THE DEVELOPMENT AND EVALUATION OF INSTRUCTIONAL UNITS DEALING WITH SELECTED PRINCIPLES OF ANIMAL NUTRITION

by

David Eugene Cox

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SIGNED: David Eugene Cox

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

Floyd G McCormick
FLOYD G. McCORMICK
Professor of Agricultural Education

September 18, 1974
Date

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ABSTRACT

This study was undertaken to develop and evaluate instructional units dealing with principles of animal nutrition identified by using a national jury of experts. The developed instructional units were designed to utilize the inductive mode of teaching.

The one-group, pretest-posttest design was employed. In order to evaluate their effectiveness, the instructional units were field tested in Arizona departments of vocational agriculture. Instructors who had previous experience in teaching by the inductive mode were involved in field testing the instructional units.

Freshmen and sophomore vocational agriculture students in Arizona were pretested, received the instruction, and were posttested using the developed evaluative instrument. The relative change in student understanding as measured by the percent change in mean correct responses between the pretest and posttest was calculated.

Major findings included: the identification of thirteen principles of animal nutrition; the development of five instructional units; and the development of an evaluative instrument possessing a reliability index of .81. Test results indicated an increase in student understanding between pretesting and posttesting of 33.4 percent which was significant at the .05

level of confidence. Further analysis of data revealed there was no statistically significant difference in student understanding of selected principles of animal nutrition between freshmen and sophomore groups involved in the field testing program.

CHAPTER I

INTRODUCTION

Vocational education in agriculture has undergone many changes and advancements in recent years. Among these changes has been an increased emphasis upon the teaching of the principles involved in agricultural science.

Today, agriculture encompasses all occupations where knowledge, skills, and abilities in agriculture are essential for entry and advancement. This presents a challenge to agricultural education to meet the educational needs of a more diversified clientele. Agricultural educators must provide greater "in-depth" instruction and, at the same time, provide for "residual" learning.

A report dealing with instructional units published by the Agricultural Experiment Station, The University of Arizona (1968:3) states:

> It is no longer educationally sound to teach only the specific facts relating to production agriculture. We need to broaden our teaching approach--we need to begin blending in the "why" with the "know-how" aspects of agriculture. In the future, instructional programs in vocational agriculture should place increased emphasis on teaching for greater understanding of basic principles that have application to the total world of work in agriculture.

A perusal of the available literature showed little work had been completed in the area of identification of principles of animal nutrition and the resultant development and evaluation of instructional units to teach animal nutrition principles. Further, animal nutrition was a recognized portion of the animal science curricula in vocational agriculture; however, few teaching materials in the subject matter area were available to vocational agriculture instructors in Arizona.

Based upon the above, the development and evaluation of instructional units for teaching principles of animal nutrition to freshmen and sophomore students enrolled in vocational agriculture in Arizona was initiated.

Statement of the Problem

The problem undertaken in this study was the development and evaluation of instructional units dealing with selected principles of animal nutrition to be taught to students enrolled in ninth and tenth grade vocational agriculture classes.

Specific Objectives

The following objectives were considered essential for the completion of this study:

1. To identify the principles of animal nutrition which should be taught to ninth and tenth grade students enrolled in vocational agriculture.

2. To develop instructional units based upon the selected principles of animal nutrition utilizing the inductive mode of teaching.

3. To evaluate the instructional units by measuring the relative change in student understanding of the selected principles of animal nutrition prior to, and following instruction by local vocational agriculture instructors.

4. To compare the relative change in student understanding between the pretest and posttest mean correct responses of the freshmen and sophomore groups used in this study.

Hypotheses

The evaluation of the effectiveness of the instructional units dealing with the selected principles of animal nutrition was based upon an assessment of the relative change in student understanding of those principles. It was hypothesized for this study that:

1. There will be no statistically significant difference in student understanding of the selected principles of animal nutrition between a pretest and a posttest when using the developed instructional units.

2. There will be no statistically significant difference in the change in student understanding between the freshmen and sophomore groups as measured by a comparison of posttest mean correct responses.

Assumptions

The following assumptions were considered by the researcher as basic to this study. It was assumed that:

1. The animal nutrition experts utilized in this study to finalize the list of selected principles of animal nutrition were highly competent individuals in the field of animal nutrition and were qualified to identify basic principles of animal nutrition.

2. The existing format for developing instructional units using the inductive mode of teaching was educationally sound.

3. The instructors who field tested the instructional units were competent to teach utilizing the inductive mode of teaching and did in fact use the material as prepared.

Delimitations

This study made no attempt to be all inclusive. The results obtained were delimited to the following:

1. Vocational agriculture students enrolled in Arizona secondary schools in grades nine and ten during the 1972-73 school year.

2. Vocational agriculture instructors in Arizona who expressed an interest in using the instructional units.

3. Vocational agriculture instructors in Arizona who had previously taught using the inductive mode of teaching or who had received instruction in teaching by the inductive mode.

4. Those principles of animal nutrition selected by the national jury of experts.

Limitations

The recognized limitations of this study were as follows:

1. The one-group pretest-posttest design used may have influenced the results since:

    a. The time lapse and events occurring between administration of the pretest and the posttest may have had an effect upon the posttest scores.

    b. The results obtained may have been influenced by the normal maturation of the students from the time of the pretest to the posttest.

    c. The students may have become sensitized to the testing instrument by their exposure to the pretest which could account for some increase in understanding as measured by the posttest.

    d. Further, some students who took the pretest did not take the posttest and their scores could have altered the findings.

2. Another limitation to this study may be due to the concept of statistical regression, or the tendency of subjects to regress toward the mean.

Need for the Study

With the advent of the principles approach in teaching agricultural science to vocational agriculture students, it was deemed necessary to develop and evaluate instructional units in animal nutrition. In formulating this study, a review of the available literature revealed that the principles approach and the inductive teaching mode had developed over a period of time. Studies dealing with the identification of agricultural and biological principles, instructional unit appraisal utilizing the inductive teaching mode, and construction of an evaluative instrument to measure student understanding had been completed.

McCormick (1964:191) identified seven profit-maximizing principles. In another study by Starling and Bender (1965:15) it was found that students who were taught biological principles integrated with instruction in vocational agriculture showed greater achievement between the pretest and posttest than did those who were only tested and not taught the biological principles. The mental maturity of those two groups was equal.

Barker and Bender (1967:24) using the inductive mode found there was a signifcant difference in the level of understanding between students who were taught by the inductive mode and those taught in the traditional manner. Those who were taught by the inductive mode obtained the highest scores on the posttest. The difference was statistically significant at the .05 level of confidence.

An Ohio study by Zurbrick (1971:110) using marketing principles taught by the inductive mode, showed that the use of the instructional materials did, in fact, result in an increase of student understanding using class means. This increase was significant at the .05 level. In the same study conducted by Zurbrick (1971:110), it was found that even more statistically significant values were achieved when the percentage increase in understanding between the pretest and posttest was used. The classes in the experimental group exhibited a mean increase from the pretest to the posttest that was significant at the .01 level of confidence.

After a critical review of literature and research, Hermann (1968:58) concluded that research tended to favor discovery learning when compared to other teaching techniques.

In a report of a project conducted under the National Defense Education Act of 1958, the California State Department of Education (1963:i) stated that the inductive mode of teaching biological principles was selected because it lends itself to instruction for understanding--leading to application.

Concerning animal nutrition, Maynard and Loosli (1962:6) state:

> Superficially, the rations of man and animals have little in common since the kinds of food eaten are so different. Yet the essential constituents of these rations; that is, the elements required for adequate nutrition, are largely the same whatever the species. The general principles of nutrition are identical.

On the basis of the above statement, prior work using the principles approach and the inductive mode, and the need for instructional units to teach selected principles of animal nutrition to ninth and tenth grade vocational agriculture students in Arizona, the researcher employed a national jury of experts to identify selected principles of animal nutrition, developed instructional units using the inductive teaching mode, and designed an instrument to measure student understanding of the selected principles of animal nutrition.

It should be pointed out that the results of this study are not necessarily limited in utility only to vocational agriculture instruction in Arizona. The resultant instructional units and the evaluative instrument could be used by agricultural educators, with only minor adaptations, nationwide, because they are based upon selected principles.

Method of Investigation

The general procedures utilized in this study were designed to:

1. Identify the basic principles of animal nutrition.
2. Develop the instructional units based upon the principles identified in this study.
3. Develop an evaluative instrument to measure student understanding of the selected principles of animal nutrition.
4. Field test the developed instructional units using the one-group, pretest-posttest design.
5. Analyze data to determine the relative change in student understanding of the selected principles of animal nutrition as measured by pretest and posttest mean correct responses.

Identification of the Principles

The identification of the selected principles of animal nutrition was considered the focal point of this study. The ultimate development of the instructional units and the evaluative instrument hinged upon the selection of the principles of animal nutrition.

The principles were selected using a four-step process. First, the writer searched the available literature and textbooks and began to synthesize a list of statements dealing with animal nutrition. The second step involved members of the faculty of the Department of Poultry Science, The University of Arizona, who were asked to review and evaluate the initial list of statements of animal nutrition and suggest additions or deletions. The third step was to identify a national jury of experts to review and validate the list of synthesized principles. The national jury of experts was selected from colleges and universities with departments of animal science.

Finally a questionnaire containing the list of principles of animal nutrition was mailed to the members of the national jury of experts for their evaluation. Members of the national jury of experts were asked to rate each principle as to its relative importance. They were asked to rate each principle on a five point scale, with "five" as the most essential and "one" as not essential. After the questionnaires were returned to the researcher, those statements that received a mean rating of at least "three" were selected for inclusion in this study.

Development of the Instructional Units

The finalized list of selected principles of animal nutrition was used in the development of the instructional units. The principles were grouped by subject matter areas into five instructional units and specific examples were developed to illustrate each principle and/or group of principles.

Development of the Evaluative Instrument

Once the instructional units were developed, the evaluative instrument was constructed. Several multiple choice questions consisting of a stem and four distractors were written for each objective included in each unit. The questions were then randomized to develop the evaluative instrument which served as the pretest and posttest. The pretest and the posttest are herein referred to as the evaluative instrument.

Selection of Pilot Schools

Vocational agriculture teachers in Arizona who had received instruction in using the inductive mode of teaching or who had previously taught using this mode were contacted to determine if they would participate in the field testing program. Those teachers who agreed to participate were surveyed to determine the approximate starting and ending dates so they could receive the evaluative instrument and the instructional units at the appropriate time. A list of the teachers and schools who participated may be found in Appendix H.

The students remained anonymous and the tests were coded by number. The students were asked to record their age and year in high school on the cover page of the evaluative instrument.

After the instructional units had been taught, using the inductive mode of teaching, the posttest administered and graded, the relative change in student understanding was calculated.

The research model used in this study to evaluate the relative effectiveness of the instructional units employed the one-group, pretest-posttest design. Granted, the inherent problems with the internal validity of this design as pointed out by Campbell and Stanley (1963:7) tend to leave some questions unanswered.

Definitions

In order to provide greater clarity for the reader of this study, the following terms were defined:

1. Animal: As it is used in this study, animal connoted the domestic cattle, horses, poultry, sheep, and swine produced on farms and ranches.

2. Basic Principles Seminar: A four-day workshop conducted, as a part of the New Teacher Program, by the Department of

Agricultural Education, The University of Arizona designed to equip the vocational agriculture instructor with the skill to utilize the inductive mode of teaching.

3. Change in Student Understanding: The relative change in students' mean correct responses on the pretest and posttest expressed as a percentage of the pretest score.

4. Freshmen Group: Those students who participated in the field testing program who were enrolled in their first year of a vocational agriculture program.

5. Inductive Mode of Teaching: The inductive teaching process involves going from the specific to the general. Instruction begins with observed or described situations that illustrate the principle(s) and which should lead students to eventually discover and state the principle, with assistance from the instructor.

6. Jury of Experts: This connoted a nationwide panel of selected personnel in the field of animal nutrition. These persons were either teaching or research faculty members, or extension personnel of Land Grant agricultural colleges and universities.

7. Nutrition: Nutrition is the biological process involved in various chemical and physiological activities which transform food elements into body elements.

8. Pilot Schools: An Arizona public secondary school having a department of vocational agriculture that agreed to field test the instructional units developed in this study.

9. Principle: A fundamental truth, or law of conduct that has general application and is a basis for action. It is a generalization based on facts and on elements of likeness common to a number of situations.

10. Principles Approach: A curriculum in which the content is based primarily on principles rather than facts and/or figures.

11. Selected Principles: The thirteen principles of animal nutrition used in this study as identified by a National Jury of Experts and incorporated into the developed instructional units.

12. Sophomore Group: Those students who participated in this field testing program who were enrolled in their second year of a vocational agriculture program.

13. Vocational Agriculture Instructor: A certificated teacher employed in a public secondary school in Arizona whose primary function is to teach vocational agriculture.

CHAPTER II

METHOD OF INVESTIGATION

The major emphasis of this study was to develop instructional units dealing with selected principles of animal nutrition employing the principles approach and utilizing the inductive mode of teaching.

The procedures utilized in this study will be reviewed in relation to: (1) identification of the principles of animal nutrition; (2) development of instructional units; (3) evaluation of the instructional units; (4) comparison of the freshmen and sophomore groups, and (5) analysis of the evaluative instrument.

Identification of the Principles of Animal Nutrition

The first and foremost area of concern in this study was the identification of those principles of animal nutrition that had practical application to all classes of livestock and that could be selected as principles by animal nutrition experts. To serve as the benchmark, the writer reviewed the available literature and related material concerning animal nutrition. A preliminary list of sixty-nine statements relative to animal nutrition was synthesized by the writer, then reviewed and edited by staff members of the Agricultural Education Department, The University of Arizona. They were asked to respond on a scale of "five" to "one" as to the relative importance of the principles. A copy of the list of principles and rating scale may be found in Appendix A.

As an additional source of information a personal interview was conducted with the Head of the Poultry Science Department in the College of Agriculture, The University of Arizona. This interview served to acquaint that faculty member with the objectives of the study and to solicit his assistance in selecting principles of animal nutrition.

The list of sixty-nine statements was then reviewed and revised by staff members and the Head of the Poultry Science Department, The University of Arizona. Their additions, deletions, and changes were synthesized into a list of twenty statements that was sent to a national jury of experts for verification. Copies of the list of statements, the rating scales, the letter used, and the questionnaire may be found in Appendices A, B, C, D, and E of this study.

A national jury of experts was selected from departments of Animal Science at Land Grant Colleges and Universities throughout the United States. A two-part questionnaire was developed and sent to each person selected. Part One which contained the twenty revised principle statements asked the respondents if each met the criterion of a principle. Space was provided for additional principles to be added by each member of the national jury of experts.

Part Two solicited reaction from the members of the national jury of experts to rate the importance of each principle on a five point scale for high school freshmen and sophomore students enrolled in vocational agriculture programs. The scale used in the questionnaire ranged from "five" to "one" as follows:

5 - Most essential

4 - Essential

3 - Somewhat essential

2 - Least essential

1 - Not essential

Twenty-three questionnaires were sent to the national jury of experts. Twenty questionnaires were returned to the writer. This represents a response of 87 percent. One of the twenty respondents did not rate the principles as he was a microbiologist working only with rumen microorganism research and did not feel qualified to make the judgments solicited on the questionnaire. After three weeks, a follow-up letter was sent to the three members of the national jury of experts who had not responded. Those three questionnaires were never received.

As soon as the twenty questionnaires were received by the writer, the results were tabulated and recorded. Those principles receiving a composite mean score of "three or above" were selected for use in this study.

Development of Instructional Units

After the principles of animal nutrition were identified, the development of the instructional units based upon the inductive mode of teaching was initiated. The selected principles were reviewed by the writer and the Head of the Department of Agricultural Education, The University of Arizona and grouped in the light of their commonalities. The titles of the instructional units are shown in Chapter III of this study.

The instructional units were prepared using specific examples that illustrated the principle in whole or in part. The instructional units were prepared, with effort made, to adapt the technical information to the level of high school student's comprehension. The units were so developed that the student could make practical application of the information contained therein.

The design of the instructional units was as follows:

I. Unit Title

II. Unit Objectives

III. Introduction

IV. Teaching-Learning Activities (Educational Experiences)

V. Association of Examples

VI. Arriving at the Principle

VII. Student Activities

I. <u>Unit Title</u>: Each instructional unit was titled by identifying the major idea(s) presented by the principles included in the specific unit.

II. <u>Unit Objectives</u>: Each instructional unit included educational objectives that were written in performance terms.

III. <u>Introduction</u>: Techniques for introducing each unit were suggested so as to appeal to the students and "build a case for learning." The introduction was designed to be part of, and not part from, the suggested examples.

IV. <u>Educational Experiences</u>: Examples were suggested in each instructional unit to assist in developing a fuller understanding of each principle included in the unit. Each example built upon the previous example, and ideas brought about by each example progressed from the simple to the more complex.

V. <u>Association of Examples</u>: Techniques were suggested so that the conclusions could be grouped to show the relationships between the examples and to assist the students in arriving at generalizations common to all examples.

VI. <u>Arriving at the Principles</u>: This section of the instructional units was designed so the students could arrive at a definition of each specific principle.

VII. <u>Student Activities</u>: The final section of each unit was devoted to suggested student activities designed to help "fix" the understanding of the principle in the student's mind. These student activities were designed to test student understanding of the selected principles of animal nutrition and provide for the practical application of the recently acquired knowledge.

In summary, the selected principles of animal nutrition included in each unit were based upon their commonalities and the concepts conveyed. Every effort was made to utilize examples and ideas that were practical and specific to the respective principles. The principles included in each unit were those identified by the national jury of experts as principles of animal nutrition. A complete set of the instructional units and their transparency masters are on file in the Department of Agricultural Education, The University of Arizona, Tucson.

Evaluation of the Instructional Units

As a means of evaluating the effectiveness of the instructional units by assessing the relative change in student understanding of the selected principles of animal nutrition the one-group pretest-posttest design was utilized and can be illustrated as follows:

$$O_1 \qquad X \qquad O_2$$

where:

O_1 = pretest

X = treatment

O_2 = posttest

The above design has certain inherent threats to internal validity as discussed in Campbell and Stanley (1963:7).

Evaluation of the instructional units was done by assessing the relative change in student understanding. A six-step approach was followed, including (1) developing the evaluative instrument, (2) selecting the pilot schools, (3) pretesting the vocational agriculture students in the pilot schools, (4) using the developed instructional units, (5) posttesting the vocational agriculture students in the pilot schools, and finally (6) analyzing the data.

Developing the Evaluative Instrument

Once the principles of animal nutrition had been selected and the instructional units developed, the next step involved was to develop an evaluative instrument that objectively measured student understanding of the selected principles of animal nutrition.

The evaluative instrument was developed based upon the specified educational objectives contained in each of the instructional units.

It was decided to develop an evaluative instrument consisting of multiple choice questions consisting of a stem and four responses. In an Ohio study, McCormick (1964:61) used such an instrument to evaluate instructional units dealing with profit maximizing principles.

A need arose to establish the acceptable criterion to determine the reliability of the evaluative instrument. In discussion with staff members of the Department of Agricultural

Education, The University of Arizona, it was revealed that no established criterion of acceptance was available. It was concluded from research done by the department, however, that evaluative instruments with reliability coefficients of .80 were acceptable.

It was agreed upon by the researcher and the staff of the Department of Agricultural Education, The University of Arizona that the criterion of acceptable reliability for the developed evaluative instrument be as follows:

.55 - .64	Low
.65 - .74	Medium
.75 - .84	High
.85 - Above	Extremely High

A series of multiple choice questions dealing with each objective, and consisting of a stem or direct question and four distractors, one of which was the most correct, was developed. The questions were placed on note cards and categorized relative to the objective that each attempted to test. Duplicate questions; those that were not specific; ambiguous questions; and questions that tended to answer other questions were eliminated through the process of face validity evaluation. Through this process also, the total number of questions per objective, and distribution of correct responses were balanced.

Finally, these questions that were deemed to measure understanding of the principles involved, that could be understood by high school freshmen and sophomores, and that tested only one objective were randomized and typed into test form. The evaluative instrument was then reviewed by the writer and the staff members of the Agricultural Education Department, The University of Arizona. Prior to actual use in the field testing program, the evaluative instrument was pilot tested in a sophomore vocational agriculture class at Baboquivari High School in Sells, Arizona. The purpose of this field testing was to assist the researcher in eliminating ambiguous questions and to help maximize clarity of the questions. Questions lacking clarity or that were misinterpreted were discarded following this pilot testing. Neither the questions nor the test pages were numbered so that they could be randomized and thus reduce the probability that students sitting next to each other would have tests that were assembled alike. The final draft of the evaluative instrument consisting of 59 questions was prepared for use as both the pretest and the posttest.

The evaluative instrument contained a cover page of instructions and an example. Space was also provided for recording the students' identification number, age, and grade in high school. A copy of the evaluative instrument with the correct answers may be found in Appendix G.

Selecting the Pilot Schools

A letter was sent to those vocational agriculture instructors in Arizona who had previously used the inductive mode of teaching or had been exposed to the inductive mode of teaching through the Basic Principles Seminar. This process did eliminate some of the vocational agriculture instructors in Arizona from participation, but it was felt that this delimitation was necessary due to the design of the developed instructional units utilizing the inductive mode of teaching.

Eleven vocational agriculture teachers were selected to participate in the field testing program. A list of those teachers may be found in Appendix H of this study.

Pretesting the Vocational Agriculture Students in the Pilot Schools

Each instructor who was selected to participate was asked to supply the researcher with the number of students and the approximate starting and ending dates for the testing phase of the project. This was necessary so that a graduate assistant at the Department of Agricultural Education, The University of Arizona could schedule the mailing of essential materials on time, and in sequence, to carry out the field testing program.

The evaluative instruments were counted and mailed to each participating vocational agriculture instructor so they would arrive at the pilot school one day prior to the administration of the pretest. This scheduling was done in cooperation with each instructor and the Agricultural Education Department, The University of Arizona.

The participating vocational agriculture instructors assigned each student to be tested a permanent number for identification purposes. The students recorded the personal information on the cover page, prior to answering the questions.

Each individual instructor had the prerogative of using the instructional units and evaluative instrument in either a ninth or tenth grade vocational agriculture class.

The students were instructed to read each question and try to answer all questions, even if they had to guess. They were allowed an entire class period to complete the test.

Upon completion of the pretest, the vocational agriculture teachers returned the evaluative instruments to the Agricultural Education Department, The University of Arizona for scoring and coding.

Using the Developed Instructional Units

The local instructors began the instruction of the principles of animal nutrition utilizing the developed instructional units the next class period following the administration of the pretest. The participating vocational agriculture instructors were asked to teach the material in the same manner as other units that utilized the inductive mode of teaching.

The instructional units were designed to be taught in sequence in a three to five week uninterrupted block of time. Some of the units were shorter and therefore could be completed in less time, depending upon the instructor and the students, which accounts for the variance in the scheduled block of time.

A complete set of the instructional units and accompanying transparency masters were provided to each of the vocational agriculture instructors who were involved in the testing program.

Posttesting the Vocational Agriculture Students in the Pilot Schools

Upon conclusion of the instruction, a second set of the evaluative instruments was mailed to the participating vocational agriculture instructors according to the previously agreed upon schedule.

The posttests were administed the day following the conclusion of the instruction and were returned to the Department of Agricultural Education, The University of Arizona for scoring and coding the data.

Analyzing the Data

As soon as either the pretests or posttests were scored, the data were recorded on master coding sheets. The data were then punched on cards and analyzed at the Computer Center, The University of Arizona. The scores from the pretests and the posttests were ranked and paired by the computer. The ranked scores, the relative change in understanding between the pretests and posttests, and the difference between the freshmen and sophomore groups were calculated.

Comparing the Performance of the Freshmen and Sophomore Groups

In an attempt to determine the most appropriate grade level to utilize the developed instructional units, data from the freshmen group were compared with data from the sophomore group. An analysis was made using the difference in mean correct responses for the posttests of each group.

Analysis of the Evaluative Instrument

To determine the effectiveness of the evaluative instrument, data collected were subjected to an analysis to determine the reliability.

As previously discussed, the evaluative instrument developed in this study was used as a pretest and posttest to calculate the relative change in student understanding. However, only posttest data were used to determine the test reliability of the evaluative instrument.

The calculated values for the test, including the reliability, the mean, and standard deviation will be discussed in Chapter III of this study.

CHAPTER III

PRESENTATION AND INTERPRETATION OF DATA

The data as presented and interpreted in this chapter were gathered by various methods, depending upon the specific objective of the study. Presentation and interpretation of these data will be discussed as follows: (1) identification of the principles of animal nutrition; (2) development of the instructional units; (3) evaluation of the instructional units; (4) comparison of the performance of the freshmen and sophomore groups, and (5) analysis of the evaluative instrument.

Identification of the Principles of Animal Nutrition

Table 1 shows the Response Frequency and Composite Mean Ratings on Twenty Statements by the National Jury of Experts.

As can be seen in Table 1, composite mean ratings of the responses of the national jury of experts ranged from a low of 1.26 to a high of 4.79. The number of "yes" responses for principle number "one" with a 4.79 composite mean rating was nineteen. Principle number "seventeen" received only two "yes" responses and a composite mean rating of 1.26. As predetermined in the design of this study, those principles receiving a composite mean rating of 3.0 or greater were

Table 1. Response Frequency and Composite Mean Ratings on Twenty Statements by the National Jury of Experts (N=19)

Principle Number	Number of Experts Responding Yes	No	Composite Mean Rating
1	19	0	4.79
2	18	1	4.57
3	7	12	2.00
4	19	0	4.63
5	16	3	3.57
6	19	0	4.26
7	17	2	3.84
8	6	13	2.05
9	19	0	4.52
10	19	0	4.63
11	17	2	3.89
12	18	1	4.42
13	15	4	3.05
14	7	12	2.42
15	6	13	2.63
16	9	10	2.55
17	2	17	1.26
18	16	3	3.84
19	15	4	3.15
20	7	12	2.31

selected for inclusion in this study. Based upon this criterion, thirteen principles were selected for final inclusion in this study. The wording of principle number "ten" on the questionnaire was altered by the national jury of experts regarding the protein, vitamin, and mineral allowance for pregnant females. Fourteen of the respondents suggested that the wording of the principle reflect those requirements in the pregnant female. Based upon the responses of the national jury of experts, that principles was reworded and is shown as principle number "thirteen" on page 30 of this study.

The principles selected for inclusion in this study were listed in their final form as follows:

1. Feed in the form of balanced rations, supplies nutrients which can be used to build and renew the components of the body and to form its products.

2. Feedstuffs vary in nutrient and energy values.

3. The nutrient and energy requirements of an animal vary with size, activity, production demands, and environment.

4. A younger animal has more critical nutritive requirements for proteins, minerals, and vitamins than do older animals.

5. The protein allowance, regardless of age or system of production, should be ample to replace the daily breakdown of the body tissues, as well as provide for growth and production.

6. After the nutrient needs for body maintenance have been met, any surplus nutrients may be used for reproduction, growth, or production.

7. Nutrients can be classified into six general classes: proteins, fats (lipids), carbohydrates, vitamins, minerals, and water.

8. Proteins are essential for building tissue; carbohydrates produce energy and heat; and fats provide fatty acids and energy.

9. Animals can be classified digestively as either ruminants or non-ruminants.

10. Young animals and monogastric animals require a more concentrated ration than do older animals and ruminants.

11. Before feed can be absorbed from the digestive system and utilized by the animal, it must undergo extensive physical and chemical changes.

12. The benefit an animal derives from its feed is dependent upon the preparation of feedstuffs, energy content of the feed, and the ability of the animal to utilize the feed.

13. Pregnant females have more critical nutritive requirements for protein, vitamins, and minerals than do non-pregnant females.

Development of the Instructional Units

The selected principles were grouped into five instructional units and titled as follows: (1) Function of Feeds; (2) The Digestion of Feed; (3) Nutrients and Their Function; (4) Nutrient and Energy Requirements of Livestock, and (5) Utilization of Feeds by Livestock.

The selected principles of animal nutrition associated with each instructional unit are listed below:

Unit I, "Function of Feeds," contained the following:

1. Feed in the form of balanced rations, supplies nutrients which can be used to build and renew the components of the body and to form its products.

2. After the nutrient needs for body maintenance have been met, any surplus nutrients may be used for reproduction, growth, or production.

Unit II, "The Digestion of Feed," incorporated:

1. Animals can be classified digestively as either ruminants or non-ruminants.

2. Young animals and monogastric animals require a more concentrated ration than do older animals and ruminants.

3. A younger animal has more critical nutritive requirements for proteins, minerals, and vitamins than do older animals.

4. Pregnant females have more critical nutritive requirements for proteins, minerals, and vitamins than do non-pregnant females.

Unit III entitled "Nutrients and Their Function" included the following principles:

1. Nutrients can be classified into six general classes: proteins, fats (lipids), carbohydrates, vitamins, minerals, and water.

2. Proteins are essential for building tissue, carbohydrates produce energy and heat; and fats provide fatty acids and energy.

3. The protein allowance, regardless of age or system of production, should be ample to replace the daily breakdown of body tissues, as well as provide for growth and production.

"Nutrient and Energy Requirements of Livestock" was Unit IV and incorporated the following principles of nutrition:

1. Feedstuffs vary in nutrient and energy values.

2. The nutrient and energy requirements of an animal vary with size, activity, production demands and environment.

Unit V was entitled "Utilization of Feed by Livestock" and encompassed the following principles:

1. Before feed can be absorbed from the digestive system and utilized by the animal, it must undergo extensive physical and chemical changes.

2. The benefit an animal derives from its feed is dependent upon the preparation of feedstuffs, energy content of the feed and the ability of the animal to utilize the feed.

Using similarities as a basis for grouping the selected principles, five instructional units were developed.

Evaluation of the Instructional Units

As a means of evaluating the effectiveness of the instructional units the relative change in student understanding was calculated. Table 2 shows the Mean Correct Responses on the Pretests and Posttests, Difference in Mean Correct Responses, and Percent Change in Student Understanding of the Principles of Animal Nutrition.

Table 2. Mean Correct Responses on the Pretests and Posttests, Difference in Mean Correct Responses and Percent Change in Student Understanding of the Principles of Animal Nutrition (N=187)

Mean Correct Responses Pretests	Mean Correct Responses Posttests	Difference in Mean Correct Responses	Per Cent Change in Student Understanding	t-value
22.253	29.834	7.481	33.4	9.442

$t \geqq 1.960$ indicates significance at the .05 level with 186 df

It will be noted that the mean correct responses on the pretests was 22.253, while the mean correct responses on the posttests was 29.834. This represents a difference in mean correct responses of 7.481.

When the scores were grouped together the overall change in understanding between the pretest and the posttest was an increase of 33.4 percent. The 33.4 percent increase in understanding between the pretest and posttest for the freshmen and sophomore students combined resulted in a t-value of 9.442 with 186 degrees of freedom. This t-value was significant at the .05 level of confidence. In fact, the t-value was significant at the .01 level of confidence. Based upon these findings, hypothesis number "one," which stated that; "there will be no statistically significant difference in student understanding of the selected principles of animal nutrition between a pretest and posttest using the developed instructional units," was rejected.

Comparison of the Performance of the Freshmen and Sophomore Groups

Table 3 shows the Mean Correct Responses on the Pretests and Posttests, and the Percent Change in Mean Correct Responses for the Freshmen and Sophomore Groups.

Table 3. Mean Correct Responses on the Pretests and Posttests, and the Percent Change in Mean Correct Responses for the Freshmen and Sophomore Groups (N=187)

Group	Mean Correct Responses Pretests	Mean Correct Responses Posttests*	Difference in Mean Correct Responses	Per Cent Change in Mean Correct Responses
Freshmen	22.01	27.51	5.50	24.98
Sophomore	22.66	29.93	7.27	32.08

*Calculated t-value = .362

t $\geq$ 1.960 indicates significance at the .05 level with 185 df

As shown in Table 3, the mean correct responses on the pretests for the freshmen group were 22.01 while the sophomore group mean correct responses on the pretests were 22.66. This table also reveals the posttest mean correct responses of 27.51 for the freshmen group and 29.93 for the sophomore group. The differences in mean correct responses between the pretests and the posttests were 5.50 for the freshmen group and 7.27 for the sophomore group. When the percent increase between the pretest and posttest was calculated for each class, the freshmen group increased 24.98 percent and the sophomore group increase was 32.08 percent. Statistical analysis of the mean correct responses on the posttests resulted in a t-value of .362 with 185 degrees of freedom. In order to be a statistically significant difference, at the .05 level of confidence, a t-value of 1.960 or greater was required. Therefore, null hypothesis number "two" which stated: "there will be no statistically significant difference in the change in student understanding between the freshmen and sophomore groups as measured by a comparison of posttest mean correct responses" was accepted.

Analysis of the Evaluative Instrument

As an outgrowth of the original research project, data became available whereby the evaluative instrument used in this study could be analyzed to determine test reliability. Although this was not part of the original study and not included as a specific objective, the reliability and standard deviation of the evaluative instrument was determined. Table 4 presents the Mean Correct Responses, Standard Deviation and Test Reliability of the Evaluative Instrument on Principles of Animal Nutrition.

When the evaluative instrument was used as a posttest, the reliability was .81, with a mean of 28.82 and standard deviation 8.16.

Based upon the criterion established in Chapter II of this study it was considered that a test with an overall reliability coefficient of .81 may be interpreted as an acceptable evaluative instrument for this study.

Table 4. Mean Correct Responses, Standard Deviation and Test Reliability of the Evaluative Instrument on Principles of Animal Nutrition (N=187)

Test	Mean Correct Responses	Standard Deviation	Test Reliability
Posttest	28.82	8.16	.81

In summary, there was a significant increase in student understanding of selected principles of animal nutrition between a pretest and posttest by freshmen and sophomore vocational agriculture students when taught by the inductive mode using the developed instructional units. However, there was no statistically significant difference between the increase in understanding of the freshmen group and the sophomore group when calculated separately. Hypothesis number "one" in this study was rejected as stated in the null form, and hypothesis number "two" was accepted as a result of the data derived from this study. The evaluative instrument developed as a result of this study possessed a test reliability of .81.

CHAPTER IV

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter deals with the summary of findings, conclusions, and recommendations based upon the findings of this study.

Statement of the Problem

The problem undertaken in this study was the development and evaluation of instructional units dealing with selected principles of animal nutrition to be taught to students enrolled in ninth and tenth grade vocational agriculture classes.

Specific Objectives

In an effort to solve the aforementioned problem, the following objectives were identified:

1. To identify the principles of animal nutrition which should be taught to ninth and tenth grade students enrolled in vocational agriculture.

2. To develop instructional units based upon the selected principles of animal nutrition utilizing the inductive mode of teaching.

3. To evaluate the instructional units by measuring the relative change in student understanding of the selected

principles of animal nutrition prior to and following instruction by local vocational agriculture instructors.

4. To compare the relative change in student understanding between the pretest and posttest mean correct responses of the freshmen and sophomore groups in this study.

Method of Investigation

The general procedures utilized in this study were designed to:

1. Identify the basic principles of animal nutrition.

2. Develop the instructional units based upon the principles identified in this study.

3. Develop an evaluative instrument to measure student understanding of the selected principles of animal nutrition.

4. Field test the developed instructional units using the one-group, pretest-posttest design.

5. Analyze data to determine the relative change in student understanding of the selected principles of animal nutrition between the pretest and posttest.

Summary of Findings

The summary of the findings from this study will be reviewed in relation to the specific objectives of the study and will be reported objective by objective using the paraphrased objectives as headings. Those headings are: (1) identification of the principles; (2) development of the instructional units; (3) evaluation of the instructional units, and (4) comparison of freshmen and sophomore groups.

Identification of the Principles

1. Thirteen principles of animal nutrition received a composite mean rating of 3.0 or greater from Part II of the questionnaire and were selected for inclusion in this study.

2. One of the thirteen principles was reworded on the recommendation of the national jury of experts.

Development of the Instructional Units

Five instructional units were developed and titled as follows:

1. Function of Feeds
2. The Digestion of Feed
3. Nutrients and Their Function
4. Nutrient and Energy Requirements of Livestock
5. Utilization of Feed by Livestock

Evaluation of the Instructional Units

1. The increase in understanding between a pretest and posttest by all students involved was 33.4 percent.

2. This was significant at the .05 level of confidence. The t-value for the mean increase was 9.442 with 185 degrees of freedom.

Comparison of the Performance of Freshmen and Sophomore Groups

1. The freshmen students who participated in the study showed a 24.98 percent increase in understanding between the pretests and posttests.

2. The sophomore students who participated had a 32.08 percent increase in understanding between the pretests and the posttests.

3. A comparison of the performance of the freshmen and sophomore groups was not significant at the .05 level of confidence as measured by a t-test.

Analysis of the Evaluative Instrument

1. An evaluative instrument was developed possessing a reliability coefficient of .81.

Conclusions

Based upon the findings presented in this study, the following conclusions were drawn:

1. The procedures utilized in this study resulted in the development and evaluation of instructional units dealing with selected principles of animal nutrition.

2. Student understanding of the selected principles of animal nutrition increased when taught using the developed instructional units.

3. The instructional units developed were effective as teaching aids as evidenced by an increase of student understanding

of the selected principles of animal nutrition for high school freshmen and sophomore students in Arizona whose vocational agriculture teachers had experience with the inductive mode of teaching.

4. The developed instructional units can be used with approximately equal results with both high school freshmen and sophomore students enrolled in vocational agriculture.

Recommendations

Based upon the findings of this study the author sets forth the following recommendations:

1. That the developed instructional units be reviewed, revised and refined.

2. That the revised instructional units be published and made available to vocational agriculture instructors in Arizona.

3. That the evaluative instrument developed in this study be further refined and tested.

4. That this study should be repeated using a control and experimental group design to determine the effect of the pretest on the results.

5. That the developed instructional units be utilized in the first two years of vocational agricultural instruction in Arizona.

APPENDIX A

TENTATIVE PRINCIPLES OF ANIMAL NUTRITION AND RATING SCALE FOR SELECTING PRINCIPLES OF ANIMAL NUTRITION

Tentative Principles of Animal Nutrition

1. Food must supply nutrients which can be used to build and renew the components of the body and to form its product.

2. Plants store and animals dissipate energy.

3. It takes more pounds of roughage than of concentrates to produce the nutrients required for a unit of production.

4. As a crop matures, the percent protein and moisture decreases, and the percent carbohydrate and fiber increases.

5. The higher the percent of lignin of a feed the lower the digestibility. (Ruminants can digest some lignin.)

6. The nutritional content of a feed tends to increase with the increase in percent dry matter.

7. The feed requirements of animals vary with the species' ability to synthesize nutrients, either themselves or with aid of symbiotic organisms, and the species' characteristic ability to digest and extract the necessary nutrients.

8. The feed requirements for maintenance of an animal varies with animal size, activity, and environment.

9. As an animal grows to maturity, the required carbohydrate percent increases.

10. As an animal grows to maturity, the required protein percent decreases.

11. As an animal grows to maturity, the ability to handle bulky feed increases.

12. When an animal does not receive a balanced ration over a period, any production of the animal will suffer first. If still not rectified, normal maintenance will be affected and the animal's body will begin to deteriorate.

13. The protein needs are greatest for young animals and lactating, gestating females.

14. The protein allowance, regardless of age or system of production, should be ample to replace the daily breakdown of the tissues of the body as well as to provide for the growth of hair, horns, hoofs, and tissue.

15. A younger animal has more critical nutritive requirements for proteins, minerals, and vitamins than do older animals.

16. The first and most important function of feeds is that of meeting the maintenance needs.

17. After the energy needs for body maintenance have been met, any surplus energy may be used for growth or production.

18. Feed accounts for the largest cost item in production of domestic livestock.

19. Cost per unit of production decreases as production increases.

20. Minerals are essential for bones, blood, heart, and normal digestion.

21. Protein supplement from plant and/or animal origin increases protein content of a ration when fed in conjunction with the ration.

22. Mineral supplements should be fed when the daily ration does not meet the minimum daily requirement of minerals.

23. Nutrient requirements increase with increased production.

24. Nutrients are divided into six classes: carbohydrates, fats, proteins, minerals, vitamins, and water.

25. Carbohydrates produce heat and energy.

26. Proteins are essential for muscles, internal organs, and outer covering.

27. Animals can be classified digestively as either ruminants or non-ruminants.

28. Energy requirements of animals are expressed as calories which include apparent digestible energy (DE), metabolizable energy (ME), and net energy (NE).

29. A particular animal's need for both plant and animal protein is inversely proportional to the length of the digestive tract.

30. As the length of the digestive system increases, the utilization of roughages increases, and concentrated food requirements decrease.

31. To maximize profits, animals must be fed the most economical ration even if rate of production is less than with the most expensive ration (MC = MR).

32. The more succulent a feedstuff, the less is the water intake requirement for a given animal.

33. Environmental conditions affect nutritive requirements and resultant production.

34. Animal health is directly proportionate to utilization of foodstuffs.

35. An animal's nutritive requirement is proportionate to the demands made of the animal.

36. Feeds, in the form of balanced rations, are necessary for proper maintenance, production, and reproduction of livestock.

37. One of the primary sources of food nutrients for animals is plants, whether growing naturally or through cultivation.

38. Before food can be absorbed from the digestive tract and utilized by the animal, it must undergo extensive chemical and physical changes to make it water soluble.

39. The method of preparing common feedstuffs is determined by the cost of preparation, the availability of feedstuffs, the ability of various animals to utilize the feed depending upon the type of digestive system they possess, and the palatability of the feed.

40. The general nutrient requirements of common domestic farm animals are, in most cases, determined by analysis and are available to producers. (students)

41. The benefit an animal derives from its food is dependent upon the composition, the nutritive value of the food, and the ability of an animal to utilize this food.

42. Water is the major constituent of all living cells; it influences the effect of temperature on living organisms, it acts as a solvent for most food substances, and it is a medium for ionization.

43. Nearly all feeds have tags attached which indicate the content and composition of the feed.

44. There is no method by which exact amounts of a feedstuff in a formula can be accurately determined, therefore, reputable manufacturers and dealers are recommended.

45. The factors of digestion are mechanical, secretory, chemical, and microbiological.

46. Most of the chemical changes occurring in the digestive processes are brought about by the action of enzymes.

47. Animals have mechanisms by which they get feed into the mouth, through the esophagus to the stomach, and into the intestines.

48. Fibrous, bulky feeds must be delayed in the digestive scheme and undergo soaking and fermentation, prior to digestion in the stomach.

49. Food nutrients and waste products are separated by the digestive processes prior to nutrient absorption.

50. Fats are principally absorbed by the lymph, in the form of fatty acids and glycerol.

51. Protein and carbohydrate digestion products, water, and inorganic salts are absorbed largely by the blood.

52. Proteins are absorbed in the form of amino acids and peptides, through the portal blood system.

53. Carbohydrates are absorbed as monosaccharides and lower (short chain) fatty acids.

54. As the percent roughage in a ration increases, the salt requirement increases.

55. Salt can serve as a carrier vehicle for other feed additives.

56. A deficiency of salt over a long period of time lowers efficiency of protein utilization, accompanied by fatigue and production losses.

57. The more animals depend upon roughage rather than concentrates in their rations, the greater their need for salt and the greater their consumption if given voluntary access to it.

58. All farm animals have been found to have a high tolerance for salt, just so they do not get excessive amounts in their feed all at once, especially not after having been starved for salt for some time previously.

59. Protein supplements of animal origin and very finely ground feeds are unpalatable to animals.

60. The manner in which animals are started and kept on feed is important for good results. Once started on feed, they cannot be limited or changed rapidly without losses in weight and economy of gain.

61. Feed additives, such as hormones and supplements, tend to increase efficiency of production and rate of production.

62. Young growing animals need a higher proportion of vitamins and minerals in their rations than do mature animals.

63. Young growing animals require less feed for each pound of gain than do mature animals.

64. The longer an animal is kept on feed, the more expensive are the gains.

65. Gestating females must be fed rations that meet the requirements of maintenance and their own growth, as well as the needs of the fetus.

66. Protein requirements are higher for production than for maintenance.

67. The proper feed additives, when needed, will increase production per unit and reduce cost of production.

68. Vitamins are required by animals in only small amounts, but a deficiency of vitamins is manifested by altered appearance and/or function of the animal.

69. Minerals contribute to the structure of an animal, particularly bones and/or teeth, aid in muscular activities, aid in reproductive processes, and in lactation and egg production.

Rating Scale for Selecting Principles of Animal Nutrition for Inclusion in a 2-Year Core Curriculum

Rate 5 as the most essential to 1 as not essential.

1.	5	4	3	2	1	24.	5	4	3	2	1	47.	5	4	3	2	1
2.	5	4	3	2	1	25.	5	4	3	2	1	48.	5	4	3	2	1
3.	5	4	3	2	1	26.	5	4	3	2	1	49.	5	4	3	2	1
4.	5	4	3	2	1	27.	5	4	3	2	1	50.	5	4	3	2	1
5.	5	4	3	2	1	28.	5	4	3	2	1	51.	5	4	3	2	1
6.	5	4	3	2	1	29.	5	4	3	2	1	52.	5	4	3	2	1
7.	5	4	3	2	1	30.	5	4	3	2	1	53.	5	4	3	2	1
8.	5	4	3	2	1	31.	5	4	3	2	1	54.	5	4	3	2	1
9.	5	4	3	2	1	32.	5	4	3	2	1	55.	5	4	3	2	1
10.	5	4	3	2	1	33.	5	4	3	2	1	56.	5	4	3	2	1
11.	5	4	3	2	1	34.	5	4	3	2	1	57.	5	4	3	2	1
12.	5	4	3	2	1	35.	5	4	3	2	1	58.	5	4	3	2	1
13.	5	4	3	2	1	36.	5	4	3	2	1	59.	5	4	3	2	1
14.	5	4	3	2	1	37.	5	4	3	2	1	60.	5	4	3	2	1
15.	5	4	3	2	1	38.	5	4	3	2	1	61.	5	4	3	2	1
16.	5	4	3	2	1	39.	5	4	3	2	1	62.	5	4	3	2	1
17.	5	4	3	2	1	40.	5	4	3	2	1	63.	5	4	3	2	1
18.	5	4	3	2	1	41.	5	4	3	2	1	64.	5	4	3	2	1
19.	5	4	3	2	1	42.	5	4	3	2	1	65.	5	4	3	2	1
20.	5	4	3	2	1	43.	5	4	3	2	1	66.	5	4	3	2	1
21.	5	4	3	2	1	44.	5	4	3	2	1	67.	5	4	3	2	1
22.	5	4	3	2	1	45.	5	4	3	2	1	68.	5	4	3	2	1
23.	5	4	3	2	1	46.	5	4	3	2	1	69.	5	4	3	2	1

APPENDIX B

SECOND DRAFT OF TENTATIVE PRINCIPLES OF ANIMAL NUTRITION AND RATING SCALE FOR SELECTING PRINCIPLES OF ANIMAL NUTRITION

Second Draft of Tentative Principles of Animal Nutrition

1. Feed must supply nutrients which can be used to build and renew the components of the body and to form its products.

2. It takes more pounds of roughage than of concentrates to produce the nutrients required for a unit of production.

3. The higher the percent of lignin in a feed, the lower the digestibility.

4. The nutritional content of a feed tends to increase with the increase in percent dry matter.

5. The feed requirements for maintenance of an animal vary with animal size, activity, system of production, and environment.

6. As an animal grows to maturity, the required carbohydrate percent increases, the required protein percent decreases, and its ability to handle bulky feeds increases.

7. When an animal does not receive a balanced ration over a period of time, production of the animal will suffer first, next, normal maintenance will be affected and the animal's body will begin to deteriorate.

8. The protein allowance regardless of age or system of production, should be ample to replace the daily breakdown of the tissues of the body as well as to provide for growth of covering, hoofs, horns, nails, and tissue.

9. A younger animal has more critical nutritive requirements for proteins, minerals, and vitamins than do older animals.

10. After the energy needs for body maintenance have been met, any surplus energy may be used for growth, production, or reproduction.

11. Nutrient supplements should be fed when the daily ration does not meet the minimum daily requirement for essential nutrients.

12. Nutrients can be classified into six general classes: carbohydrates, fats, proteins, minerals, vitamins, and water.

13. Nutrient requirements increase with increased production.

14. Proteins are essential for building tissue, carbohydrates produce energy and heat, and fats provide fatty acids and choline.

15. Animals can be classified digestively as either ruminants or non-ruminants.

16. As the length of the digestive system increases, the utilization of roughages increases, and concentrated feed requirements decrease.

17. To maximize profits, animals must be fed the most economical ration even if rate of production is less than with the most expensive ration (MC=MR).

18. Feeds, in the form of balanced rations, are necessary for proper maintenance, production, and reproduction of livestock.

19. One of the primary sources of food nutrients for animals is plants, whether growing naturally or under cultivation.

20. Before food can be absorbed from the digestive tract and utilized by an animal, it must undergo extensive chemical and physical changes to make it water soluble.

21. The preparation of common feedstuffs is determined by the cost of preparation, the availability of feedstuffs, the ability of various animals to utilize the feed depending upon the type of digestive system, and the palatability of the feed.

22. The benefit an animal derives from its feed is dependent upon the composition, the nutritive value of the feed, and the ability of the animal to utilize this feed.

23. As the percent roughage increases in a ration, the greater is an animal's need for salt.

24. A salt deficiency over an extended period of time lowers an animal's efficiency of feed utilization, accompanied by losses in production.

25. Once an animal is started on feed, they should not be limited or changed drastically or rapidly without suffering losses in weight and economy of gain.

26. Feed additives, such as hormones or supplements, tend to increase efficiency of production and rate of production.

27. Young growing animals need a higher proportion of vitamins and minerals in their rations than do mature animals.

28. As an animal grows to maturity, efficiency of production decreases.

29. Protein requirements are higher for production than for maintenance.

30. The proper feed additives, when needed, will increase production per unit and reduce cost per unit of production.

Rating Scale for Selecting Principles of Animal Nutrition for Inclusion in a Two-Year Core Curriculum in Vocational Agriculture

Rate 5 as the most essential, 1 as not essential.

1.	5	4	3	2	1	16.	5	4	3	2	1
2.	5	4	3	2	1	17.	5	4	3	2	1
3.	5	4	3	2	1	18.	5	4	3	2	1
4.	5	4	3	2	1	19.	5	4	3	2	1
5.	5	4	3	2	1	20.	5	4	3	2	1
6.	5	4	3	2	1	21.	5	4	3	2	1
7.	5	4	3	2	1	22.	5	4	3	2	1
8.	5	4	3	2	1	23.	5	4	3	2	1
9.	5	4	3	2	1	24.	5	4	3	2	1
10.	5	4	3	2	1	25.	5	4	3	2	1
11.	5	4	3	2	1	26.	5	4	3	2	1
12.	5	4	3	2	1	27.	5	4	3	2	1
13.	5	4	3	2	1	28.	5	4	3	2	1
14.	5	4	3	2	1	29.	5	4	3	2	1
15.	5	4	3	2	1	30.	5	4	3	2	1

APPENDIX C

LIST OF MEMBERS OF THE NATIONAL JURY OF ANIMAL NUTRITION EXPERTS

List of Members of the National Jury of Animal Nutrition Experts

Name and Address	Geographic Area	Subject Area
Dr. J. K. Loosli, Head Department of Animal Science College of Agriculture Cornell University Ithaca, New York 14850	Northeast (NY)	Animal Nutrition
Dr. W. G. Merrill Associate Professor Dairy Nutrition Cornell University Ithaca, New York 14850	Northeast (NY)	Dairy
Dr. R. H. Harms, Chairman Poultry Science Department College of Agriculture University of Florida Gainesville, Florida 32601	South (Fla)	Poultry
Dr. S. P. Marshall, Nutritionist Department of Dairy Science University of Florida Gainesville, Florida 32601	South (Fla)	Dairy
Dr. H. A. Henneman Professor of Animal Husbandry College of Agriculture Michigan State University East Lansing, Michigan 48623	North Central (Mich)	Physiology and Nutrition
Dr. R. P. Niedermeier, Chairman Department of Dairy Science College of Agriculture University of Wisconsin Madison, Wisconsin 53706	North (Wisc)	Dairy
Mr. E. K. Faulkner Assistant Professor Division of Animal Science College of Agriculture University State P. O. 3354 Laramie, Wyoming 82070	Northwest (Wyo)	Sheep and Swine

Dr. A. L. Esplin Professor of Sheep Department of Animal Science College of Agriculture Colorado State University Fort Collins, Colorado 80521	Mountain (Colo)	Sheep
Dr. R. E. Moreng, Head Department of Poultry Science Colorado State University Fort Collins, Colorado 80521	Mountain (Colo)	Poultry
Dr. R. B. Bradfield Extension Nutritionist College of Agriculture Science University of California at Berkeley Berkeley, California 94720	West Coast (Calif)	Subject Matter Specialist in Nutrition
Dr. R. C. Ewan, Assistant Professor Swine Nutrition College of Agriculture Iowa State University Ames, Iowa 50010	Midwest (Iowa)	Swine
Mr. J. J. Kiser Associate Professor of Horses Department of Animal Science College of Agriculture Iowa State University Ames, Iowa 50010	Midwest (Iowa)	Horses
Dr. V. C. Speer Professor of Swine Nutrition Department of Animal Science College of Agriculture Iowa State University Ames, Iowa 50010	Midwest (Iowa)	Swine
Dr. L. H. Brewer Assistant Professor of Ruminant Nutrition Department of Animal Science College of Agriculture Texas A & M University College Station, Texas 77843	South (Texas)	Ruminant

Dr. J. R. Couch Professor of Nutrition Department of Poultry Science Texas A & M University College Station, Texas 77843	South (Texas)	Poultry
Dr. D. K. Andrews, Poultry Specialist Department of Animal Science College of Agriculture Washington State University Pullman, Washington 99163	Northwest (Washington)	Poultry
Dr. M. R. Selke Associate Professor Animal Nutrition Department of Animal Science College of Agriculture University of Arizona Tucson, Arizona 85721	Southwest (Ariz)	Horse, Sheep, Swine
Dr. W. H. Brown Associate Professor Animal Nutrition Department of Dairy Science College of Agriculture University of Arizona Tucson, Arizona 85721	Southwest (Ariz)	Dairy
Dr. B. L. Reid, Head Department of Poultry Science College of Agriculture University of Arizona Tucson, Arizona 85721	Southwest (Ariz)	Poultry
Dr. J. P. Baker Assistant Professor Department of Animal Science College of Agriculture University of Kentucky Lexington, Kentucky 40506	Southeast (Kentucky)	Horses
Dr. A. J. Clawson Associate Professor Swine Nutrition Department of Animal Science School of Agriculture North Carolina State University Raleigh, North Carolina 27607	Southeast (North Carolina)	Swine

Dr. J. J. McNeil Associate Professor Animal Nutrition Department of Animal Science School of Agriculture North Carolina State University Raleigh, North Carolina 27607	Southeast (North Carolina)	Animal Nutrition
Dr. F. N. Dickinson Assistant Professor of Dairy College of Agriculture University of Massachusetts Amherst, Massachusetts 01002	East (Mass)	Dairy

APPENDIX D

LETTER TO THE NATIONAL JURY OF EXPERTS

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

COLLEGE OF AGRICULTURE
DEPARTMENT OF AGRICULTURAL EDUCATION

April 2, 1969

I am conducting a study to develop instructional units for teaching basic principles of animal nutrition to high school freshmen and sophomore vocational agriculture students utilizing the inductive teaching process.

By reviewing the relevant literature, and with the assistance of Dr. B. L. Reid, and other nutritionists at the University of Arizona, a tentative list of principles of animal nutrition has been developed. As a basis of understanding in developing this list, a principle connotes a basic truth applicable to many specific examples or situations.

I would like to solicit your professional assistance and judgment as a member of a nationwide jury of experts in the field of animal nutrition in determining whether the enclosed statements are, in fact, basic principles of animal nutrition. Furthermore, for those that are identified as principles, please rate their appropriateness for teaching to high school freshmen and sophomore students in vocational agriculture.

This masters degree study is being directed by Dr. Floyd G. McCormick, Head of the Department of Agricultural Education at the University of Arizona.

Please find the enclosed form and indicate on PART I whether or not the statement is a basic principle of animal nutrition by circling "YES" or "NO." For those statements that you rate "Yes," please indicate on PART II the appropriateness of each principle for teaching to high school freshmen and sophomore vocational agriculture students. A five-point scale ranging from "Most Essential" to "Not Essential" is provided in PART II.

Page 2
April 2, 1969

If there are other principles of animal nutrition that you are familiar with, and are not covered in the enclosed list, please note those in the space provided. A self-addressed, stamped envelope is enclosed for your convenience.

Thank you for your time and professional assistance.

Yours truly,

David E. Cox
Graduate Student
Department of Agricultural Education

DEC:jc

Enclosures

cc: Dr. B. L. Reid
Dr. F. G. McCormick

APPENDIX E

RATING SCALE FOR THE IDENTIFICATION AND SELECTION OF BASIC PRINCIPLES OF ANIMAL NUTRITION TO BE TAUGHT TO HIGH SCHOOL FRESHMEN AND SOPHOMORE VOCATIONAL AGRICULTURE STUDENTS

Rating Scale for the Identification and Selection of Basic Principles of Animal Nutrition to Be Taught to High School Freshmen and Sophomore Vocational Agriculture Students

DIRECTIONS FOR PART I:

Please indicate whether or not the following statements are basic principles of animal nutrition by circling "YES" or "NO" beside each statement of PART I. Please complete all statements before proceeding to PART II.

DIRECTIONS FOR PART II:

For each statement that you circled "YES" in PART I, indicating that the statement is a basic principle of animal nutrition, please circle the appropriate number below to indicate how essential the principle is for teaching animal nutrition to high school freshmen and sophomore vocational agriculture students.

PLEASE USE THE FOLLOWING SCALE:

5 - Most Essential

4 - Essential

3 - Somewhat Essential

2 - Least Essential

1 - Not Essential

EXAMPLE:	Is the Statement a Principle?		EXAMPLE:
a. All beef cattle are black.	YES	NO	a. 5 4 3 2 1
b. All domestic animals require some type of food nutrients to remain alive.	YES	NO	b. 5 4 3 2 1

	Is the Statement a Basic Principle of Animal Nutrition?		
1. Feed, in the form of balanced rations, supplies nutrients which can be used to build and renew the components of the body and to form its products.	YES	NO	a. 5 4 3 2 1
2. Feedstuffs vary in nutrient content and energy values.	YES	NO	b. 5 4 3 2 1
3. The higher the percent lignin or crude fiber in a feed, the lower the digestibility of the feedstuff.	YES	NO	c. 5 4 3 2 1
4. The energy requirements of an animal vary with size, activity, production demands, and environment.	YES	NO	d. 5 4 3 2 1
5. A younger animal has more critical nutritive requirements for proteins, minerals, and vitamins than do older animals.	YES	NO	e. 5 4 3 2 1

		Is the Statement a Basic Principle of Animal Nutrition?							
6.	The protein allowance, regardless of age or system of production, should be ample to replace the daily breakdown of the body tissues, as well as to provide for growth and production.	YES	NO	f.	5	4	3	2	1
7.	After the energy needs for body maintenance have been met, any surplus energy may be used for growth, production, or reproduction.	YES	NO	g.	5	4	3	2	1
8.	Feed additives, such as hormones, antibiotics, vitamins, minerals, or supplements, tend to increase efficiency and rate of production.	YES	NO	h.	5	4	3	2	1
9.	Nutrients can be classified into six general classes: carbohydrates, protein, fats (lipids), minerals, vitamins, and water.	YES	NO	i.	5	4	3	2	1
10.	Nutrient and energy requirements of animals increase with increased production.	YES	NO	j.	5	4	3	2	1
11.	Proteins are essential for building tissue, carbohydrates produce energy and heat, and fats provide fatty acids and energy.	YES	NO	k.	5	4	3	2	1
12.	Animals can be classified digestively as either ruminants or non-ruminants.	YES	NO	l.	5	4	3	2	1

	Is the Statement a Basic Principle of Animal Nutrition?							
13. Young animals and monogastric animals require a more concentrated ration than do older animals and ruminants.	YES	NO	m.	5	4	3	2	1
14. To maximize profits, animals must be fed the most economical balanced ration, even if rate of production is less than with the most expensive ration.	YES	NO	n.	5	4	3	2	1
15. The value of a particular protein in animal nutrition is directly proportional to its amino acid structure.	YES	NO	o.	5	4	3	2	1
16. The ration which has the highest protein quality is the one which supplies all the essential amino acids in the most nearly correct proportions.	YES	NO	p.	5	4	3	2	1
17. Palatability of feedstuffs is proportionate to the total amount consumed and digested by animals.	YES	NO	q.	5	4	3	2	1
18. Before feeds can be absorbed from the digestive system and utilized by the animal, it must undergo extensive chemical and physical changes.	YES	NO	r.	5	4	3	2	1

	Is the Statement a Basic Principle of Animal Nutrition?							
19. The benefit an animal derives from its feed is dependent upon the composition, energy content of the feed, and the ability of the animal to utilize the feed.	YES	NO	s.	5	4	3	2	1
20. As an animal grows to maturity, efficiency of production decreases.	YES	NO	t.	5	4	3	2	1

APPENDIX F

FOLLOW-UP LETTER TO THE NATIONAL
JURY OF EXPERTS

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

COLLEGE OF AGRICULTURE
DEPARTMENT OF AGRICULTURAL EDUCATION

April 26, 1969

Approximately three weeks ago you received a letter and a questionnaire from me relative to the identification and selection of basic principles of animal nutrition to be taught to high school freshmen and sophomore vocational agriculture students. Some of the questionnaires have been returned as of this date.

I would like to begin compiling the data from these various questionnaires and identify these basic principles. If you have not completed the questionnaire, would you please take a few minutes and do so. If you have completed and returned the questionnaire, please disregard this letter.

Thank you very much for your assistance.

Sincerely yours,

David E. Cox
Graduate Student
Agricultural Education

DEC/jc

APPENDIX G

MULTIPLE CHOICE QUESTIONS ON PRINCIPLES OF ANIMAL NUTRITION

No. ________

<u>Multiple Choice Questions on Principles of Animal Nutrition</u>

Please check (✓) the one answer for each question which you think most nearly correct. Check only one answer for each question. Answer <u>all</u> questions even if you have to guess. Read each question carefully, then study all of the choices before marking your decision. You do not need to sign your name.

EXAMPLE: (✓) Check one

Question: In relation to calcium-phorphorus content of feedstuffs, what is generally true of roughages such as alfalfa hay:

✓ a. it is high in P and low in Ca

____ b. it is high in both P and Ca

____ c. it is high in Ca and low in P

____ d. it is low in both Ca and P

Please fill in the following blanks before starting.

1. Age ________________.

2. Grade in high school ________________.

QUESTION: Which of the following animals would be classified as ruminants:

____a. humans
____b. chickens
✓ c. cattle
____d. horses

QUESTION: Which of the following uses of feed would be the least important when feeding a pregnant cow that is also nursing a young calf:

✓ a. growth
____b. reproduction
____c. production
____d. maintenance

QUESTION: In growing feeder pigs, the relative amount of roughages in the ration as compared to feeder calves is:

____a. equal
____b. higher
____c. constant
✓ d. lower

QUESTION: Preparation of feedstuffs can alter:

____a. nutrient content of feeds
✓ b. digestibility of feeds
____c. energy content of feeds
____d. all of the above

QUESTION: What is the major body function of proteins? They serve as:

____a. an energy source
✓ b. building block of new tissue
____c. a source of digestive enzymes
____d. a source of heat

QUESTION: In the digestive system of a ruminant, which part acts as a catch-all for foreign materials:

____a. 1
✓ b. 2
____c. 3
____d. 4

QUESTION: If a cattle feeder wanted to increase the efficiency of feed utilization, he would:

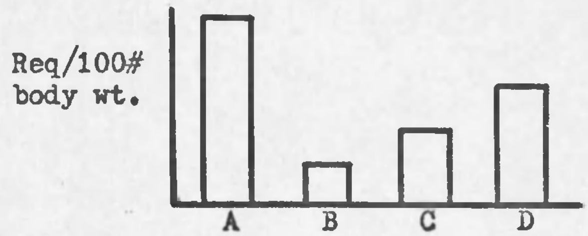
____a. increase protein content of ration
____b. increase carbohydrate content of ration
✓ c. use balanced rations
____d. use TDN

QUESTION: The nutrient and energy requirements of an animal vary with:

____ a. size
____ b. production demands
____ c. environment
__✓__ d. all of above

QUESTION: Based upon the chart, which animal would probably be monogastric:

__✓__ a. A
____ b. B
____ c. C
____ d. D



QUESTION: A balanced ration:

____ a. provides equal amounts of roughage and concentrate
____ b. provides the animal with equal amounts of vitamins and minerals
__✓__ c. provides all the nutrients an animal needs in 24 hours
____ d. all of the above

QUESTION: Which one of the following animals have the most critical need for protein, vitamins and minerals:

____ a. older ruminant animals
____ b. younger ruminant animals
__✓__ c. younger non-ruminant animals
____ d. older non-ruminant animals

QUESTION: Feeds must undergo physical and chemical changes because:

____ a. nutrients are not supplied in the feedstuff
____ b. nutrients contain high amounts of dry matter
__✓__ c. nutrients are not available in original form
____ d. nutrients contain a percentage of non-digestible protein

QUESTION: The amount of feed needed by an animal may vary because of:

____ a. the environment in which the animal is kept
____ b. the quality of feed
____ c. the condition of the animal
__✓__ d. all of the above

QUESTION: Assuming a feeder pig should have not more than 25% roughage in his daily ration, and you feed him 3 lbs. of feed per day; if the feed he consumes daily contains 1.27 lbs. of alfalfa hay, the roughage content is:

- ____ a. too low
- ✓ b. too high
- ____ c. the wrong kind
- ____ d. proper

QUESTION: In general, as the moisture content of a feed decreases, the TDN content:

- ____ a. decreases
- ____ b. remains the same
- ✓ c. increases
- ____ d. none of the above

QUESTION: Why does an animal receive less net energy from a roughage than from a concentrate?

- ____ a. less energy is required to digest green roughages
- ____ b. roughages contain less energy than concentrates
- ✓ c. more energy is required to digest roughages
- ____ d. less energy is required to digest roughages

QUESTION: Nutrients are used by the animal to:

- ____ a. supply energy for maintenance and production
- ____ b. build and renew components of the body
- ____ c. form products of the animal's body
- ✓ d. all of the above

QUESTION: Monogastric animals require rations that contain feedstuffs high in:

- ____ a. fats
- ____ b. oils
- ✓ c. proteins
- ____ d. lipids

QUESTION: Based upon the table, which feedstuff contains the highest nutrient value:

- ____ a. alfalfa hay
- ✓ b. corn, no. 1
- ____ c. oats
- ____ d. grain sorghum

Feedstuff	TDN %	Dig. protein
alfalfa hay	50.7	10.9
corn, no. 1	81.9	6.9
oats	70.1	9.4
grain sorghum	79.9	8.8

QUESTION: Which of the following is not considered as one of the six general classes of nutrients:

- ✓ a. oils
- ____ b. protein
- ____ c. fats
- ____ d. carbohydrates

QUESTION: Considerable digestion and absorption of nutrients takes place in the:

- ✓ a. small intestine
- ____ b. large intestine
- ____ c. omasum
- ____ d. esophagus

QUESTION: An animal with a monogastric digestive system:

- ____ a. needs more roughage
- ____ b. has four stomachs
- ____ c. has a poor feed conversion efficiency
- ✓ d. requires a concentrated ration

QUESTION: The ability of an animal to receive benefits from the feed fed depends upon:

- ____ a. preparation of the feed
- ____ b. energy content of the feed
- ____ c. animal's ability to utilize feeds
- ✓ d. all of the above

QUESTION: Which of the following feedstuffs would provide the greatest amount of vitamins:

- ✓ a. alfalfa meal
- ____ b. meat scraps
- ____ c. tankage
- ____ d. oat straw

QUESTION: Which of the following is the normal priority for feed usage by the animal:

- ____ a. reproduction, production, growth, maintenance
- ____ b. maintenance, growth, production, reproduction
- ____ c. growth, reproduction, maintenance, production
- ✓ d. maintenance, reproduction, growth, production

QUESTION: When an animal first eats feed, what is usually the first changes that take place in the feedstuff:

- ____ a. biological
- ✓ b. physical
- ____ c. chemical
- ____ d. cultural

QUESTION: Relative to stage of maturity at harvest, which of the following alfalfa feedstuffs contains the highest TDN content:

✓a. alfalfa hay - before bloom
____b. alfalfa hay - $\frac{1}{2}$ bloom
____c. alfalfa hay - full bloom
____d. alfalfa hay - past bloom

QUESTION: Which of the following is one of the general classes of nutrients:

____a. compounds
✓b. minerals
____c. elements
____d. chemicals

QUESTION: The initial use of feed in an animal's body goes for:

____a. production
____b. growth
____c. reproduction
✓d. maintenance

QUESTION: Proper nutrient balance in rations fed livestock results in:

____a. minimum growth
____b. maximum growth
✓c. optimum growth
____d. none of the above

QUESTION: In general, which part of the plant would produce feedstuffs highest in TDN?

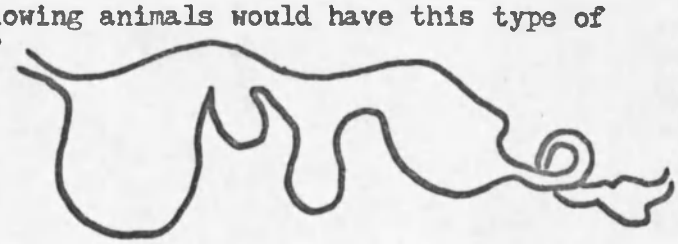
____a. stems
____b. roots
____c. leaves
✓d. seeds

QUESTION: Which nutrient provides the greatest amount of energy per pound?

✓a. fats
____b. carbohydrates
____c. protein
____d. dry matter

QUESTION: Which of the following animals would have this type of digestive system?

✓a. cow
____b. horse
____c. pig
____d. chicken



QUESTION: In the normal analysis of a feedstuff, the carbohydrate content is indicated in the percent of:

✓ a. total digestible nutrient
____b. liquids in the feedstuff
____c. total digestible protein
____d. none of the above

QUESTION: Which of the following feedstuffs would contain the highest energy values?

____a. alfalfa hay
____b. beet pulp
____c. cottonseed meal
✓ d. grain sorghum

QUESTION: One way a roughage differs from a concentrate is that:

____a. A roughage is higher in nitrogen free extract.
____b. A concentrate is higher in dry matter.
✓ c. A concentrate contains more TDN.
____d. A roughage contains more TDN.

QUESTION: Which of the following feedstuffs would provide the largest amount of carbohydrates in an animal's ration?

____a. barley straw
____b. barley silage
✓ c. barley (grain)
____d. barley pasture

QUESTION: The major difference between the digestive systems of cattle and swine is:

____a. the small intestine
____b. the pancreas
✓ c. the stomach
____d. the esophagus

QUESTION: Which dietary deficiency would result in the greatest reduction in daily gain in non-ruminant animals?

____a. vitamin
____b. mineral
✓ c. vitamin & mineral
____d. protein and vitamin

QUESTION: Which one of the following feedstuffs derived from corn would be most efficiently utilized by feeder steers?

____a. whole corn
____b. cracked corn
✓ c. ground corn
____d. rolled corn

QUESTION: For maximum production and health of an animal, the ration fed must contain:

____a. roughages and TDN
____b. concentrates and protein
____c. all vitamins & minerals
__✓__d. all nutrients essential

QUESTION: Poor quality feedstuffs will not sustain animal life for an extended period of time. Why?

____a. It is not palatable.
____b. The animal will not eat sufficient amounts.
__✓__c. It does not contain sufficient nutrients.
____d. The animal cannot digest the feed.

QUESTION: For a given animal, as the work (production) demands increase; the nutrient and energy requirements:

____a. decrease
____b. remain the same
__✓__c. increase
____d. none of the above

QUESTION: The primary use of protein in an animal's body is for:

____a. removing wastes
____b. producing heat
____c. providing energy
__✓__d. building new tissues

QUESTION: A great amount of bacterial action takes place in the rumen. Therefore, ruminants are able to break down and utilize which of the following more effectively than non-ruminant animals?

____a. carbohydrates
__✓__b. roughages
____c. supplements
____d. concentrates

QUESTION: Changes in an animal's environment may affect:

____a. digestibility of feeds
____b. palatability of feeds
__✓__c. nutrient requirements
____d. net energy

QUESTION: The primary function of the rumen is to:

____a. store water
__✓__b. ferment roughages
____c. store vitamins
____d. synthesize minerals

QUESTION: A specific chemical element or compound supplied by the diet and absorbed into the blood from the digestive tract is referred to as a:

____a. supplement
__✓__b. nutrient
____c. roughage
____d. concentrate

QUESTION: During digestion, considerable changes in feedstuffs occur in the stomach. The greatest change that occurs is:

____a. physical
__✓__b. chemical
____c. biological
____d. cultural

QUESTION: The physical and chemical changes that occur to feedstuffs are called:

____a. regurgitation
____b. oxidation
____c. fermentation
__✓__d. digestion

QUESTION: Assuming you are a manager of diversified livestock operation, which class of animals would you be most concerned about their protein requirements?

____a. bulls
__✓__b. gilts
____c. cows
____d. open mares

QUESTION: If you were going to select a feed high in carbohydrates which one of the following would you select?

____a. alfalfa hay
__✓__b. cracked corn
____c. silage
____d. alfalfa green chop

QUESTION: Which is the single most important indicator of a feedstuff's value?

____a. energy value
__✓__b. net energy value
____c. TDN
____d. total therms

QUESTION: If a feed contained in a ration supplies nutrients in excess of those required for body maintenance, the excess nutrients:

____a. may cause the animal to become ill
____b. are not used efficiently
✓___c. are used for growth, production and reproduction
____d. are not digested until needed and then used for synthesis of amino acids

QUESTION: The net energy value of alfalfa silage (wilted) is higher than alfalfa silage (not wilted). Why?

____a. fresher when fed to livestock
____b. cut at a different stage of maturity
✓___c. contains less moisture
____d. all of the above

QUESTION: Animals with single stomachs can be classified as:

____a. monogastric
____b. non-ruminants
____c. simple stomached
✓___d. all of the above

QUESTION: The major difference between the feed fed ruminants as compared to feed fed non-ruminants is that the ruminant feed:

____a. costs more
____b. costs less
____c. contains less roughage
✓___d. contains more roughage

QUESTION: Which of the following nutrients would be most readily utilized by an animal?

____a. proteins
____b. fats
____c. minerals
✓___d. carbohydrates

QUESTION: Why is an abundance of water important in animal nutrition?

____a. It controls temperature of the body.
____b. It takes part chemically in body processes.
____c. It helps eliminate waste products.
✓___d. All of the above

APPENDIX H

PARTICIPATING SCHOOLS AND TEACHERS OF VOCATIONAL AGRICULTURE IN ARIZONA

High School	Vocational Agriculture Teacher
Amphitheater	Andy Groseta
Bowie	Tom Jones
Buckeye	Homer Stewart
Chandler	Odro Ragsdale
Dysart	Paul Wellman
Eloy	John McKee
Gilbert	Joe Granio
Marana	Ted De Spain
Peoria	James Brown
Tuba City	James Watkins
Westwood	Chester Crandell

LIST OF REFERENCES

Agricultural Experiment Station, University of Arizona, Instructional Units on Profit Maximizing Principles. A Developmental Research Project of the Department of Agricultural Education, The University of Arizona, 1968.

Barker, Richard L. and Bender, Ralph E., An Appraisal of Instructional Units to Enhance Student Understanding of Profit Maximizing Principles. A Research Report of a Graduate Study, The Ohio State University, 1967.

California State Department of Education, Biological Principles in Agriculture. A Report of a Project Conducted Under the National Defense Education Act of 1958, 1963.

Campbell, Donald R. and Stanley, Julian C., Experimental and Quasi-Experimental Design for Research, Chicago, Illinois: American Educational Research Association, Rand McNally & Co., 1963.

Hermann, G. "Learning by Discovery: A Critical Review of Studies," The Journal of Experimental Education, Vol. 38, Fall, 1968; pp. 58-72.

Maynard, Leonard A. and Loosli, John K., Animal Nutrition. McGraw-Hill Book Co., New York, 5th ed., 1962.

McCormick Jr., Floyd G., "The Development of an Instrument for Measuring Understanding of Profit-Maximizing Principles," Unpublished Ph.D. Dissertation, The Ohio State University, 1964.

Noll, Victor N., Introduction to Educational Measurement, 2nd ed., Houghton Mifflin Company, Boston, 1965.

Starling, John T. and Bender, Ralph E., Integrating Biological Principles With Instruction in Vocational Agriculture, A Research Report of a Graduate Study, The Ohio State University, 1965.

Zurbrick, Phillip R., "Effectiveness of a Teacher Reference Utilizing an Inductive Mode and Principles Approach in Teaching High School Vocational Agriculture Students," Unpublished Ph.D. Dissertation, The Ohio State University, 1971.