of a two and four-cycle engine.

References:


Subject Matter:

a. See following pages.

Teacher and Student Activities:

a. Teacher introduces lesson, discusses references and assigned reading, and other procedures for unit.
b. Teacher leads discussion of lesson.
c. Teacher makes comparison of two and four-cycle engines through student discussion (see last page of subject matter.)
d. Students are assigned to read pages 1-4 in GTO and SGESH.
e. Students asked to make a list of internal combustion engines they have at home, so can make comparison tomorrow.
SMALL GASOLINE ENGINES

Subject Matter Outline

Day 1

I. History

A. Man has progressed through ages.

1. Living standards have improved as he learned to harness various forms of energy to do work for him.
2. First accomplishment was to domesticate and train animals to carry materials and eventually to pull simple machines.
3. Later man learned to get useful work from flowing water by means of water wheels.
4. Next came the use of fuels - coal and oil.

   a. The changing of energy of coal and oil into useful mechanical work is accomplished in a number of ways.
   b. Steam engines operated from coal fired boilers have been used in providing useful work.
   c. These are classed as heat engines of the external combustion types. In other words, combustion of the fuel and release of heat energy takes place outside of engine.
   d. On an internal combustion engine combustion of the fuel and release of heat energy takes place within the engine. The power stored in the fuel is released when it is burned.

II. The internal combustion engine.

A. Operation.

1. Our most common fuel is gasoline.
2. If gasoline is to burn inside the engine there must be oxygen present to support combustion.
3. When ignited, a fuel mixture of gasoline and air burns ferociously. The engine is designed to harness this power.

B. Four stroke cycle (Have students follow diagram in SGESHB).

1. Engines are described by the number of strokes required by the piston to complete one operating cycle.

   a. A stroke is defined as the movement of piston from one end of its travel to the other. Four strokes are required for 1 cycle in the 4-stroke engine.
2. **Intake Stroke** – With the intake valve open and the piston traveling down the cylinder, the fuel mixture rushes in easily.

   a. When the piston is at the top of its stroke there is normal atmospheric pressure in the combustion chamber, but when the piston travels down the cylinder there is more space for the same amount of air and the air pressure is reduced.

   b. The intake valve opens, normal atmospheric pressure (14.7 lbs/sq. in. at sea level) rushes in to equalize this lower air pressure in the combustion chamber.

3. **Compression Stroke** – With air in the cylinder and the piston at the bottom the intake valve closes. Piston now travel up the cylinder compressing fuel mixture.

   a. When fuel mixture compressed into this small area it can be ignited more easily and it will expand very rapidly.

   b. Compression Ratio applies to this stroke (will talk about later).

4. **Power Stroke** – When piston reaches top of its stroke, and fuel mixture is compressed, a spark jumps across spark plug igniting fuel mixture. Fuel mixture burns rapidly, and burning expanding gases exert great pressure in combustion chamber. Combustion pressure felt in all directions, but only piston free to react; this it does by being pushed rapidly down the cylinder.

   a. This is the power stroke. Rapidly burning fuel creates pressure that pushes piston down turning crankshaft and producing usable rotary motion.

5. **Exhaust Stroke** – When piston reaches bottom of power stroke, momentum of flywheel and crankshaft bring piston back up cylinder; this is exhaust stroke. Exhaust valve opens, intake valve remains closed and piston pushes burned exhaust gases out of cylinder.

   a. Exhaust valve closes at the end of the stroke and engine is ready to repeat cycle.
C. Two stroke cycle engine - means that it takes two strokes of the piston to complete the operating cycle of the engine. The piston goes down the cylinder and back up again and the cycle is completed. This takes only one revolution of the crankshaft.

1. With piston at top of its stroke, the fuel mixture tightly compressed in the combustion chamber, engine is ready for its first stroke, the power stroke.
   
   a. Spark ignites fuel mixture; great pressure pushes piston rapidly down cylinder. As piston nears bottom of the stroke, exhaust ports begin to uncover and exhaust gases (still hot and under pressure) rush out. Just after exhaust ports uncover, piston uncovers intake ports. Fuel mixture rushes into cylinder, being deflected to the top of cylinder first by a domed shaped piston head; thus forcing out last bit of exhaust.

2. Piston now has reached bottom of its stroke and is on its way back up the cylinder; ports are sealed off, trapping fuel mixture.
   
   a. Therefore, this is compression, the piston pushing fuel mixture into smaller space.

3. Further explanation of why fuel mixture rushes through intake ports into combustion chamber.

   a. Answer lies in crankcase and reed valves. As piston moves up the cylinder, a low pressure is created in the crankcase; there is larger space for some amount of air. Greater atmospheric pressure outside "see" this low pressure and quickly rush through the carburetor, pushing open springy reed valve, filling crankcase with fuel mixture. When pressures equal the valve shuts.
   
   b. As the piston moves back down on power stroke, fuel mixture trapped put under slight pressure and as piston uncovers intake port, fuel mixture is forced into cylinder.
### Comparison of Two- and Four-Cycle Engines

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<thead>
<tr>
<th>Item</th>
<th>Two Cycle</th>
<th>Four Cycle</th>
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<tr>
<td>Weight</td>
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<td>More expensive</td>
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<tr>
<td>Number of moving parts</td>
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<td>Depends on care received</td>
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<td>Smoother at low speeds</td>
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<td>Lubrication efficiency</td>
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<td>May be difficult</td>
<td>Usually easier</td>
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<td>Gasoline</td>
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<tr>
<td>Quietness of operation</td>
<td>More Noise</td>
<td>Quieter</td>
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<tr>
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</table>
Day 2

2. PROBLEM AREA: Nomenclature - Compression Factors

Objectives:

To develop an understanding of piston displacement and compression ratio as related to horsepower in a small engine.

References:


Subject Matter:

a. See following pages.

Teacher and Student Activities:

a. Teacher spends 5-10 minutes listing different types of engines students found on their home farms.
b. Teacher should have engines parts so can show students as he leads discussion on nomenclature.
c. Teacher discusses piston displacement and compression ratio. Example problems of each are done by teacher in classroom.
d. Teacher assigns pages 4-7 in GTO and 5-7 in SGESH.
e. Teachers passes out problem sheet that is due tomorrow. (see end of subject matter for problem sheet).
Day 2

I. Basic engine nomenclature

A. Have been talking about engine and various parts. Let's officially identify.

1. **Cylinder** - hollow, stationary, part in what piston moves up and down in.
   - In engine specifications, the diameter of the cylinder is an important measurement.
   - It is referred to as the "bore" of the engine.

2. **Cylinder head** - Forms top of combustion chamber and is bolted tightly to the cylinder.

3. **Piston** - Slides up and down in cylinder. It is only part of combustion chamber that can move when pressure of rapidly burning fuel mixture is applied.
   - May be made of cast iron, steel, or aluminum.
   - Distance piston moves up and down is called the "stroke" of the engine. TDC to BDC.

4. **Piston rings** - Provides a tight seal between piston wall and the cylinder wall.
   - Made of cast iron or steel and are finely machined.

5. **Piston pin or wrist pin** - Is a precision ground hollow pin that connects the piston and connecting rod.

6. **Connecting rod** - Connects the piston (with the aid of the piston pin) and the crankshaft.
   - Many small engines have cast aluminum; larger engines may have steel connecting rods.

7. **Crankshaft** - Vital part that converts reciprocating motion of the piston into rotary motion.
   - One end has provision for power take off and the other is machined to accept the flywheel.
8. Flywheel - Relatively heavy piece that helps to smooth engines operation. On small engines may also be a part of ignition and cooling system.

9. Valves - "doors" for admitting fuel mixture and releasing exhaust.

10. Crankcase - The body of the engine. Contains most of engines moving parts.

These are the basic parts. Certainly, there are many other parts and these will be brought in as we go along.
II. Engine compression factors.

A. Piston displacement.

1. Piston displacement is the space displaced by the piston in its movement (stroke).
2. By definition, it is the volume which the piston displaces.
3. Piston displacement is computed in cubic inches by the following formula:

\[
\text{Displacement} = \frac{\text{(bore in inches)}^2}{4} \times 3.1416 \times \text{stroke} \times \text{number of cylinders}
\]

4. Problem - If an engine has a 2" bore and a 2" stroke the piston displacement would be what? (1 cylinder engine).
   a. Answer \( \frac{(2)^2}{4} \times 3.1416 \times 2 \times 1 = 6.2832 \)

5. By increasing the size of the bore or length of stroke or both, the displacement of the engine is increased.
6. Piston displacement is a measure of the quality of fuel mixture that can be taken into the cylinder on the intake stroke. This indicates the relative size of engine, and the horsepower is usually in direct proportion to size.
7. A rule of thumb in reference to displacement vs horsepower for small engines is 2.5 cubic inches of displacement to 1 horsepower.

B. Compression ratio.

1. Compression ratio is a comparison of the volume of the cylinder when the piston is at the bottom of its stroke and the volume of the cylinder when the piston is at the top of its stroke.
2. In every engine there is a small volume of air around the heads of the valves and in the contours of the combustion chamber, even when the piston is at top dead center. This is called clearance volume. This volume, plus piston displacement, is the total volume.
3. Compression ratio is defined as the total volume divided by the clearance volume, or the displacement volume plus the clearance volume divided by the clearance volume.
4. As a formula it may be expressed.

\[
\text{Compression Ratio} = \frac{\text{Total volume}}{\text{Clearance volume}} = \frac{\text{Displacement vol.+clearance vol.}}{\text{Clearance volume}}
\]

5. When we say an engine has a compression ratio of 6 to 1, we mean the space in the cylinder when the piston is at the top of its stroke is only one sixth as great as when the piston is at the bottom of the stroke.

6. Compression ratio does not tell us the horsepower of an engine.
   a. However, they do have a meaning regarding efficiency of an engine.
   b. For a given piston displacement, the higher the compression ratio, the more power you can expect from an engine.
   c. The efficiency with which fuel is burned is also higher with a high degree of compression.

7. Problem - Determine the compression ratio for a one-cylinder engine with a piston displacement of 4.41 cubic inches and a clearance volume of 0.4 inches.

   a. Answer - \( CR = \frac{4.41 + .4}{.4} = 12.025 \)
Piston Displacement and Compression Ratio Problems

Show work on this worksheet

1. What would the piston displacement be for an engine with a 2.5" bore and a 3" stroke?

2. Assuming your 4020 John Deere has a 4.25" bore and a 4" stroke, what would be the piston displacement, (6 cylinders)?

3. What would the compression ratio be for a one cylinder engine with a piston displacement of 7.28" and a clearance volume of .8"?

4. The compression ratio would be what for the engine in question number 1 if it had a clearance volume of 1.5 inches?
Day 3 and 4

3. PROBLEM AREA: Valves, Valve timing and Camshafts.

Objectives:
To develop and understanding of:

a. Valve operating conditions.
b. Valve failures.
c. Timing an engine.

To develop an ability to:

a. Identify parts of valve train.
b. Determine usable valve margin and valve seat tolerances.

References:

b. Small Gasoline Engines Student Hardbook, Penn. State University, pp. 5-7.

Subject Matter:

a. See following pages.

Teacher and Student Activities:

a. Teacher collects problem sheets on piston displacement and compression ratios. Also, answers any questions in reference to problems.
b. Teacher leads discussion on valves. If possible have valves that are examples of various valve problems.
c. Teacher will cover as much has time for, maybe up to valve timing on first day.
d. On day four teacher discusses typical valve timing; etc.
e. Teacher will have students take a look at an engine and study the timing sequence. (mark the fly-wheel and checks degrees).
f. Teacher assigns pages 8-11 in SGESH.
Day 3 and 4

I. Valves.

A. Probably most important factor in maintaining good compression in a four cycle engine.

1. Properly seated valves are important in efficient compression.

B. Most common valves used today are called poppet valves.

1. With these valves, exhaust gases can be removed from the combustion chamber and new fuel mixture can be brought in.

   a. To accomplish this, valve actually pops open and snaps closed.
   b. In normal four cycle combustion chamber there are two valves; one to let exhaust out (Exhaust) and one to allow fuel mixture to enter (Intake).

C. Valve parts name.

1. The important parts of a valve are the:

   a. head
   b. margin
   c. face
   d. stem

2. They make contact with the seat and valve guide.

D. Valve operating conditions.

1. Timing - Valves must be timed to open wide as possible at right instant and to close quickly and completely.

   a. At 3,000 rpm, each valve opens and closes in 1/50 of a second.
   b. More later on timing.

2. Heat - Heads of valves in combustion chamber are often heated to 1200° F. or more.

   a. Intake valve cooled by incoming fuel mixture.
b. Exhaust valve difficult to cool as is subjected to high temperature exhaust gases passing over on way out of cylinder.
c. Cylinder head, cylinder and top of piston exposed to same heat but are cooled from flywheel and fan and oil from crankcase.
d. Cooling of exhaust valve done mainly by contact between valve face and valve seat during time valve is closed.

3. Pressure - Valves have to seal well enough to stand pressures up to 500 lbs/sq.in.

E. Valve problems.

1. Valve seat burning - Caused by accumulation of carbon or fuel lead either on valve stem or on valve face or from insufficient tappet clearance.
   a. These deposits hold valve open, allowing hot flames to eat away valve face and seat.

2. Valve sticking - Caused by fuel lead, gum, or varnish forming on valve stem and in valve guide.
   a. Amount of fuel lead varies in different fuels and rate of deposit build-up also varies.
   b. When exhaust valve no longer closes properly, due to excess deposits, hot gases escaping from combustion chamber heat valve stem and guide excessively. Causes oil on valve stem to oxidize into varnish which holds valve partially open and causes burning.
   c. Intake valve sticking may be caused by use of fuels having excessively high gum content. Fuels that are stored too long may contain high amounts of gum.

F. Valve inspection.

1. Burned valve face.
   a. Caused by deposits, or insufficient tappet clearance.
   b. Discard if burned so deep it cannot be refaced.
2. Warped stem or head.
   a. Dished valve one that has sunken head.
   b. Caused by operating at too high temperature with too strong a spring or
      head was eroded away by highly leaded fuel.

3. Scored or damaged stem.
   a. Caused by too much clearance in valve guide.
   b. A necked valve is one that has stem directly beneath head badly eroded away
      by heat.

4. Head margin.
   a. Discard valve if head margin less than
      1/64 of an inch or less than 1/2 thickness of margin on new valve.

G. Valve guides.
   1. If valve guide is worn, vacuum created by
      intake stroke draws oil through between
      valve stem and valve guide.
   2. Check valve guide and valve stem for wear.
      a. Any time clearance of valve stem to
         valve guide can be reduced by more
         than .001" by replacing valve, it is
         recommended that new valve be used.
   3. Valve guides can be restored by a process
      known as nurlizing. A nurlizing tool is used
      to expand the valve guide, then a reamer is
      used to size the valve guide.

H. Valve seat width.
   1. Valve seat must always be reworked when re-
      facing or replacing valve.
   2. Should check manual for recommended seat width
      (3/64 - 1/16 for Briggs and Stratton engine).
   3. Reason for valve seat requirements is relation-
      ship between valve spring tension and pres-
      sure of valve face to valve seat.
      a. As valve seat is widened, area of con-
         tact increases resulting in a reduced
         pressure of valve face to seat.
      b. The less pressure, the less cooling
         from valve fact to seat and the
         greater possibility of compression leak.
   4. Valve lapping should be completed when newly
      ground valves are installed in an engine.
      Use grinding compound and hand valve grinder.

I. Valve margin dimensions.
   1. Margin is edge of valve head.
2. As general rule, valve should be discarded when margin becomes less than one-half of original thickness.

3. Margin on most new small engines is 1/32 of an inch.
   a. When margin less than 1/64 of an inch, valve should be discarded.
   b. Valve with too thin a margin will not be able to withstand heat and will quickly crack and burn.

J. Valve springs.
   1. Condition of valve springs can best be determined by comparing to new one.
   2. Some engines have stronger spring on exhaust side. Be sure stronger spring is put back on exhaust valve.
   3. When valve seats and valve face have been refaced the valve spring tension will be reduced because valve stem will extend further into valve chamber.
      a. Replacing valve or installing a new seat will eliminate this.
      b. A thin washer may be placed on top of valve spring to compensate for reduced spring tension.

K. Valve tappet clearance.
   1. Check when engine is cold.
   2. Check when valves fully closed.
   3. Measure gap between end of valve stem and tappet with flat feeler gauge.
   4. Too little tappet clearance.
      a. Very serious as it will not allow valve to close fully when stem has expanded with heat.
      b. Cause burning of valves.
   5. Too much clearance.
      a. Makes valve open a little late.
      b. Also opens less than full amount.
      c. Both will cause some loss of power.
6. Refacing and reseating causes valves to seat deeper so tappet clearance is generally reduced.
   a. Restore proper clearance by grinding off valve stem.

L. Typical valve timing events.

1. In order to have valve open a suitable amount by the time the piston starts drawing the airfuel mixture into the cylinder, the intake valve must open before the piston reaches top dead center.
   a. When piston approaches bottom dead center; the air-fuel mixture is being drawn in at a rapid rate. Because this mixture has inertia, the intake can stay open somewhat beyond bottom dead center and the momentum of the mixture in the intake system tends to compress more of the mixture in the cylinder.
   b. The ideal place to close the intake valve would be where the air movement starts to reverse itself. In most engines this point will occur between 35° and 65° of crank travel beyond bottom dead center.

2. Both valves are closed during the compression stroke and most of the power stroke.

3. During the power stroke, some of the energy from the expanding gases is sacrificed to make sure that the exhaust gases are completely cleared from the cylinder in preparation for the next intake stroke.
   a. It is a common practice to open the exhaust valve before bottom dead center, normally 35°-40° before BDC.

4. Valves over-lap - Number of degrees both valves open, near TDC after exhaust stroke and just before intake stroke.

5. Valve range.
   a. Time valve opens until it closes.
   b. This is measured in degrees.
**TYPICAL VALVE TIMING EVENTS**

- **Intake Stroke**
  - Intake valve opening - 150° before top center

- **Compression Stroke**
  - Intake valve closing - 50° after bottom center

- **Power Stroke**
  - Exhaust valve opening - 50° before bottom center

- **Exhaust Stroke**
  - Exhaust valve closing - 150° after top center
II. Cams and camshaft.

A. Hard to say much about valves without bringing in something about cams and camshaft.

B. Camshaft.

1. Primary function of camshaft assembly is to open and close the valves at the proper time.
   a. Used only on 4 cycle engines as two cycle engines generally have no poppet valves.

2. Camshaft has two cams machined on shaft.
   a. Located so that when shaft turns valves open and close at proper time.
   b. Valves are closed by spring tension.

3. Camshaft driven by crankshaft through gears.
   a. Since only one power stroke for each two revolutions of the crankshaft, the gear ratio is designed so that the camshaft will turn at only half the speed of the crankshaft.
   b. This is done by making twice the number of teeth in the camshaft as in the crankshaft.

C. In conclusion, valves must open and close properly, as must spark for ignition of fuel mixture appear at the correct time.

1. Thus, magneto for magneto ignition system or distributor for battery ignition system must be timed with the crankshaft gear and camshaft gear.

2. Will talk more about this under ignition area.
Day 5

4. PROBLEM AREA: Ring Adjustment.

Objectives:

To develop an understanding of:

a. The purpose of rings.
b. Ring types and each's function.

To develop an ability to:

a. Measure various ring clearances.
b. Identify types of rings.

References:


Subject Matter:

a. See following pages.

Teacher and Student Activities:

a. Teacher leads discussion on rings.
b. Teacher should show different types of rings to students. May ask student to identify.
c. Teacher informs students how to measure clearances on rings.
d. Time permitting, teacher should ask for questions over first week's work.
e. Teacher assigns students to read pp.12-19 SGESH.
f. Students given weekend assignment due Monday—Answer questions on page 20, 21 and 22, SGESH. (Maybe easier for teacher to grade if teacher runs off copies of these pages and hands them out).
Day 5

I. Rings.

A. Piston rings provide a tight seal between the piston and cylinder wall.

1. By having piston rings between piston and cylinder wall there is small area of metal sliding against cylinder wall.
   a. Therefore piston rings reduce friction and accompanying heat and wear that are caused by friction.
   b. Another function of piston ring is to control lubrication of cylinder wall.

B. Compression rings.

1. One of two distinct classification of rings; the other is oil rings.
2. Top two rings on piston are compression rings.
3. Top ring.
   a. Unusually plain or beveled on inner top corner.
   b. Idea of bevel is to cause ring to twist in groove in such manner that outside lower edge presses on cylinder wall more tightly than rest of ring face.
   c. Must be installed right.
   d. Exerts a pressure of 8-12 lbs. on cylinder wall.
4. Second ring from top.
   a. Also a compression ring.
   b. Commonly called scraper ring.
   c. Prevent excessive amounts of oil from entering combustion chamber.

C. Oil ring.

1. Vary all way from simple to extremely complicated types.
2. Job of this piston ring is to control the lubrication of the cylinder wall.
   a. These rings spread correct amount of oil on cylinder wall, scraping excess from wall and returning it to the crankcase.
b. These rings are slotted and grooves are cut into piston behind the ring.

c. This enables much of the excess oil to be scraped "through" the piston and it drips back into the crankcase.

3. It should be noted that compression rings have a secondary function of oil control.

C. Two clearances or tolerances are important in piston rings.

1. End gap.

   a. Is space between ends of piston ring, measured when ring is in cylinder.
   b. Gap must be large enough to allow for expansion due to heat but not so large that power loss due to blow-by will result.
   c. Often .004" is allowed for each inch of piston diameter (top ring), .003" is allowed for rings under top ring.
   d. Since second and third rings exposed to less heat their allowance can be smaller.
   e. Normal end gap of top ring is .025"-.035".

2. Side clearance of ring groove clearance.

   a. Often .0025" is allowed for top ring and .003" is allowed on second and third ring.
   b. More than .007" on any rings calls for new ones.

D. Two serious problems caused by bad piston rings, bad piston, warped cylinder, distortion, and/or scoring.

1. Blow-by - Pressures of combustion great enough to break oil seal provided by piston rings. Then gases of combustion force way into crankcase resulting in loss of engine power and contamination of crankcase.

2. Oil pumping - Rings not fitted properly may start pumping oil. This leads to fouling in combustion chamber, excessive oil consumption and poor combustion characteristics.
Day 6

5. PROBLEM AREA: Measuring Devices.

Objectives:

To develop an understanding of various measuring devices.

To develop an ability to read micrometer and other measuring devices.

References:


Subject Matter:

See SGESH, pp.12-19.

Teacher and Student Activities:

a. Teacher passes back Problem Sheet that was handed in previous week and answers any questions.

b. Teacher collects assignments given Friday.

c. Teacher explains need for measuring devices when working with small gasoline engines.

d. Teacher leads discussion in principles of micrometer.

e. Teacher passes out job sheet on micrometer and works through it with students.

f. Micrometers passed out to students and they measure object furnished by teacher. (Small sections of pipe, bars, students pencil, etc.).

g. Teacher assign students to read pp. 8-13, GTO, and pp. 27-37, SGESH.
Day 6

I. Measuring devices.

READING THE MICROMETER

1" - 2" Micrometer

Part Identification:
1. 1. 6.
2. 2. 7.
3. 3. 8.
4. 4. 9.
5. 5. 10.

Operational Procedure:
1. Complete the part identification section
2. Reading the micrometer:
   a. List the smaller number of inches that can be read with the micrometer illustrated to the left
   b. Denote the number on the sleeve that the thimble edge just passed, this indicates the number of hundred thousandths
   c. Count the number of full spaces that is between the last numbered line (Step b) and the thimble edge and multiply by .025
   d. Locate the line on the thimble that matches the horizontal line on the sleeve and list this number in thousandths
   e. Total the valves (a+b+c+d)

3. Determining the measurements of the two-step machined, practice cylinder:
   a. Using a 1" - 2" micrometer list the measurement of the top step in thousandths. Proper measurement should be the average of measurements made at 3 points around the cylinder
   b. Determine the measurement of the lower step
   c. Subtract the reading in Step (b) from reading in Step (a) to determine the difference in thousandths of an inch

4. Determine the readings of the micrometers shown below:
   A. 0" - 1" Micrometer
   B. 2" - 3" Micrometer

Materials:
1 - 1" - 2" micrometer
1 - two-step practice cylinder (top step between 1.75" and 2.00" lower step between 0.75" and 1.00"

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<td>Determining the difference in the measurements of the practice cylinder (3-c) (plus or minus .001&quot; = 30 pts., + or .002&quot; = 20 pts., + or .003&quot; = 10 pts., greater than .004&quot; off correct reading = 0 pts.)</td>
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<td>Determining the reading of the micrometer (inches, 5 pts. each)</td>
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Grade:
6. PROBLEM AREA: Carburetion, Carburetor Types and Adjustment and Governors.

Objectives:

To develop an understanding of:

a. Principles of operation of carburetors.
b. How gaseous mixture is controlled within the carburetor.
c. Governor types and operation.

To develop an ability to:

a. Identify basic parts of the carburetor.
b. Explain operation of various types of carburetors.
c. Governor types and operation.

References:


Subject Matter:

a. See following pages.

Teacher and Student Activities:

a. Teacher will as a review of yesterday's lesson, ask student to turn to page 24 in SGESH and go through #12 with students providing the answers.
b. Teacher will lead discussion on carburetor. He will bring into class example carburetors so that he can use them in his teaching. Also, he will want to make maximum use of the pictures in the reference material.
c. Teacher will have students turn to page 41 and 42 in SGESH and have them color in with colored pencil the various systems.
d. On ninth day, teacher will pass back assignments previously handed in. Discuss them with students.
e. Teacher will assign students to read p. 14, GT0 and pp. 37-39, SGESH.
f. Teacher will ask that any student that can without too much inconvenience, to take off and bring in an 'air cleaner off' one of their engines from home. Don't do any cleaning on it before bringing it in.
I. Carburetor and fuel systems.

A. Fuel system must maintain constant supply of gasoline for engine, and carburetor must correctly mix gasoline and air together to form a combustible mixture which will burn rapidly when ignited in the combustion chamber.

B. Typical fuel system would contain following parts.

1. Gasoline tank - the reservoir for gasoline
2. Carburetor - a mixing device for gasoline.
3. Fuel line - tubes made of rubber or copper which lead gasoline from gas tank to carburetor.
4. Air cleaner - a device for filtering air brought into the carburetor.

II. Carburetor.

A. Function.

1. Control flow of fuel from tank to carburetor so as to maintain constant level of fuel in carburetor.
2. Create a rich fuel mixture for starting a cold engine.
3. Allow engine to operate at its maximum power output.
4. Allow engine to operate at idle speeds when power is not needed.
5. Allow engine to accelerate smoothly from idle to high speeds.
6. Deliver correct amount of fuel and air having correct richness to combustion chamber for various phases of engine operations.

B. Parts of carburetor.

1. Float and bowl.
   a. Found on all carburetors except suction fed.
   b. Maintain constant gasoline level in the carburetor.

2. Venturi.
   a. Section of carburetor that is constructed, or has smaller cross sectional area for air to flow through.
   b. On suction type carburetor throttle plate is thickened and acts as venturi in air passage.
c. Gasoline and air brought together and here mixing begins.
d. Produces low pressure area.

3. Needle valve.
a. Controls amount of gasoline available to carburetor.
b. Controls richness or leanness of fuel mixture.

4. Idle valve.
a. Also controls amount of gasoline available to carburetor but functions only at low speeds or idling.

5. Throttle or butterfly.
a. Controls speed of engine by controlling amount of mixture that enters combustion chamber.
b. More fuel mixture admitted, the faster the engine speed.

6. Choke.
a. Controls air flow into carburetor.
b. Used only for starting.
c. With choke closed, most of engine's air supply cut off, producing a rich mixture.

7. Jets.
a. Small openings through which gasolines passes within carburetor.
b. Squirt gases into an air stream.

C. Principles of operation.

1. As piston moves down (on intake stroke) a partial vacuum is developed in the cylinder.
2. Atmosphere pressure pushes air through the carburetor intake to equalize the pressure.
3. Air speed increases in the venturi - the narrow passage in the air intake tube.

a. Since the same volume of air must pass through the narrow passage that passes through the section that is not restricted, the speed increases at that point.
b. Fuel discharge tube placed in venturi section and action of incoming air causes high pressure on front of jet; but very low pressure on back of jet.
c. When pressure lowers in venturi, atmospheric pressure in fuel bowl pushes fuel through discharge tube to the venturi and into air stream.

4. The speed of the air in the venturi and the air turbulence past the venturi atomize the fuel and mix the tiny droplets with the air.

   a. Mixture is 14-15 parts air to 1 part gasoline by weight.
   b. In other words, one gallon of fuel requires about 8,000 gallons of air for combustion.
   c. Once air and fuel are mixed, next job of carburetor is to provide a means whereby the amount of mixture that enters engine cylinder can be controlled.

D. Control of mixture.

1. Throttle or butterfly valve system.

   a. Controls fuel and air flow.
   b. Throttle shaft is built with arm on end which can be connected to governor or other device for controlling speed.
   c. Throttle stop screw also mounted on shaft for purpose of regulating idle speeds.
   d. Throttle valve does not change ratio of fuel to air. just regulates amount of mixture going in.

2. Idle system.

   a. Have problem when the throttle is closed and engine begins to idle. very little air is drawn through carburetor and difference between atmospheric pressure and venturi air is slight. So little gasoline is drawn from discharge jet.
   b. In many carburetors, main discharge jet continued up past venturi section to area of throttle.
   c. It discharges fuel into small well and jet that are behind throttle butterfly when it is closed.
d. The air pressure behind butterfly is very low. Therefore gasoline streams from idle jet readily and mixes with the small amount of air that is coming through the carburetor.

e. In most cases air is bled into the fuel through air bleed holes in the idle passages before it is discharged into the air stream to obtain a better air-fuel mixture for idling.

3. High speed system.

a. Is used when engine is called upon to supply power for full, partial, or no load at various operating speeds.
b. System works according to basic principle talked about earlier.
c. Dirty air cleaner will restrict flow of air to carburetor resulting in rich mixture (will talk about later).

4. Choke system.

a. Placed on air-intake side of carburetor before the venturi section.
b. When choke closed, air going into carburetor is restricted. Pressure inside carburetor and cylinder further is reduced from that which was caused by downward stroke of piston. Lower pressure increases vaporization of fuel.
c. Richer fuel-air mixture provided by lower pressure created in venturi section the lower the pressure, the more fuel is forced into fuel intake system by atmospheric pressure.

E. Types of carburetor systems.

1. Gravity feed.

a. Consists of tank, shut-off valve, lines, and fuel filter.
b. Tank located above level of carburetor to allow fuel to travel downward to carburetor by force of gravity.
c. Carburetor incorporated within it a float and float chamber to prevent gasoline from continuously pouring through carburetor.
d. Float provides constant level of gasoline for full throttle and not too much so as to flood engine.

e. In actual practice float and float valve do not rapidly open and close, but "assume a position" allowing correct amount of fuel to constantly enter float chamber.

f. Important to have a hole in gas tank cap and in carburetor bowl so air can flow out or fuel flow in.

g. Operation - Low pressure area created in carburetor throat and venturi when piston moves down cylinder.
   - Fuel is pushed down in the bowl and into the nozzle to discharge holes by air pressure above fuel bowl.
   - Air rushes in carburetor air horn and through venturi where velocity greatly increased.
   - Nozzle extends through air stream, creating still lower pressure area on upper side.
   - This allow fuel to stream out of nozzle though discharge holes into venturi where it mixes with the air.
   - Now a combustible mixture ready for combustion in cylinder.

2. Suction feed.

a. Very popular on economy priced equipment due to simplicity and low manufacturing costs.

b. Consists of carburetor mounted at top of fuel tank.

c. Operation - Vacuum from engine intake stroke causes low pressure in venturi.
   - Atmospheric pressure forces fuel up through the tube into low pressure area of venturi and then into engine.
   - In other words, low pressure created by engine intake draws fuel from tank directly into carburetor.
   - Carburetor has no fuel reservoir so depends on fuel tank for reserve.

d. Horsepower limited on engines using this type of simple carburetor (1/2 to 3 horsepower).
3. Pump system.
   a. Consists of fuel tank, fuel lines, and pump.
   b. Operation - fuel pump picks up fuel from the tank and forces it through fuel lines to carburetor.
   c. This type system is usually more expensive than other systems and is generally found on units where other types are practical.

F. Carburetor adjustment.

1. Start engine and allow it to warm up.
2. Set idle speed adjustment first.
   a. Consult the instruction manual for the recommended idle speed; normally 1700-1800 rpm.
   b. Turn the idle speed adjusting screw until the engine runs at the desired speed.
3. Set idle jet adjustment. (3/4 to 1/2 turns off seat).
   a. Turn the idle adjustment screw in until the engine begins to falter (lean mixture).
   b. Turn it out past the point where the engine operates smoothly until it runs unevenly (rich mixture).
   c. Now turn the screw in to the midpoint between rich and lean to where the engine runs smoothly.
   d. If necessary, readjust the idle speed screw.
4. Set main fuel jet. (1 1/2 to 2 turns off seat).
   a. Advance the throttle to full speed and adjust main fuel jet, turning the screw in slowly until the speed falters, then back out carefully to the point where speed picks up again and the engine runs smoothly.
   b. The engine should accelerate without hesitation or sputtering. If it does not accelerate properly, the carburetor should be readjusted, using a slightly richer mixture.
   c. Adjustment should be made with air cleaner in place.
III. Governor.

A. Connected to throttle.
   1. Used to keep engine at constant speed regardless of load.
   2. Two main types - air vane and mechanical.

B. Air vane.
   1. An air vane, which is located near flywheel blower, controls speed.
   2. As engine speed increases, flywheel blower pushes more air against air vane, causing it to change position.
   3. Force and movement of air on air vane tends to close throttle plate, thus slowing down engine because less fuel can enter combustion chamber.
   4. Governor spring opposes this by tending to pull in opposite direction, opening throttle.
   5. At "governed speed" air vane overcomes governor spring tension and a balance assumed.
      a. Spring usually connected to adjustable control of some sort.
      b. Increasing tension on spring increases engine speed - decreasing lowers it.

C. Mechanical governor.
   1. Operates on centrifugal force.
   2. When engine stopped, mechanical governors spring will pull throttle to open position.
   3. Governor springs tend to keep throttle open, but as engine speed increases, centrifugal force throws the counterweights further and further from the closed position.
      a. Puts tension on spring in other direction to close throttle.
   4. At governed speed spring tension overcome by counterweight and throttle opens no further.
      a. Balanced position is maintained and so is engine speed.
Day 10

7. PROBLEM AREA: Air Cleaners.

Objectives:

To develop an understanding of:

a. The importance of an air cleaner.
b. The different types and principles of operations of air cleaners.

To develop an ability to service various types of air cleaners.

References:


Subject Matter:

a. See following pages.

Teacher and Student Activities:

a. Teacher leads discussion on air cleaners. Teacher will bring in examples of each kind.
b. During last 10 minutes have students look at and discuss the air cleaners they brought in.
c. Teacher will assign students to read, pp. 15-18, GTO, and pp. 45-51, SGESH.
d. Teacher will give students weekend assignment due Monday - Answer question on pages 22, 23, 40, 41, & 43, SGESH. (May be easier for teacher to grade if teacher runs off copies of these pages and hands them out.).
I. Air cleaners.

A. Importance of servicing air cleaner.

1. Three horsepower engine operating at 3600 r.p.m. requires about 390 cu. ft. of air an hour.
2. Providing protection from dirt more difficult for small engines because they operate under worst possible conditions, that is, near ground and in dusty places.
   a. Efficiency of air cleaner is limited, not by its design, but by improper servicing.
   b. Either not serviced often enough or improperly.
3. Most recommend servicing every 25 hours if engine is being operated under ideal conditions.

B. If the air cleaner is not cleaned.

1. Dust and dirt are drawn into the engine.
   a. Dirt in oil forms an abrasive mixture which wears moving parts instead of lubricating them.

2. The flow of air is restricted and mixture will be too rich.
   a. All the gasoline does not burn.
   b. Unburned gasoline washes oil from cylinder wall.
   c. Then piston and cylinder walls become scuffed and scored from lack of lubrication.
   d. Fuel also enters crankcase and dilutes oil.

3. Clogged air cleaner will choke engine resulting in high fuel consumption, smoking, loss of power, and excessive build-up of carbon deposits in combustion chamber.
C. Types of air cleaners.

1. Oil bath - Air cleaner.
   a. Washes dirt particles from air by forcing it through bath of oil.
   b. Air enters cleaner under edge of cover and is directed downward to bottom of cup.
   c. When air reaches this point its path of travel changes abruptly to an upward movement.
   d. Oil in filter picked up and carried with air.
   e. This action coats dirt particles and causes them to dodge in mesh of filtering element.
   f. As more dirt and oil collect in filtering element, it drains back into outer chamber of oil cup.
   g. Here dirt settles out and oil used to trap more dirt.
   h. Servicing - Disassemble and wash in clean-solvent.
      - Use compressed air to remove solvent from meshed cover.
      - Fill to correct level same type and grade of oil as used in crankcase (usually SAE 20 or 30).

2. Oil soaked - Air cleaner.
   a. Polyurethane
      1.) Consists of sponge like plastic material called polyurethane.
      2.) Filter designed so air passes over large area of air surface.
      3.) Oil on filter material picks up dust and dirt particles and prevents them from going into the engine.
      4.) Many people feel oiling of this filter unimportant; however, without oil, filter of no practical value.
      5.) Dirt goes right through it.
6.) Servicing - After removing from container, wash it in hot water, using soap to remove dust, dirt and original oil.
   - When dry use S.A.E. 20 or 30 engine oil to resaturate it. Use enough oil to cover surface.
   - Squeeze it several times to insure even distribution of oil.

b. Metallic mesh - Air cleaner

1.) Consists of filtering material such as aluminum foil mesh.
2.) Operates on same principle as previous one.
3.) Servicing - Agitate vigorously to remove all dirt and dust from metallic mesh.
   - Drip air cleaner in oil and replace filter on engine.

3. Dry filter.

a. Consists of porous filtering element usually made of paper (some of moss or hair).

b. Has filter with minute (very small) openings that keep all except extremely fine particles from passing through.

c. Advantages - easy to service
   - fuzz and chaff cause less restriction to air passage.
   - When need servicing, engines warns you by running improperly (choke effect).

d. Servicing - Depends on type: some must replace when dirty.
   - Other can be cleaned; brush with a bristle brush; not a wire brush.
   - Tap on a flat surface.
   - Do not wet or soak.
   - Handle with care; don't use compressed air; one small hole in filter may be as bad as no filter at all.
Days 11 and 12

8. PROBLEM AREA: Ignition and the Magneto Cycle.

Objectives:

To develop an understanding of:

a. The purpose of ignition systems.
b. Types of ignition systems.
c. Principles of magneto-ignition systems.
d. A complete magneto cycle.

To develop an ability to:

a. Identify parts of magneto-ignition system.
b. Differentiate between a hot and cold spark plug.

References:


Subject Matter:

a. See following pages.

Teacher and Student Activities:

a. Teacher collects assignment given Friday.
b. Teacher will lead discussion on ignition and magneto cycle. Example parts will be brought in to aid teacher.
c. Teacher should show difference between hot and cold spark plug (see attached sheet).
d. On 12th day teacher will ask students to bring in spark plugs from home.
e. Teacher will also assign reading of pp. 15-18, GT0, and pp. 45-51, SGESH.
f. Teacher will give assignment due tomorrow. Answer questions on page 52 and 53 SGESH. (May be easier for teacher to grade if teacher runs off copies of these pages and hands them out).
Days 11 and 12

I. Ignition systems.

A. Purpose.

1. To provide a strong spark in the combustion chamber at the proper time for igniting fuel-air mixture.

B. Requirements of spark.

1. The spark must be of proper strength.
   a. Too weak - fuel will not ignite.
   b. Too strong - spark plug electrodes will burn.

2. The spark must take place at exactly the proper time.
   a. Best time on most engines is just before piston reaches top dead center on compression stroke.
   b. Gives burning head start so expanding gases will be most effective in pushing piston down.

C. Types of ignition systems commonly used on small engines.

1. Magneto ignition.
   a. Most common.
   b. Ideal for small engines where have no electrical load other than igniting fuel in combustion chamber.
   c. Produces own electricity without, battery or generator.
   d. Simple economical relatively trouble free and easy to maintain.
   e. One we will work with.

2. Battery ignition.
   a. May be used on small engines where additional electrical loads are needed.
   b. Also found on automobiles, trucks, and tractors.
   c. Will usually see ignition coil, battery and generator as means to identity.
D. Types of magnetos on small engines.

1. Flywheel type.
   a. Not visible from outside of engine.
   b. Built in and around flywheel.

2. External type.
   a. Self contained unit mounted on side of engine.

II. Magneto - Ignition system.

A. Best to study basic parts before studying how magneto operates.
B. Permanent magnets.

1. Many made of alloy called Alnico.
   a. Combination of aluminum, nickel and cobalt.

2. New magnets of the ceramic types - See Briggs manual.

3. On flywheel magneto the magnet is cast into flywheel and cannot be removed.
   a. Other magneto parts often are mounted on fixed plate underneath flywheel.
   b. Magnet therefore revolves around other parts of magneto.

C. Coil - (Primary and secondary windings).

1. Primary winding consist of about 175-200 turns of heavy wire (about 18 gage wrapped around laminated core.)
   a. Primary coil in electrical circuit containing breaker points and condenser.
   b. When magnet brought near this coil and iron core, magnetic lines of force cut coil and electrical current is generated.
   c. Normally current flows through coil, closed points and into ground, a complete circuit.
   d. One end of primary circuit is connected to frame of magneto as ground and other and is connected to line insulated breaker point.
2. Secondary winding of wire consists of 10,000 to 20,000 turns of very fine wire wrapped around primary coil.

   a. Secondary coil is in electrical circuit containing spark plug.
   b. Inside end of secondary coil is grounded with primary ground. Outside is connected to spark plug.
   c. When current flows in primary, a magnetic field gradually expands around both coils but voltages in secondary are quite small.
   d. However, when breaker points open, circuit is broken, electricity stops flowing and magnetic field suddenly collapses.
   e. Suddenly collapsing magnetic field induces very high voltage in secondary coil, enough to jump spark gap, 12,000 and 15,000 volts.

D. Laminated iron core - Armature.

1. Made of many strips of soft iron fastened tightly together.

   a. Soft iron core helps strengthen magnetic field around primary and secondary coils, but core will not retain magnetism and become permanently magnetized.
   b. Purpose of using many strips instead of solid core is to reduce eddy currents which create heat in core.
   c. Shapes may vary, but function remains the same.

E. Breaker points.

1. Made of tungsten; part of primary circuit.
2. Two points normally closed (some have magneto with points normally open) providing path for current (electron) flow. Current is flowing in primary circuit.
3. Just before spark is desired, breaker points are opened, breaking electrical circuit.

   a. Point opening causes a collapse of magnetic field.
   b. Also, the magnetic field is reversed due to the position of the magnet in reference to the armature legs.
   c. This collapse and reversing of magnetic field creates high voltage (12,000-15,000) in the secondary circuit of the coil.

4. Breaker points open and close anywhere from 800 times per minute to 4,500 or more depending on engine speed.
5. When open usually separated by .020".
   a. Exact opening varies from engine to engine.
   b. Amount of opening is critical to function of magneto.

F. Breaker cam.

1. Actuates the breaker points.
2. One bracket of breaker assembly rides on this cam.
3. As cam rotates, it opens and closes the points.
4. In most small gasoline engines 5 horsepower and less, breaker points open by a cam or crankshaft or by a flat spot on crankshaft.
   a. There is a spark for every revolution of the crankshaft.
   b. This means there is a spark also at the end of the exhaust stroke.
   c. The spark serves no useful function and is called a "mavrick spark".
5. In four cycle engines (usually 5-horsepower and larger) it is mounted to operate from the camshaft which is turning at one-half crankshaft speed.
   a. By mounting breaker points here, they open every two revolutions of the crankshaft.
   b. Thereby they provide a spark for the power stroke, but none for the exhaust stroke.

G. Condenser.

1. Acts as electrical storage tank in primary circuit.
   a. Consists of two strips of foil with paper insulation in between them.
   b. Wound so that one of strips of foil can be grounded and other connected to line breaker points.
2. When breaker points open quickly, current tends to keep flowing, so it stores this surge of current.

   a. If condenser were not present, a spark would actually arc across the breaker points.
   b. If this happened breaker points would soon burn.
   c. Also, weakening effect on voltage produced by magneto secondary coil.

3. Condenser provided as electrical storage tank for this last surge of current flow.

4. Condenser can be easily located because it usually looks like a small tin can.

5. Capacity of condenser is measured in microfarads.

   a. Proportioned to total area of foil and inversely proportional to thickness of insulating sheets.
   b. Insulating materials referred to as dielectric; is glycerine treated paper material.

II. Spark plug cable.

1. Connects secondary winding in coil and spark plug.

2. This part often referred to as high tension lead.

I. Spark plug.

1. Vital part of ignition system; in this part resulting work of magneto parts is seen.

   a. Provides gaps across which voltage arcs.
   b. Ignited compressed mixture.

2. Basic parts.

   a. Stud
   b. Cement
   c. Insulator
   d. Center electrode
   e. Sillment seals
   f. Shell
   g. Inside gasket
   h. Reach
   i. Spark plug gap
   j. Thread diameter
   k. Terminal nut
   l. Ribs
   m. Hex or hexagon
   n. Shell knurling
   o. Gasket seat
   p. Ground electrode
3. Types of spark plugs (term "heat range" refers to classification according to ability to transfer heat from firing tip of insulator to cooling system of an engine).

   a. "Cold" plug—has relatively short insulator nose and transfers heat very rapidly into engine's cooling system.
      - Such a plug used in heavy duty or continuous high speed operation to avoid overheating of plug tip.
      - If you use a cold plug under extensive idling and light-load conditions you can expect it to foul with carbon causing engine to skip. Plug not hot enough to burn off carbon so there will be a gradual build up of carbon inside the combustion chamber (700-800°).
      - A cold plug in an engine which burns oil will tend to become oil fouled because the oil will not be burned away by combustion.

   b. "Hot" plug—has much longer insulator nose and transfers heat more slowly away from firing end.
      - This runs hotter and burns off combustion deposits which might tend to foul plug during prolonged idle or low-speed operation.
      - If you use a hot plug under heavy load conditions, you can expect it to overheat. Overheating will cause blistering, burning of the electrodes, lead fouling, and engine knock. Knock is caused by plug becoming so hot it ignites the fuel charge before the spark plug fires. (1600-1700° F.)

4. "Reach" length of spark plug.

   a. Refers to thread reach of length of plug from gasket seat on shell to end of threads.
b. Engine design affects length of "reach" of plug.

c. If a longer reach plug is used than is recommended it will extend into the combustion chamber and may interfere with piston or valve action. Exposed threads on plug will collect deposits and plug will be hard to remove.

d. If the reach is too short, the spark is shielded, thus resulting in improper combustion of fuel in the cylinder. In this case the exposed threads in the cylinder head fill with deposits; consequently, it is difficult to install a plug with the proper reach until the threads are cleaned with a thread tap.

e. Reach of plug has no direct tie in with whether plug is of hot or cold heat range.

5. Size.

a. Determined by thread diameter.

b. Most use 14 mm threads - available in four "reached" - 3/8", 7/16", 1/2", and 3/4".

c. Also have 10 mm, 18 mm, and 7/8".

6. Gapping

a. Spark must be proper length in order to fire mixture efficiently at various engine speed.

b. Length controlled by width of gap.

c. If gap too narrow, engine may run rough at low speeds.

d. If gap too wide, current may be unable to leap it and cause engine to "miss".

e. Gap width or "setting" determined by each manufacturer. (0.025, .030 on most small engines).
III. The complete magneto cycle.

A. Observation of what happens in one revolution of crankshaft and the flywheel magneto.

1. Principles of generator and transformer apply to magneto.
2. A permanent magnet rotates past a coil.
   a. Coil consists of stationary primary and secondary windings.
   b. Both are wound around center leg of soft-iron core called the armature of yoke.
   c. In a magneto the primary serves as a primary coil and also as the generating coil.
3. When permanent magnet is far away from the coil, it has no effect on the coil.
4. At point where the two poles of the magnet start to align—one with the left hand leg of the armature and the other with the center leg of the armature—magnetic lines of force flow through the center and left hand legs of the armature.
   a. Lines of force are cut by the coil as magnet continues to rotate.
   b. Voltage is induced in the primary coil and current flows in the primary because the breaker points are closed and the circuit is complete.
   c. No current flows in the secondary circuit at this time because it is open at the spark plug electrode and there is not enough voltage generated to cause the current to jump the gap.
   d. Current flow in the primary increases the strength of the magnetic field by adding more lines of force.
5. As the magnet continues to rotate to a position where the X pole of the magnet is a little to right of center of the middle leg the lines of force start to flow in the right leg and the center leg of the armature.
   a. When this happens, the lines of force change direction.
   b. Magnetic field is strongest at this point.
   c. Therefore, the breaker points are timed to open at this instant.
d. The flow of current stops in the primary circuit at the time the points open.
e. Strong magnetic field collapses.
f. This sudden collapse and reversal of the strong magnetic field induces enough voltage in secondary coil to cause current to jump gap at the spark plug, (12,000 - 15,000 volts).
g. Spark ignites fuel mixture and piston is forced down cylinder.

6. Reason current does not jump gap at breaker points is voltage is not as great in primary as it is in secondary circuit.
7. Another reason of course is that there is a condenser in the primary circuit which absorbs surge of current produced in primary circuit of coil.

IV. Spark Advance

A. When fuel burns in combustion chamber, it does not explode and exert all its power instantly.

1. If wait until piston reached dead center before igniting mixture piston would already be started back down before full force of burning fuel is reached; thus resulting is power loss.
2. Spark advances more and more as engine speed increases, because less time for combustion to take place.
3. Regulating spark advance is done by controlling time breaker points open.
4. There is no spark advance on most small gasoline engines 5-horsepower and under.
HOT & COLD SPARK PLUGS

HOT PLUG

A

COLD PLUG

B

AUTO-LITE

CYLINDER HEAD

WATER

THE ELECTRIC AUTO-LITE CO. E-470
9. **PROBLEM AREA:** Preventative Maintenance.

**Objectives:**

To develop an understanding of:

a. The importance of maintenance on small gasoline engines.
b. Why clean, fresh, regular gasoline should be used in small gasoline engines.
c. API Service Classification and SAE Viscosity rating of oil.

To develop an ability to:

a. Determine and analyze engine problem by observation of spark plug.
b. Properly service engine at proper time (spark plugs, breaker points, air cleaners and oil).
c. Properly prepare small gasoline engine for storage.
d. A service and maintenance schedule.

**Reference:**


**Subject Matter.**

a. See following pages.

**Teacher and Student Activities:**

a. Teacher will collect assignment given yesterday.
b. Teacher will lead discussion on preventative maintenance.
c. In discussion on spark plugs, teacher may want to use job sheet on spark plugs. Either today or tomorrow will want to look at plugs students brought in and discuss, depending on time.
d. Teacher will make copies of attached service schedule, pass out and discuss with students.
e. Teacher will assign reading of pp. 64-65 in SGESH.
Day 13

I. Preventative maintenance.

A. Gasoline engine represents investment in money.

1. To safeguard investment, engine operator must perform certain routine steps in care and maintenance.
2. This insures longest possible life for engine parts and may save costly repair bills.

B. Small gasoline engines have no odometer such as in automobile to act as reminder for servicing.

1. Only guide in small gasoline engines that can be used is number of operating hours.
2. A comparison of engine hours to automobile miles will reveal that service requirements are very close to those of an automobile.

   a. When relating engine hours to vehicle miles, ratio commonly used is:
      
      1 engine hour = 40 miles
   b. In making comparisons, multiply the number of hours by 40.
   c. Following table lists some of more common hourly service intervals and equivalent vehicle miles.

<table>
<thead>
<tr>
<th>Engine hours</th>
<th>Vehicle miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>1,000</td>
</tr>
<tr>
<td>50</td>
<td>2,000</td>
</tr>
<tr>
<td>100</td>
<td>4,000</td>
</tr>
<tr>
<td>250</td>
<td>10,000</td>
</tr>
<tr>
<td>500</td>
<td>20,000</td>
</tr>
<tr>
<td>750</td>
<td>30,000</td>
</tr>
<tr>
<td>1,000</td>
<td>40,000</td>
</tr>
</tbody>
</table>

d. Many small engines operate under most undesirable conditions compared to automobile engine.

C. Spark plug.

1. Spark plugs should be cleaned and regapped once each 100 hours of operation.
2. Spark plug can be valuable indicator about what is happening when your engine is operating.
a. Normal - brown to grayish tan deposits.
   - gap increase will be slight.
   - clean, regap and reinstall for further service.

b. Oil fouling - indicated by wet oily, black "sludgy" deposits on plugs.
   - In old engine may indicate worn piston rings or excessive cylinder or sleeve wear.
   - may occur during "break in" of new or recently overhauled engine, before normal oil control is obtained by proper seating of rings.
   - in old engine, hotter plug may help but condition may have to be remedied by engine overhaul.

c. Gas fouling - indicated by sooty, black deposits on insulation tips, electrodes and shell surfaces.
   - cause may be excessively rich fuel mixture, light loads, or long periods at idle speeds.

d. Carbon fouling - appears as dry sooty black carbon deposits.
   - may result from over-rich carburetor over choking, or clogged air cleaner.
   - faulty breaker points, weak coil or condenser can reduce voltage and cause misfiring.
   - excessive idling, slow speeds under light load can keep plug temperature so low that normal combustion deposits not burned off.

e. Lead fouling - Indicated by soft, tan powdery deposit on plug.
   - deposits of lead salts build up during low speeds and light loads.
   - cause no problems at low speed but at high speed, when plug heats up, fouling causes plug to misfire.

f. Burned electrodes - white or yellow glaze and a burned or blistered insulator nose; worn thin.
   - may indicate incorrect plug heat range.
   - may be caused by too lean a fuel mixture, too low octane fuel, or long periods of operation at high speeds and with heavy loads.
SERVICING THE SPARK PLUG

Part Identification:
1. __________________ 9. __________________
2. __________________ 10. __________________
3. __________________ 11. __________________
4. __________________ 12. __________________
5. __________________ 13. __________________
6. __________________ 14. __________________
7. __________________ 15. __________________
8. __________________ 16. __________________

Operational Procedure:
1. Identify parts of the spark plug.
2. Remove plug after cleaning plug-well.
3. Remove oily deposits from plugs with cleaning solvent.
4. Check condition of the porcelain (good - fair - poor).
5. Remove carbon deposits from plugs.
7. File electrodes until surfaces are flat.
9. Determine proper spark gap (in.
10. Regap plug using correct gauge.
11. Check plug reach.
12. Check plug gasket condition (good - fair - poor).
14. Tighten plug with torque wrench to recommended.

Evaluation Score Sheet:

<table>
<thead>
<tr>
<th>Part Properly Identified</th>
<th>Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>2. Oil removed and threads cleaned</td>
<td>4</td>
</tr>
<tr>
<td>3. Condition of porcelain</td>
<td>5</td>
</tr>
<tr>
<td>4. Carbon deposits removed</td>
<td>10</td>
</tr>
<tr>
<td>5. Electrodes properly filed</td>
<td>10</td>
</tr>
<tr>
<td>6. Spark plug heat range</td>
<td>5</td>
</tr>
<tr>
<td>7. Correct gauge for gapping used</td>
<td>10</td>
</tr>
<tr>
<td>8. Plugs properly gapped</td>
<td>15</td>
</tr>
<tr>
<td>9. Proper reach used</td>
<td>5</td>
</tr>
<tr>
<td>10. Gasket condition</td>
<td>5</td>
</tr>
<tr>
<td>11. Determining torque for plug</td>
<td>5</td>
</tr>
<tr>
<td>12. Plug correctly torqued in engine</td>
<td>10</td>
</tr>
</tbody>
</table>

Total 100

Job sheet prepared in cooperation with Randy Rumery and Dean Bartelt.

Name ____________________________ Date ___________ Grade ____________
g. Worn-out - electrode worn out, eroded and pitted.

3. Servicing.
   a. Remove and check condition replace with new plug if worn.
   b. Remove deposits from plug using wire brush penknife, gasoline or other solvent.
   c. File surfaces of electrode using point file until get flat surfaces. 20-40% less voltage required to fire a spark plug with sharp edges on central electrode.
   d. Gap to engine specification - adjustment should be made on side electrode.
      - gap is .025-.030 on most small engines.
      - check gap width with round wire type gauge.
      - can use float feeler gauge if plug is new.
   e. Install new gasket and tighten plug.
   f. Use torque wrench to tighten plug to proper torque as recommended by manufacturer.
   g. Sand blast cleaning of plugs is not recommended by most engine manufacturers in fact, some companies will not stand behind warranty if plugs have been abrasively cleaned.

D. Magneto.

1. Should be cleaned if necessary.
2. Breaker points.

   a. Should be adjusted properly.
   b. Check every 100 hours.

3. Condenser.

   a. Must be in good condition and of proper capacity.
   b. Badly pitted breaker points may indicate condenser is bad or is improper capacity. Pitting on negative or ground side of points and build-up on positive indicates condenser is weak or has lost its ability to absorb recommended capacity. Pitting on positive point and build-up on negative side indicates condenser has excessive capacity.
   c. Manufacturers say odds of condenser going bad are 1,000 to 1.
   d. Condenser can be checked for capacity; storage and resistance.
4. Servicing.

   a. Breaker points - Gap every 100 hours of operation.
      - will be set for .020" in most engines.
      - If rough, but show little pitting, smooth with ignition file.

E. Air cleaners.

1. Protecting an engine from dirt is probably more important to its life than any other single factor.

   a. The more dirt that is allowed to enter the engine, the shorter its life span will be.
   b. Tests have shown that intake of as little as 1/2 teaspoon of dust per hour can completely ruin engine within 8 hour period.
   c. Furthermore, operating with clogged element causes a richer fuel mixture which can lead to formation of harmful sludge deposits.
   d. So importance of maintaining air cleaner in proper condition cannot be over emphasized.

2. Servicing (Procedure discussed under Air Cleaners unit).

   a. Oil bath - should be serviced after each 25 hours of operation depending on conditions.
      - If extremely dusty or dirty conditions exist, service more frequently.
   b. Oil soaked - same as above.
   c. Dry filter - should be serviced after each 50 hours.
      Replaced if dirt does not drop off easily when tapped.
      - Do not wash in any liquid or attempt to blow dirt off with air hose.
      - Replace after 100-200 hours under normal operating conditions.

F. Fuel system.

1. Servicing

   a. Every 100 hours - empty and clean fuel tanks, gas lines filter, sediment bowl, and carburetor.
b. Parts should be washed in alcohol, acetones, or a good commercial gum solvent.

H. Gasoline.

1. Use clean, fresh regular gasoline.
   a. If not clean, dirt will clog lines, carburetors, or go on through into engine and cause wear.
   b. When stored for extended periods of time, certain portions tend to oxidize and form a heavy gummy substance. This can plug or restrict lines on carburetor jets.
   c. Octane rating of regular grade gasoline (90-92 octane) is sufficient for compression ratio of most small engines.

2. No need to use premium fuel in engine.
   a. May cause vapor lock in fuel line when engine becomes hot.

3. Do not recommend using high leaded fuels.
   a. Shorten engine life by leaving deposits on valve seats, spark plug, electrodes, and in cylinder.

I. Engine oil.

1. Oil in crankcase of a four-cycle small engine has four purposes, it:
   a. lubricates.
   b. cools.
   c. cleans.
   d. seals.

2. Specifications given in two ratings.
   a. API (American Petroleum Institute)-Service Classification or Type.
   b. SAE Viscosity.
3. API Service classifications.
   a. ML (motor light) - used under light and favorable operating conditions.
   b. MM (motor moderate) - used under moderate to severe operating conditions.
   c. MS (motor severe) - used under unfavorable or severe types of operating conditions.

4. SAE Viscosity.
   a. Viscosity is resistance to flow.
   b. Rated in SAE numbers.
   c. Manufacturers recommend different viscosity grades for different temperatures.

<table>
<thead>
<tr>
<th>Air temp.</th>
<th>Oil viscosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 320° F.</td>
<td>SAE 30</td>
</tr>
<tr>
<td>32° to 0° F.</td>
<td>SAE 10</td>
</tr>
<tr>
<td>Below 0° F.</td>
<td>SAE 5</td>
</tr>
</tbody>
</table>

d. Single viscosity oils (SAE 30) or multiviscosity oils (SAE 10-30).

5. Oils with additives recommended for most four-cycle engines (MS oils have additives).
   a. Additives are chemicals put in oil to improve quality.

6. Detergent additives help pick up dirt and sludge, and suspend them in oil.

7. Servicing.
   a. Should be changed after each 25 hours of operation under normal conditions.
   b. Drain oil while engine is warm; oil will flow more freely and carry away greater amount of contamination.
   c. On new or rebuild engines, oil should be changed after first five hours of operation.
   d. Check oil each time before engine is used.

J. Storing.

1. If the engine is to be out of service for a long period of time, such as over the winter, the following pre-storage procedure is recommended:
   a. Drain fuel tank and carburetor; let engine run to make sure all gasoline is out of the fuel system.
b. Drain oil from crankcase while engine is still hot, and flush with kerosene. Refill with the proper grade of fresh oil.
c. Clean exterior of engine.
d. Service air cleaner.
e. Spread a light film of oil over any exposed surfaces of engine which are subject to rust and corrosion.
f. Remove, clean, and regap spark plug.
g. Pour a tablespoon of oil into spark plug hole, crank engine slowly by hand, and replace spark plug.
h. Store engine in a dry place.
i. Cover engine if possible with canvas, etc.
# SERVICE SCHEDULE

<table>
<thead>
<tr>
<th>SERVICE FUNCTION</th>
<th>PERFORM SERVICE AT INTERVAL INDICATED (X)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EACH DAY</td>
</tr>
<tr>
<td>LUBRICATION SYSTEM</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Check and add oil as needed.</td>
</tr>
<tr>
<td>AIR INTAKE SYSTEM</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Thoroughly drain, refill with oil of proper grade and weight.</td>
</tr>
<tr>
<td>AIR INTAKE SYSTEM</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Clean element. (Replace element every 200 hours under normal operating conditions.)</td>
</tr>
<tr>
<td>AIR INTAKE SYSTEM</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Drain oil, clean bowl, wash element, add new oil to level mark.</td>
</tr>
<tr>
<td>FUEL SYSTEM</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Remove and clean bowl. If filter element used, clean in clean fuel. Reinstall and check for and correct leakage.</td>
</tr>
<tr>
<td>IGNITION SYSTEM</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Remove plug, clean and re-gap to .025&quot;. (Use new plug if needed.) Point plug and tighten to 324 in. lbs. Torque.</td>
</tr>
<tr>
<td>IGNITION SYSTEM</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Remove cover, check condition of point contacts, service (or replace) as necessary.</td>
</tr>
<tr>
<td>IGNITION SYSTEM</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Check and retighten as necessary. Set breaker point gap to 0.020&quot; fully open or use timing light method.</td>
</tr>
<tr>
<td>ELECTRICAL (CHARGING - STARTING) SYSTEMS</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Check and correct belt tension if needed. Check brushes and commutator - service as required.</td>
</tr>
<tr>
<td>ELECTRICAL (CHARGING - STARTING) SYSTEMS</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Remove cover, check condition of point contacts and contact point gap. Service as required.</td>
</tr>
<tr>
<td>ELECTRICAL (CHARGING - STARTING) SYSTEMS</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Regular service not required - check condition of leads, tighten loose terminal or connections.</td>
</tr>
<tr>
<td>ENGINE - GENERAL</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Clean air intake screen, reading line, and black especially in oil spill area.</td>
</tr>
<tr>
<td>ENGINE - GENERAL</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Remove cover, check clearance between valve stems and tappet. (See Valve Clearance Adjustment), adjust as needed.</td>
</tr>
<tr>
<td>ENGINE - GENERAL</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Remove components, check need valve and gaskets, clean filter. Reinstall in proper sequence.</td>
</tr>
<tr>
<td>ENGINE - GENERAL</td>
<td></td>
</tr>
<tr>
<td>MLRFORM</td>
<td>- Clean after. Remove all carbon deposits with piece of wood. Install new gasket, reinstall head and tighten bolts in proper sequence and to specified torque value.</td>
</tr>
</tbody>
</table>
Day 14

10. PROBLEM AREA: Trouble Shooting and Review.

Objectives:

To develop an understanding of procedures used in trouble shooting.

To develop an ability to trouble shoot an engine.

Reference:


Subject Matter:

a. See following pages.

Teacher and Student Activities:

a. Teacher will discuss trouble shooting.
b. Teacher will run off trouble shooting guide, pass out to students and discuss.
c. Teacher will pass back the assignments previously handed in. Discuss them with students.
d. Teacher will briefly review all assignments that were turned in and answer any other questions.
e. Time permitting, teacher may give short summary of subject matter and what they hoped student learned.

RECOVER OBJECTIVES IN REVIEW
Day 14

I. Trouble shooting.

A. Trouble shooting step by step process of locating engine.
B. First, establish symptoms and then narrow down.
C. Remember three essentials for combustion when trouble occurs.
   1. Compression.
   2. Carburetion.
   3. Ignition.
D. All three must be functioning properly before an engine will start.
E. See trouble shooting guide.
Trouble Shooting Guide for Small Gasoline Engines

Complete the following trouble shooting guide. As each item is completed, check the blank and proceed to next item.

Engine Data: Make_____________________, Model Number_____________________, Horsepower Rating_____________________.

1. Remove air cleaner: Type_____________________.

2. Check choke travel. Does choke remain partially closed when off?_______

3. Adjust main jet on carburetor: Mfgrs. Specs. no. of turns off seat_______

4. Adjust idle jet on carburetor: Mfgrs. Specs. no. of turns off seat_______

5. Check throttle linkage: Does throttle plate open for high speed and close for idle speed?_______

6. Check governor linkage; is it connected according to the Mfgrs. Specs.?_______

7. Remove flywheel housing.

8. Check engine compression by spinning the flywheel counterclockwise or by using the compression tester.

9. Check condition of high voltage lead.

10. Remove spark plug, check condition and plug gap: Mfgrs. Specs. for gap_______, Mfgrs. Specs. for plug type_____________________.

11. Ground plug to engine, crank engine, testing for quality of spark.

12. Remove flywheel.

13. Inspect condition of flywheel key.

14. Remove breaker point cover.

15. Check for loose connections, oil or damaged leads.

16. Check points condition and gap clearance: Mfgrs. Specs._____________________.

17. Check capacity and condition of condenser: Capacity_______Microfarads, Mfgrs. Specs._______Microfarads.

18. Reassemble: replace breaker point cover, replace flywheel, flywheel key, and flywheel nut.

19. Check air gap at armature: Mfgrs. Specs._____________________.
186

18. Replace spark plug and flywheel housing.

21. Check fuel level, fuel lines, and oil level.

22. Replace air cleaner.

23. Crank engine, if engine does not start remove spark plug to check if air-fuel mixture is getting into the combustion chamber.


25. Make final adjustments on carburetor main jet and idle jet, make final speed adjustments.

Engine is now ready for performance inspection.
II. List of troubles and probable causes.

A. Hard starting.

1. Faulty ignition.
   a. Loose or grounded high tension or breaker point leads.
   b. Improper breaker point gap.
   c. Faulty spark plug or improper gap.
   d. Faulty condenser of coil.
   e. Incorrect spark timing.
   f. Defective breaker points.
   g. Faulty condenser or coil.

2. Faulty carburetion.
   a. Gas not getting to carburetor - dirt or gum in fuel line.
   b. Dirt in carburetor.
   c. Carburetor improperly adjusted.

3. Compression loss.
   a. Valves leaking or sticking.
   b. Rings worn or broken.
   c. Head gasket leaking.
   d. Loose or cracked head.
   e. Piston cracked and cylinder scored.

B. Overheating.

1. Lack of cool air.
2. Dirty air cleaner and cooling fins.
3. Improper fuel.
4. Fuel mixture too lean.
5. Improper ignition timing.
6. Engine overloaded.
7. Tight tappet clearance.

C. Backfiring.

1. Fuel mixture too lean.
2. Sticky intake valve.
3. Improper timing.

D. Occasional missing at high speeds.

1. Spark plug gap too wide.
2. Improper carburetor setting or lack of fuel.
3. Wrong type spark plug.
4. Improper timing.

E. Missing under slow hard pull.

1. Spark plug gap too wide
2. Pitted breaker points.
3. Partially fouled spark plug.
4. Defective ignition cable.

F. Engine knocking.

1. Fuel octane rating too low.
2. Overheated engine.
3. Improper timing.
4. Loose connecting rod.
5. Excessive carbon in combustion chamber.

G. Operating erratically.

1. Clogged fuel line.
2. Water in fuel.
3. Faulty choke control.
4. Improper fuel mixture.
5. Loose ignition system connections.
6. Air leaks in manifold or carburetor connections.
7. Vent is gas cap plugged.

H. Engine not idling properly.

1. Improper carburetor idling adjustment.
2. Carburetor jets clogged.
4. Leaking carburetor or manifold gaskets.
5. Sticking or leaking valves.
6. Weak coil or condenser.
Day 15

I. Post test - Small Gasoline Engines.