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Evaluation of a Programed Instruction Device for the Utilization of Scientific Principles in the Teaching of Food Science

Patricia Ervin Marovich
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To the Graduate Council:

I am submitting herewith a thesis written by Patricia Ervin Marovich entitled "Evaluation of a Programed Instruction Device for the Utilization of Scientific Principles in the Teaching of Food Science." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Nutrition.

Ada Marie Campbell, Major Professor

We have read this thesis and recommend its acceptance:

Bernadine Meyer, Jane R. Savage

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

December 1, 1965

To the Graduate Council:

I am submitting herewith a thesis written by Patricia Ervin Marovich entitled "Evaluation of a Programed Instruction Device for the Utilization of Scientific Principles in the Teaching of Food Science." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Science.

Ada Marie Campbell
Major Professor

We have read this thesis and recommend its acceptance:

Bernadine Meyer

Jane R. Savage

Accepted for the Council:

____
Dean of the Graduate School

EVALUATION OF A PROGRAMED INSTRUCTION DEVICE FOR THE UTILIZATION OF SCIENTIFIC PRINCIPLES IN THE TEACHING OF FOOD SCIENCE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Patricia Ervin Marovich

December 1965

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P. E. M.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Since the publication of Skinner's (1954) discussion of teaching machines in relation to programed instruction, considerable attention has been directed to the use of programed instruction as a teaching tool. In its simplest form a "program" consists of a body of information presented in a series of small steps and requiring active response on the part of the student. Immediate knowledge of correctness of response is essential to the student's progress (Deterline, 1962). Most writers on the subject agree as to the desirability of a reasonably small number of errors. According to Evans *et al*. (1960) this goal is attainable through careful programing.

Programed instruction has been used in such diverse fields as education, industry, and government (Komoski, 1962). Functional programs have been developed in some areas of education, particularly in the field of science. To the writer's knowledge no program is currently available in the area of food science. The purpose of this study was to develop and evaluate a workable tool for the utilization of scientific principles in a food science course.

CHAPTER II

REVIEW OF LITERATURE

The subject of programed instruction has aroused considerable controversy in the field of education. This method of learning had its origin with Socrates and his pupils. Through the centuries it did not gain much favor until Pressey developed his teaching machine in 1926. Although his was not the first teaching machine, it served to stimulate others to experiment with various methods of teaching (Deterline, 1962).

Pressey built two devices which automatically scored multiple-choice examinations (Horn, 1965). His devices did not employ the Socratic method to the extent of those developed later by Skinner. The latter followed Socrates' plan of guiding a student toward a designated goal by requiring him to respond actively to questions and then informing him of the correctness of his response. According to DeCecco (1964), Skinner's name is intimately connected with the subject of programed instruction.

Skinner in 1954 discussed laboratory techniques that produced modification of behavior in experimental subjects and the application of these techniques to classroom instruction. This persuasive publication reintroduced the concept of teaching machines. Since then, the field of teaching machines and other forms of programed instruction has grown at a rapid pace.

Although teaching machines were used in the first programed instruction, they were not the only form in which this method of learning was presented. Glaser, Homme, and Evans developed in 1959 a programed text which has been accepted widely (Deterline, 1962).

As various forms of programed instruction for classroom use became available, a cry of opposition arose from some advocates of conventional teaching methods that the teacher was about to be replaced and the human element eliminated from education (Deterline, 1962). The supporters of programed teaching are as convinced of its value as the opposition is of its shortcomings. According to Creegan (1962), much of the confusion is due to lack of information and unfounded claims.

The values of programed instruction are numerous. The program consists of a series of many small pieces of information which the student must master in succession before proceeding to the following one. Thus each student can proceed at his own rate; the slower student can complete the program with the same mastery as the faster student without retarding the progress of his classmates (Evans et al., 1960).

Since the program is self-instructional, it may be used with groups of various sizes. It also may be used either as the primary method of instruction or as supplemental material such as homework. More class time is freed for laboratory work or discussion (Evans et al., 1960) as a result of using programs. The opposition argues that programed instruction will take the teacher out of the classroom. According to Lewis (1961), however, she will be freed for the creative activities for which she has spent so many years in preparation.

Programed instruction is applicable to a wide variety of subjects. It has been used with students of different grade levels and academic backgrounds. Industry, education, and government have utilized this method for many purposes (Komoski, 1962). The University of Georgia Medical School has employed programed teaching in the rehabilitation of unskilled criminals (Bender, 1965). Diabetic patients have learned about their disease by programed instruction (Skiff, 1965).

One of the greatest advantages of programed instruction over conventional teaching is the student's immediate knowledge of the correctness of his response. When a correct response is given, the knowledge that it is correct reinforces the response. When an incorrect response is made, the student sees the correct answer and does not continue with his previous misconception (Markle et al., 1961). Programed instruction requires active participation. Therefore, the student must pay attention to the program in order to progress.

Style is important in holding the attention of the student. Many of the existing programs have been developed carefully with respect to style and variety. Other programs fail to draw the student into the subject matter because of inferior style. The opposition has cited poor writing as evidence of the inferiority of the method (Caulfield, 1963).

The construction of a program involves first a decision as to the form of programed teaching to be used. Skinner originated the linear or "extrinsic" type of program. According to his theory, the end goal of an acquired behavior should be decided upon and then the student should be directed toward that goal in such a way that there is little chance

for error. Errors made during the learning process necessitate relearning and thus retard progress (Lewis, 1961).

Following the development of Skinner's linear program, Crowder (1963) produced his branching or "intrinsic" type of programed instruction based on the theory that students naturally make some errors in the learning process. His programs involved multiple-choice questions and larger increments of learning than recommended by Skinner. In an intrinsic program, rather than all students proceeding in a straight line as in linear programing, each student follows certain branches, depending on his responses. By this means the weaker student receives reinforcement through the completion of additional frames while the stronger student is not restrained by repetition. Some authorities believe that a combination of the two types of programing would be good (Lewis, 1961).

Construction of a program is an ambitious undertaking. The programer must analyze the knowledge and reading ability of the students who will use his program and design the program with this in mind (Bender, 1965). A program consists of subject matter which is to be learned and the programer or author usually finds that he still has something to learn on his particular subject (Markle, 1964). The programer decides what is to be learned; then he breaks down this body of knowledge into small segments which are called frames. A question to which the student must respond is written for each frame. The response to the question is to be checked for accuracy and immediately reinforced if it is correct. The responses lead to the goal set up by the programer (Bender, 1965).

There are two current principles applied in frame construction: one states that the student is held responsible only for that part of the material to which he has responded correctly; the other that the student is held responsible for the entire frame. The latter principle is more in line with conventional teaching (Margulies, 1964).

Prompting and cuing are two techniques used to insure that the student gives the correct responses. The use of "prompts" helps the student respond to material which he has not completely learned. A cue is a weaker prompt. As the student's knowledge is reinforced, these aids are withdrawn gradually (Markle *et al.*, 1961).

Some programs can be presented equally well by machine or text. Importance must be placed upon the content and the style of the program. Good writing is a necessity; knowledge of the subject matter alone does not make one a good programer. The programer also must fill the human need for variety (Komoski, 1962).

Students' dislike for certain courses often is associated with the frequency of errors made during mastery of the subject matter involved. Now it is possible to learn without errors provided the subject matter is programed carefully (Evans *et al.*, 1960). Learning is also possible with some errors if the incorrect responses are corrected and the corrections reinforced. Whether workers in this field hold to Skinner's view that error-proof programing is desirable or whether they consider some errors advantageous, they all agree that the student's response should be guided in ways that will aid in the occurrence of a correct response (Beck, 1959).

A large number of errors made by students on a program requires immediate attention; there is definitely something wrong and revision of the program may be necessary. No agreement has been reached as to an unacceptable error rate. Figures of 2, 5, and 10 per cent often are given (Markle, 1964). Becker (1964) states that 5 per cent is a high error rate for linear programs and 30 per cent for the intrinsic programs.

Errors may be attributed to several types of poor construction such as copy frames, irrelevant frames and responses, overloaded frames, too many prompts, and a poor selection of questions and alternatives. Other defects of construction may include poor communication and too early removal of the prompts. Even more fundamental are failure to analyze the subject matter properly and to assess students' knowledge of subject matter accurately (Markle, 1964).

Evaluation is continuous with programed instruction. Testing that is carried out with individuals as the program is developed is known as developmental testing. Then groups of students representative of those for whom the program is intended are used in field testing (Becker, 1964).

Prior to the administration of a program, a prerequisite test may be given to determine whether the student has the necessary skills and information to take the program. Then a pre-test is given to ascertain whether the student already knows the subject matter presented in the program. Following the completion of the program a post-test is

administered to evaluate the effectiveness of the program as an instrument of learning (Horn, 1964).

The use of students in program development enables the programer to obtain information as to whether his program needs revision. He learns from these students: (1) which objectives were not accomplished, (2) which frames gave undue difficulty, and the reason for this difficulty, (3) which responses were incorrect, and (4) how the trainees rated the program (Horn, 1964).

Developmental testing is quite effective when done face-to-face with the students. The programer receives a good idea of how well his program is accepted. In interviews with the students, the programer must not defend his work, for he may stifle frank comments (Becker, 1964). Ideally the students should inform the programer when they are able to obtain correct responses without understanding the material (Horn, 1964). Markle (1964) believes that the failure of a student to master a program is due to the inadequacy of the program and not to the student. The acid test of a good program "is whether the learner develops the desired concept when he gets the right answer" (Reed, 1965).

The most recent catalogue of the United States Office of Education (1963) lists 352 available programs. Textbook presentation alone accounts for 56.6 per cent of the programs while 23.7 per cent can be used as textbooks or in teaching machines. Only 9 per cent of all the programs listed were developed for use at the college level. The subject matter areas represented in the listing are varied but 35 per cent

of the total programs are in the area of arithmetic and higher mathematics. No food science program is listed in the catalogue.

Studies of the effectiveness of programed instruction have been carried out in industry and in the field of education. A representative group of such studies will be reviewed.

Industry has been keenly interested in programed instruction, especially in the area of job training. The Schering Corporation conducted a case study to compare the effectiveness of programed instruction and traditional methods of training their professional service representatives (Hain and Holder, 1962). The subject matter covered was the clinical and pharmacological background of griseofulvin, an antifungal agent for chronic fungus infections of the skin. The physician who served as lecturer for traditional presentations also prepared the subject matter for the programers. Basic Systems, Incorporated, programed the material with the assistance of the staff from Grace New Haven Hospital and Yale University Medical School. The program was of the linear type and was presented in an economical text form consisting of 783 frames.

The control group was made up of nineteen men, two of whom had the Master's degree, fourteen the Bachelor's degree, and three some college training but no degree. In the experimental group, there were fourteen men, two of whom were Cuban physicians who had a fair command of English; nine had the Bachelor's degree, and three had some college training.

Lectures and audiovisual presentations were given to the control group. They also received brochures on the subject matter. The lectures and audiovisual presentations lasted a total of four hours and forty-five minutes. The experimental group received the programed text which required ten hours on the average for initial completion. Individuals reviewed the material, either traditional or experimental, as many times as they felt necessary.

Similar comprehensive tests were given to both groups. The experimental group had a mean score of 91.9 as compared with 60.1 for the control group. According to the Student's t test, the difference between the two mean scores was highly significant. In the experimental group, there was unanimous acceptance of this method of instruction. The Schering Corporation decided from the results to continue its investigation of this method of instruction in the training of new employees.

Several studies have been conducted at The University of Tennessee. In one such study, Kennedy (1964) investigated the effect that grade level had upon the learning of mathematical concepts taught by programed instruction. Students were tested with the Otis Intelligence Test, the Stanford Achievement Test, and the Metropolitan Achievement Test and on the basis of these test scores fifteen students each were selected randomly from a seventh grade and a ninth grade. A pre-test was administered before distribution of the programed text. Then the students received the subject matter in a programed text form. They utilized the text as homework material. Each student kept a record of the time involved in

using the text. A post-test was administered at the completion of the programed instruction period. The students were requested to reply to a questionnaire on their opinions of programed instruction.

Kennedy found that grade level had no effect on achievement in learning the designated mathematical concepts and that study time did not vary considerably with the different grade levels. She believed that the programed text was too difficult, for the average error rate for both grades was 10 per cent. The attitude of the students was generally favorable toward programed instruction as a method of teaching.

Carico (1964) used programed instruction for teaching young deaf children to read. The six subjects were students at the Tennessee School for the Deaf. The six students were divided equally into a control and an experimental group. The students in the experimental group utilized teaching machines which presented the programed subject matter. The control group was instructed in a conventional manner. The students using the teaching machines were exposed to the programed material for thirty-minute intervals at the end of which their progress was checked. The children progressed through the subject matter at their own rate of speed.

The program was analyzed in terms of the time required for the students to complete it as well as the number and types of errors made. The reactions of the children toward the use of the teaching machines and the programed instruction method of teaching were observed. Carico found that the students using the teaching machines made substantial gains in sight vocabulary and sentence recognition. The subjects made

only a small number of errors in completing the program. The teaching machine was simple to operate and seemed to motivate the children to study the material it presented. The children displayed eagerness and enthusiasm toward the programed instruction. They seemed much more willing to complete the program at their own rate of speed when using the machine and were less perturbed by others finishing ahead of them than when completing an assignment of a traditional nature.

Rossi (1965) recently conducted a study utilizing programed instruction in beginning clothing construction classes in the College of Home Economics at The University of Tennessee. She compared the effectiveness of programed instruction with traditional teaching methods in the presentation of basic concepts of both pattern alteration and pattern making by the flat pattern method.

Thirty-four students in three beginning clothing construction classes were divided equally into two groups in each class according to their composite scores on the American College Test. A program was constructed for the presentation of each of the two topics to the experimental group. Analogous lecture-demonstration presentations were developed for the control group. Before being exposed to the subject matter, all groups took a pre-test on the topic to be taught. In two consecutive class periods, the two programs were administered to the experimental groups while the control groups had a lecture-demonstration presented by the investigator. Following the completion of the programs and the lecture-demonstration, all groups took the pre-test as a post-test with the questions arranged in a changed sequence.

Rossi found no significant difference in learning between the two methods of instruction. The program-instructed group had a wider range of scores on the post-test of one of the programs than did the control group. There was no important difference in the post-test scores for the other program. In the program-instructed groups performance on one of the post-tests correlated with the scores from the American College Test. A high number of errors for both experimental and control groups on post-test questions pointed out a need for refinement of materials, both programed and traditional.

CHAPTER III

PROCEDURE

The study was conducted in a food science course offered for the first time during the fall quarter of 1965. The members of the class were sixteen juniors who had previously taken either two or three courses in foods, none of which required chemistry as a prerequisite. However, general chemistry is a prerequisite for the course in which the students were presently enrolled. Additional chemistry, at least through organic, had been taken by ten of the sixteen students.

Programs were written for the portion of the course included in the study and covered four topics: heat transfer, heating media and methods of cooking, dispersions, and high protein foods. Source materials were textbooks in chemistry (Altschul, 1965; Braverman, 1963; Keenan and Wood, 1961; Meyer, 1951) and physics (Avery, 1960), as well as in food science (Griswold, 1962; Meyer, 1960; Peckham, 1964; Sweetman and MacKellar, 1954). The program on dispersions is included in Appendix A.

After the programs were written, they were pre-tested with one sophomore student and revised slightly. Then they were presented to two junior students who were representative with respect to academic background of the students for whom the programs were written. Additional revision was made before further use of the programs.

The revised programs were administered to the entire class. It was believed that this was too small a population to divide into an

experimental and a control group. Another reason for not dividing the group was the feeling that a new teaching approach would make a contribution to the over-all curriculum revision. It was believed that concern should be with the effectiveness of the procedure per se rather than with its effectiveness relative to that of another method of presentation.

A pre-test was prepared for administration at both the beginning of the course and after completion of the four programs. The test consisted of one hundred questions requiring short completion answers. It was believed that the difference in scores achieved by students before and after administration of the programs would provide an indication of the effectiveness of the entire presentation including the programs.

I. TEACHING PROCEDURE

Approximately one-half of the course content was covered by the programs over a period of five weeks. Except for the topic of heating media and methods of cooking, each program was divided into two parts because of length.

At the first meeting of the class programed instruction, as well as the purpose and plan of the study, was explained to the subjects. Then the pre-test was administered. The students utilized the programs as homework material, completing them at their individual rates of speed. Each program was given to the students at a class period for completion prior to the next class period. The students were instructed to read each frame carefully and then to write a response on a separate sheet (Appendix B). Each response was to be compared with the correct one,

which was revealed by sliding down the cover paper on the program. Whenever a response was incorrect, the frame was to be reread until the correct response was clear before the next frame was attempted.

The time required for initial completion of each program, as well as the initial response made to each frame, was recorded by each student. At the conclusion of a program, the student completed a questionnaire (Appendix C) concerning the clarity, style, difficulty, and interest-holding capacity of that program. Any additional comments of the student were recorded on this questionnaire. The students retained the programs for additional study and were asked to record the number of times any further review of the program was made (Appendix D).

At the beginning of the period following the assignment of each program, a short quiz was given. The questions usually were of a discussion type and required an application of the scientific principles presented in the programs (Appendix E). After the quiz, the students asked questions about the programed material and supplemental subject matter was presented by a lecturer other than the investigator.

The pre-test was administered again as a post-test at the completion of all of the programs. Finally the students completed a questionnaire concerning their over-all evaluation of the programs and of the general procedure (Appendix F).

II. EVALUATION

From the students' records of the time spent in initial completion of the individual programs each student's total time expenditure, the

average time expenditure for the class, and the average time spent per frame in each program were calculated.

Error rate (the average number of incorrect responses expressed as per cent of total responses), as well as per cent of correct answers, was calculated for each program and for the entire text. The students' assessments of degrees of difficulty were tabulated. The different degrees of difficulty were assigned numerical values which then were averaged for each student for the entire program. The averages were used in calculation of the correlation coefficient (Snedecor, 1953) for degree of difficulty and number of times the entire text was reviewed. The total number of indications of each degree of difficulty was calculated as a per cent of the possible number of indications for the entire text. A tabulation was made of the frequency with which each reason for erroneous response was checked on the students' evaluation sheets.

Performance on quizzes was of special interest because the quizzes required explanations and were given without prior discussion. Each student's quiz scores were totalled and a frequency distribution was made. Correlation coefficient was calculated for correct response rate on individual programs and the corresponding quiz scores, as well as for correct response rate on the entire programed text and total quiz scores.

Individual pre-test scores were compared with scores on the same test given as a post-test. Per cent increase in score from the pre-test to post-test was calculated for each student and averaged for the class. The correlation coefficient was computed for per cent of correct

responses on the programed text and the post-test score as well as for the total quiz scores and post-test scores.

From the students' records of the number of times they reviewed the various programs a sum was computed and an average value obtained per student for the entire text. These averages were used in the calculation of a correlation coefficient for numbers of times of program review and students' degrees of difficulty in completing the program. The average numbers of program review also were studied for correlation with scores on the post-test.

CHAPTER IV

RESULTS

In the evaluation of the text employed in this study the following factors were considered: (1) time required for the initial completion of the programs, (2) error rate on the programs, (3) students' degree of difficulty in completing the programs, (4) scores made on quizzes, pre-test, and post-test, (5) number of times the programs were reviewed, and (6) attitude of the class toward programed instruction as expressed on the over-all questionnaire.

I. TIME REQUIRED

The time required by the students for initial completion of the entire text varied considerably. In Figure 1 frequency distributions are shown in ten-minute intervals for the four programs. The histogram for the second program shows the most dramatic difference. Fifteen of the students spent not more than thirty minutes in responding to the program while one student required sixty minutes for the same material. The total time spent by the students on the four programs ranged from one hour forty-nine minutes to four hours and forty-five minutes, averaging two hours and forty-two minutes. The wide range of time required may be attributed to differences in individual rates of speed in reading and comprehension as well as to previous knowledge of the subject matter.

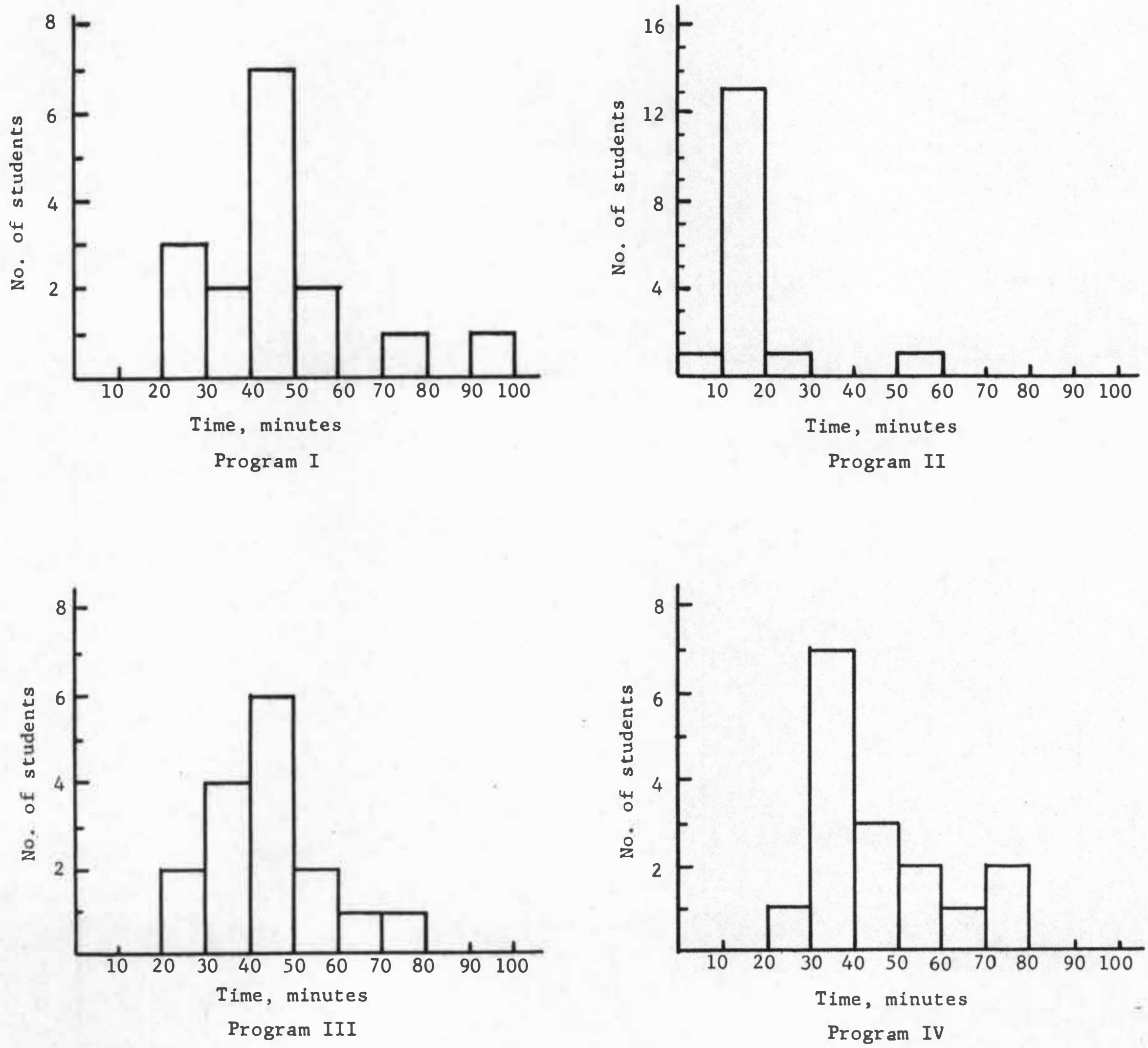

FIGURE 1

TIME SPENT BY STUDENTS IN COMPLETION OF PROGRAMS

The average time spent per frame by the students was forty, twenty-nine, thirty-five, and thirty seconds, respectively, for the four programs. Differences among programs probably were due both to varying degrees of familiarity with the subject matter by the group as a whole and to their becoming accustomed to the programed text.

II. ERROR RATE

Although variation in the literature exists as to an acceptable error rate on a linear programed text, 5 per cent is the most widely recognized maximum value. Error rate, the per cent of incorrect responses, is often a measurement employed in the decision to revise a program.

The over-all error rate on the four programs in the study was 9 per cent, well above the generally accepted maximum. This high value indicates that the programs were more difficult than the programer had anticipated.

The first program had the highest error rate, 10.8 per cent, probably because of content as well as the new method of presentation. A few of the students had been exposed to programed instruction in other courses but the majority had not. Error rates on the second and third programs were slightly lower than on the first program. Students became more proficient in responding to the programed text by the time they had completed the final program, which had an average error rate of 6.7 per cent. Because the final program concerned high protein foods, the students probably also had less difficulty because of their previous knowledge of this subject.

III. DIFFICULTY OF PROGRAMS

The students evaluated their degree of difficulty after completion of each of the homework sessions with the programs. In view of the relatively high error rate, an assessment of a high degree of difficulty might have been expected; however, approximately half of the class considered the programs to be moderately difficult and the other half found them moderately easy. The use of unfamiliar terms was found to be the least frequent cause of incorrect responses to frames while the students' failure to read the frames carefully was the most common reason given for errors.

IV. SCORES ON QUIZZES, PRE-TEST, AND POST-TEST

The quizzes were intended to serve as a means of evaluating the students' ability to apply the concepts presented in the programs. The histogram in Figure 2 shows the distribution of the total quiz scores over the range of seventy possible points. The scores tended to fall toward the upper end of the grade scale; seven members of the class scored between fifty and sixty points and three scored more than sixty points.

When correlation coefficients were calculated for performance on individual programs and on related quizzes, there was a highly significant positive correlation for the first half of the program on dispersions (Table I). Although performance on the other programs individually showed no such correlation with that on related quizzes, the total quiz

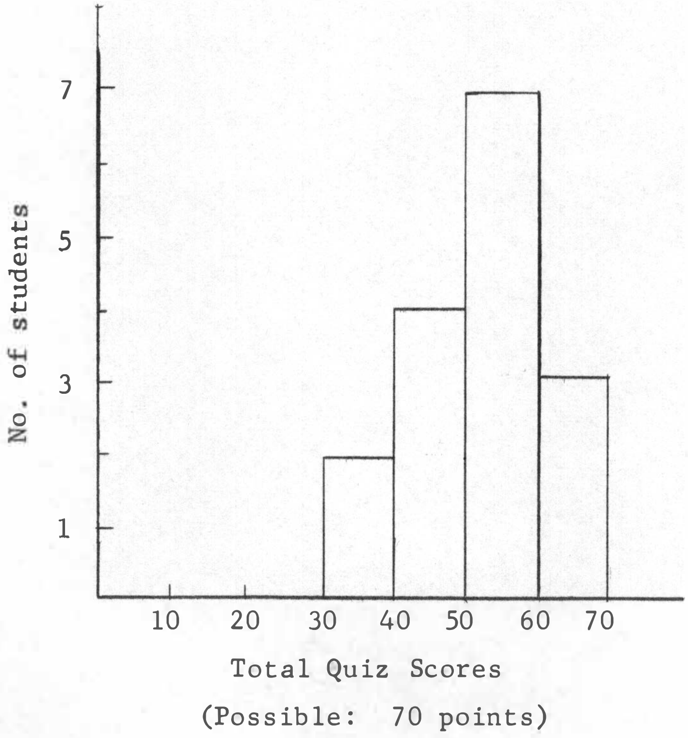

FIGURE 2

DISTRIBUTION OF TOTAL QUIZ SCORES

TABLE I

CORRELATION COEFFICIENTS FOR PERFORMANCE FACTORS

Factors Correlated	Correlation Coefficient
Quiz scores and per cent of correct initial responses on part I of dispersion program	0.63**
Total quiz scores and per cent of correct initial responses on entire program	0.42**
Per cent of correct initial responses on entire text and scores on post-test	0.70**
Total quiz scores and scores on post-test	0.90**
Program review and difficulty of programs	0.57*
Program review and post-test scores	-0.60*

*Significance at the 5 per cent level.

**Significance at the 1 per cent level.

scores and the per cent of correct initial responses on the entire program were correlated at the 1 per cent level of significance.

Progress of the students is indicated by a comparison of scores on the post-test with those on the pre-test (Table II). The students varied considerably in their knowledge of the program content prior to this study, as indicated by the range of twenty to fifty-six out of a possible one hundred for the pre-test scores. The range for the post-test was two-thirds that for the pre-test. Not a single question was answered correctly on the pre-test by the entire class, whereas forty-nine questions were answered correctly by the entire class on the post-test. On every question there was a decrease in the number of errors when the pre-test was administered as a post-test. Three questions were answered incorrectly by at least seven students on the post-test, indicating a probable need for revision of test questions and/or program material.

The average score on the post-test was ninety-one as compared with forty on the pre-test. Per cent increase in score from the pre-test to the post-test, calculated for the sixteen individuals, averaged 151 per cent and ranged from 74 to 343 per cent. The largest per cent increase represented a score of twenty-one on the pre-test and a score of ninety-three for the post-test. The only students who did not at least double their scores on the second test were those who made fifty or more points on the pre-test.

The students' performance on the post-test was highly correlated with that on both the program and the quizzes (Table I, page 24). The

TABLE II

SCORES ON PRE-TEST AND POST-TEST

Test	Average	Range
Pre-test	40	20 - 56
Post-test	91	75 - 99

correlation coefficient 0.70** for per cent of correct responses on the entire program and post-test scores indicates that those students who most completely mastered the programs also best retained the subject matter. The value of r, 0.90**, for total quiz scores and post-test scores demonstrates that those individuals who were relatively successful in applying the concepts presented in the programs also wrote satisfactory responses to the objective questions in the post-test.

Performance on the post-test might be considered in relation to chemistry background of the students because of the feeling of inadequacy expressed by some students. In Table III, the average pre-test and post-test scores are shown for three groups based on the chemistry completed. Average pre-test scores increased slightly as the background in chemistry improved. Generalization is difficult, however, because one individual in the general chemistry group made the highest score on the pre-test. More important than knowledge of the subject matter on the pre-test is the knowledge indicated by the post-test score. The general chemistry group on the average appears to have learned as much new material as did the most advanced group although the former's average level of achievement was lower. The intermediate group, with a somewhat lower average pre-test score than the advanced group and an equal post-test score, appears to have learned the most. Again generalization is difficult because the intermediate group consisted of only two individuals. Group averages obscured the fact that three of the six individuals in the general chemistry group scored more than ninety points on the post-test and that one of them had the highest score on that test. From these data,

TABLE III

AVERAGE SCORES ON PRE-TEST AND POST-TEST OF GROUPS OF STUDENTS WITH DIFFERENT CHEMISTRY BACKGROUNDS

Group	Number in Group	Test	Average Score
Completed general chemistry	6	Pre-test Post-test	36 88
Completed general and organic chemistry	2	Pre-test Post-test	38 93
Completed general, organic, food, and physiological chemistry	8	Pre-test Post-test	42 93

it would appear that a general chemistry background is sufficient for an acceptable degree of mastery of the program content but that organic chemistry might be helpful.

V. PROGRAM REVIEW

The number of times that the students reviewed the programs was correlated positively with the degree of difficulty that they encountered in completing the programs (r = 0.57*, Table I, page 24). The value of program review cannot be evaluated from the data. The average number of times that the entire program was reviewed ranged from two to ten, averaging four times for the entire class. The negative correlation (r = -0.60*, Table I, page 24) between the amount of review and the post-test score does not necessarily indicate a cause and effect relationship. It is possible that a student who had difficulty in comprehending the subject matter as he initially completed the programs and thus studied the material repeatedly did in fact increase his comprehension, though not to the level of other members of the class. It was observed that these weaker students did not take advantage of the opportunity to clarify hazy concepts during lecture periods but apparently depended upon review of the program.

VI. ATTITUDE TOWARD PROGRAMED INSTRUCTION

The programer benefits from the evaluation of those who have utilized his programed material. Evaluative observations by a large group during the preliminary period theoretically should contribute to

quality of programs. When the programs are actually used by classes, the evaluation and comments are still needed by the programer for continuous improvement. In this study the class members evaluated the program segments as they initially completed them. Most members of the class found themselves interested in the programs while one person was usually indifferent to the programed content.

The data obtained from the first four questions of the over-all evaluation of programed instruction are presented in Table IV. The consensus was that frames were stated clearly, subject matter was presented logically, and content was interesting. The most apparent weakness was lack of variety in the manner of presentation. One student commented that more examples relating the preparation of foods to the material introduced in the programs would increase understanding of concepts.

A problem expressed by the students early in the use of the programed text was that one would find himself looking for a word to use as the response to a frame rather than learning the principle presented in the frame. The students often concentrated too much on the response as they became acquainted with programed instruction. Some of the frames were too long or had the important term obscured in the presentation. Utilization and evaluation of the programs by more students in the preliminary period would have improved the quality of the programs.

The over-all questionnaire also concerned the students' attitudes toward this method of instruction. Five of the students considered programed instruction to be more efficient than conventional teaching; one-half of the class members believed the two methods to be equally

TABLE IV

STUDENT EVALUATION OF PROGRAMED TEXT

Factors Evaluated	Distribution of Sixteen Responses for Each Factor			
	Always	Usually	Sometimes	Never
Clearly stated frames	0	15	1	0
Logically presented subject matter	6	8	2	0
Interesting content	6	7	3	0
Sufficient variety in manner of presentation	3	7	6	0

effective; and three students thought that programed instruction is less effective. Although programed instruction was not the unanimous choice of the class, it was valued as superior or equivalent to conventional teaching by thirteen of the sixteen students. All sixteen believed that programed instruction should be used as a supplement either to lecture or to both lecture and a conventional text.

Comments of the students in this investigation indicated that programed instruction can provide a learning situation in the area of food science. The majority expressed approval of the active participation required.

VII. IMPLICATIONS FOR REVISION

The need for program revision is indicated by the relatively large number of incorrect initial responses to specific frames. Study of the responses indicated several apparent types of weakness in the programs. In some cases the response was poorly chosen. For example, in the fourth frame of the program on dispersions (Appendix A, page 42) the expected response was a word that had not been used previously. The word "phase" probably would have been a better response.

In some cases the students' responses apparently were incorrect because of weakness of previous frames. Response to frame number twenty-three in the program on dispersions frequently was incorrect because of unclear wording in frame number twenty-one. The last sentence in frame number twenty-one will be changed to read, "The condition is achieved during cooling (after heating)." The response for frame number

forty-seven was based on the forty-second frame, in which an important term was de-emphasized by placement in parentheses. This weakness may be eliminated by substitution of the phrase ",called micelles," for the parenthetical term.

Assumption of previous knowledge apparently resulted in erroneous responses. The students had no difficulty in arriving at the correction of 5.5°C. in frame number thirty-seven, but some were unable to apply the correction. In the revision, the clause "If the boiling point of water at sea level is 100°C.," will be inserted at the beginning of the question.

An example of too large a step between frames is found in frames sixty-five and sixty-six of the program on dispersions (Appendix A, page 49). The revision will include an additional frame inserted between the above two frames and reading, "The stabilizer forms a film at the boundary between the air and _____ phases."

Further use of the programs undoubtedly will reveal the need for additional revision. It is possible that weaknesses quite different from those detected this time will become apparent in the future.

CHAPTER V

SUMMARY

A programed text was developed for utilizing scientific principles in a food science course. The effectiveness and student acceptance of the tool were studied with a class of sixteen students.

Considerable variation in the time required to complete each program illustrated one of the frequently stated advantages of programed instruction, each student's opportunity to progress at his own rate. In this study the slowest student required more than two and one-half times as long to complete the entire text as did the most rapid student.

The average error rate of 9 per cent was higher than is generally desirable. Approximately one-half of the class members, however, considered the text to be moderately easy, while the other half characterized it as moderately difficult.

With respect to chemistry background the class members fell into three groups. The relative performance of the groups suggests that the program content may be mastered by a student with a general chemistry background but that organic chemistry is helpful.

Pre-test scores averaged forty and ranged from twenty to fifty-six; post-test scores averaged ninety-one and ranged from seventy-five to ninety-nine. The average per cent increase in score from the pre-test to the post-test was 151 per cent. Only the few students who scored fifty points or more on the pre-test did not at least double their

initial score. A highly significant positive correlation was found between quiz scores and post-test scores, as well as between per cent of correct responses on the program and post-test scores.

In the over-all evaluation the consensus of the class was that the frames were stated clearly, subject matter was presented logically, and content was interesting. They felt that the most apparent weakness in the programs was lack of variety in the manner of presentation of subject matter. All of the students preferred that programed instruction be used as a supplement to lectures or to lectures and a conventional text rather than as the sole method. The majority of the class members considered programed instruction to be an interesting way of learning.

The performance of the class in this study, as well as their attitude, would seem to indicate some value in further use of programed instruction. Error rates on individual frames need to be studied and weak frames revised. In the revision, more variety in the manner of presentation should be included. The employment of a larger group of test subjects, while not always possible, would aid the programer in detecting weakness in construction and presentation.

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APPENDIXES

APPENDIX A

SAMPLE OF PROGRAMED TEXT

FOOD SCIENCE 301
Dispersions

A. General

1. Although foods differ in composition and structure, they are similar in that they all are dispersions. Disperse means to ______; therefore, a dispersion must be some sort of scattering. — scatter

2. A dispersion may be defined as a distribution (scattering) of some sort of subdivided substance throughout one that is not ______________. — subdivided

3. The subdivided phase may be referred to as the discontinuous phase or dispersed _____. — phase

4. The nonsubdivided phase is the __________ phase or the dispersion medium. — continuous

5. The dispersed phase may be a gas, liquid, or _____. In foods the usual dispersion medium is a liquid. — solid

6. The liquid that serves as the usual dispersion medium in foods is ________. — water

7. Types of dispersions differ basically in the size of dispersed particles. In solutions the dispersed particles are molecules or ions. A solution of a nonionizing substance such as sugar is an example of a molecular __________. — dispersion

8. Sodium chloride ionizes in water. Its solution is one in which the particles are __________. — ions

9. Whereas particle diameters are less than one mμ in solutions, they range from 1 mμ to 100 mμ in colloidal dispersions. Particles may be very large molecules or small aggregates of molecules. Most proteins form colloidal __________. — dispersions.

10. In suspensions the dispersed particles have diameters greater than 100 mµ and consist of large aggregates of molecules. Starch granules, each containing hundreds of molecules, form ________ in water. — suspensions

    Note: Lines of demarcation are not as sharp as implied above but some classification is necessary for convenience. In some scientific literature suspensions are classed as a special group of colloidal dispersions.

11. Because of their difference in size of dispersed particles, dispersions differ in their properties. For example, solutions may exert high osmotic pressure, colloidal dispersions only low osmotic pressure and suspensions no appreciable ________ ________. — osmotic pressure

12. Dispersions differ also with respect to activity of the dispersed particles. In solutions the particles themselves have energy and are in constant ________. — motion (or equivalent)

13. In colloidal dispersions the only activity of the dispersed particles is due to their being "pushed about" by the dispersion medium. This is referred to as Brownian movement. Brownian movement is characteristic of ________ dispersions. — colloidal

14. In suspensions the only movement of the dispersed particles is gravitational. Whether the effect of gravity can be observed depends on the relative densities of dispersed phase and dispersion medium. Raw starch particles will settle out of water because raw starch is more ________ than water. — dense

15. Viscosity is a property of all liquid dispersions. It is resistance to flow, due to friction between dispersed particles. A liquid with a high resistance to flow has a high ________. — viscosity

B. Solutions

16. In solutions the dispersed phase often is referred to as solute and the __________ __________ as solvent. — dispersion medium (or continuous phase)

17. Concentration of a solution is the amount of solute in relation to the amount of __________. — solvent

18. Concentration may be expressed in specific terms, as molarity, normality, and per cent. More general terms are saturated, unsaturated and super__________. — saturated

19. A saturated solution contains all of the solute that can be dissolved at a given temperature. Soluble substances differ as to amount that will __________ in a given amount of water at a given temperature; i.e., they differ in solubility. — dissolve

20. An unsaturated solution contains less solute than can be dissolved at a given temperature. Solutes become increasingly soluble with increasing temperature. Therefore, a solution that is saturated may become __________ when heated. — unsaturated

21. A supersaturated solution contains ________ solute at a given temperature than it normally would contain at that temperature. The condition is achieved by heating, then cooling. — more

22. At 25°C. 210 grams of sugar can be dissolved in 100 grams of water. If the solution is heated to 100°C., sugar may be added until 487 grams are dissolved in 100 grams of water. If the solution is cooled carefully to 25°C., it will continue to hold the 487 grams of sugar/100 grams of water. The solution is __________. — supersaturated

23. Boiling away water would have the same effect as adding sugar. Note: Boiling does not supersaturate; it concentrates a solution. Supersaturation occurs during __________. — cooling

24. Solutions containing nonvolatile solutes have lower vapor pressure than does water. _______ _______ is the pressure exerted by molecules of the liquid tending to leave the surface. — vapor pressure

25. Solutes affect the boiling point of water. Boiling point is the ________ at which the vapor pressure of a liquid is barely sufficient to overcome the effect of the pressure exerted on the surface of the liquid. — temperature

26. Boiling point of a liquid may be altered by: (1) altering its vapor pressure, (2) altering the ________ exerted on the surface. — pressure

27. One method of decreasing the _______ _______ and thus increasing the boiling point of water is adding a soluble substance. — vapor pressure

28. For each gram molecular weight of a nonionizing substance dissolved in a liter of water, the boiling point is elevated 0.52°C. A gram molecular weight (mole) of a substance is its molecular weight in grams. One gram molecular weight of sucrose, $C_{12}H_{22}O_{11}$, is ________. — 342 grams

atomic weights:
C - 12; H - 1; O - 16

29. Note: The _______ _______ is elevated only if the substance added to the water is dissolved. — boiling point

30. When the solution becomes saturated, i.e. no more substance can be ________ in it, the boiling point remains constant. — dissolved

31. When ionizing nonvolatile substances are dissolved in water, each ion has as much effect on boiling point as a molecule of a nonionizing substance. NaCl forms two ions in water. Therefore, one gram molecular weight of sodium chloride will raise the boiling point of one liter of water how much? — 1.04°C.

32. The statement in No. 31 assumes complete ionization. Actually ionizing solutes vary in extent of ________. — ionization

33. Increasing the pressure exerted on the surface of the water raises its boiling point. The increase in ________ is achieved by retention of steam, as in a pressure saucepan. — pressure

34. In a pressure saucepan foods cook faster than in an ordinary saucepan because the boiling point is ________. — higher

35. The ________ ________ of water in a pressure saucepan varies with the pressure. The following boiling points are expressed in °C. at sea level: 5 lb., 109°; 10 lb., 115°; 15 lb., 121°. — boiling point

36. The boiling point of water may be lowered by reducing the pressure upon the liquid, as when heating in a partial vacuum. The ________ ________ also is lowered with an increased elevation because atmospheric pressure decreases with increasing altitude. — boiling point

37. The column of air exerting force upon the water is decreased at an increased elevation and the boiling point is decreased 1°C. for each 960 feet above sea level. What is the approximate boiling point of plain water in Denver, Colorado (altitude 5280 feet)? (Show work) — 94.5°C.

C. Colloidal dispersions

38. Gas, liquid, or solid matter may be found in colloidal dispersion. There are eight classes of ________ dispersions: solid-in-solid; solid-in-liquid; solid-in-gas; gas-in-solid; gas-in-liquid; liquid-in-solid; liquid-in-liquid; liquid-in-gas. — colloidal

39. Because water is the usual dispersion medium in foods the three most likely types of colloidal dispersions are: solid-in-liquid; ______-in-liquid; ______-in-liquid. — liquid, gas

40.	Proteins such as gelatin, milk casein, and egg albumin form ________ dispersions of the solid-in-liquid type.	colloidal
41.	The above type of dispersion may be in a fluid or solid state. A colloidal dispersion in the fluid state is a sol and one in the ________ state is a gel.	solid
42.	Because of the size of colloidal particles (micelles), one would be able to disperse ________ colloidal particles than (more, fewer) molecules or ions in a given volume of dispersion medium.	fewer
43.	The statement of No. 42 explains the fact that substances that form colloidal dispersions affect boiling point and freezing point much ________ than do soluble substances. (more, less)	less
44.	The statement of No. 42 also explains the fact that colloidal dispersions cannot exert as much osmotic pressure as can ________.	solutions
45.	Some colloidal substances are lyophilic, i.e., have an affinity or "liking" for the dispersion medium. Others are lyophobic, i.e., ____(complete)__.	do not have an affinity for the dispersion medium
46.	Lyophilic substances are termed hydrophilic when the dispersion medium in question is water. Dispersions of ______________ substances are common in foods.	lyophilic or hydrophilic
47.	For a colloidal system to be stable, the dispersed particles (or ________) must be prevented from clumping together.	micelles
48.	Some colloidal systems are stabilized by an electric charge on the micelles. While the particles may be positively or negatively charged, all particles in a given system have the same charge. Why would the particles not clump together?	like charges repel

49. In other colloidal systems a film such as a shell of adsorbed water prevents __________ from clumping together. — micelles

50. Both of the above means of stabilization may exist in a colloidal dispersion. For example, pectin micelles are stabilized both by a water shell and by an electric __________. — charge

51. Another property that colloids exhibit is imbibition, the ability to pick up water and swell when they come in contact with __________. — water

D. Suspensions

52. A foam is a dispersion of a gas in a __________; an emulsion is a dispersion of of a liquid in a __________. — liquid, liquid

53. Foams and emulsions may be considered suspensions, regardless of whether suspensions are classed as a third type of dispersion or as a special class of __________ dispersion with particularly large particles. — colloidal

54. Surface-active or wetting agents are stabilizers for two types of __________, foams and emulsions. Examples of such stabilizers in food are proteins, gums, fatty acids. — suspensions or dispersions (the former preferable)

55. The molecules of such agents arrange themselves on a surface with the water-soluble (polar) end of each molecule in the water and the non-polar end in the other phase; thus these stabilizers form a protective film around the dispersed __________. — particles

56. In liquid-in-liquid dispersions, or __________, the two liquids are not capable of mingling; i.e., they are immiscible. — emulsions

57. Food emulsions usually contain oil and water and may be of the oil-in-water or ________-in-________ type. The former is more common. — water, oil

58. Emulsions may be either temporary or permanent. A third substance, or stabilizer, is required for a ________ emulsion. Stabilizers of emulsions are called emulsifying agents. — permanent

59. A lyophilic emulsifier promotes the frequently occurring dispersion of oil in water. Most proteins, the most common emulsifying agents, are ____________________. (lyophilic, lyophobic) — lyophilic

60. Examples of foods containing ________ are milk, mayonnaise, gravies, butter. — emulsions

61. Mayonnaise is an oil-in-water (vinegar) emulsion. The lecithoprotein of egg yolk forms a protective ________ around the oil droplets, preventing their joining together. — film (or coating)

62. Freezing and thawing of a mayonnaise, as well as agitation, may cause the emulsion to break. When this occurs, the ________ tends to rise to the top because it is the less dense phase. — oil

63. Evaporation of water also may cause an emulsion to break when the amount of dispersion medium becomes too small for the amount of dispersed ________. — phase (or oil)

64. The gas which most often is the ________ phase of a food foam is air. — dispersed

65. ________ is incorporated through agitation of a liquid containing a stabilizer. — air

66. Properties of liquids that contribute to foam formation are: low surface tension, low vapor pressure, moderately high viscosity, and the presence in adequate amounts of a material which can form a film at air-liquid boundaries. The latter substance is referred to as a ________. — stabilizer

67. Criteria for judging foam formation include: time required, volume attained, and stability. Note: Maximum volume may not necessarily be optimum volume because maximum volume may be associated with _________ stability. poor (or low)

68. The protein in egg white serves as _____ of an egg white foam by forming a film around the trapped air cells. stabilizer

69. The egg protein becomes denatured during the beating process and tends to make the _________ stiff. Unless carried too far, this denaturation also confers some stability on the foam. foam

70. Whipped cream is a very stable foam so long as it is kept cold. Stability is due in part to denatured _________ and in part to firmness of fat globules trapped in the protein film. protein

71. Fat has a low melting point. Whipped cream collapses when put on a hot dessert because of melting of the _________ which is partially responsible for stiffness. fat

72. Although a good foam can be produced with cream containing 20% fat, a stiffer and more stable _________ is obtained with cream containing 30-33% fat. foam

73. Dried milk can be made into a foam. The character of the _________ is dependent upon the amount of dried milk used for reconstitution with a given amount of water. foam

74. Undiluted evaporated milk, chilled, will form a relatively unstable _________. foam

75. When acid in the form of lemon juice is added to evaporated milk, the milk forms a more _________ foam. stable

76. The acid lowers the pH of the milk protein to the isoelectric point. The resulting coagulation of protein surrounding the air cells increases __________. — stability

77. The use of too much acid results in over-__________ and thus foams that are unstable due to brittleness of protein films. — coagulation

78. Chilling evaporated milk prior to beating it increases its viscosity and thus aids in retention of incorporated __________. — air

79. Instability of a foam is indicated by collapse. __________ is lost and liquid "leaks" from the foam. — gas (or air)

APPENDIX B

RESPONSE SHEET

Time required for
initial completion____________

Name________________________

Program_____________________

Response Sheet

1____________________

2____________________

3____________________

4____________________
____

5____________________

6____________________

7____________________

8____________________

9____________________

10____________________

11____________________

12____________________

13____________________
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14____________________
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15____________________

16____________________
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17____________________

18____________________

19____________________

20____________________
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21____________________
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23____________________

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25____________________

26____________________

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28____________________
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29____________________
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30____________________

31____________________

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33____________________

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35____________________

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37____________________
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38____________________

39____________________
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40____________________
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42____________________

43____________________

44____________________

45____________________
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46____________________

47____________________

48____________________
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49____________________
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50____________________

51____________________

52____________________
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53____________________

54____________________
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55____________________

56____________________

APPENDIX C

STUDENT'S EVALUATION FORM

Name ______________________________

Date ______________________________

Program ___________________________

STUDENT'S EVALUATION

Please write the numbers of the appropriate frames in the spaces below as you proceed with the program.

I believe I had difficulty due to unfamiliar terms in frames no.:__________

I believe I had difficulty due to poor phrasing of statements or to illogical presentation of material in frames no.:__________

I believe I had difficulty due to my own failure to read carefully in frames no.:__________

I believe I had difficulty due to my forgetting previous material in frames no.:__________

Please make check-marks to complete the statements below after you have finished the program.

I found myself: interested in_____, indifferent to_____, bored with_____, the program.

I found the program as a whole: difficult_____, moderately difficult_____, moderately easy_____, simple_____.

If there are additional comments that you would like to make, please write them below.

APPENDIX D

REVIEW SHEET

Name________________________________

Program_____________________________

Please make a mark on this sheet each time you review the program between your completing it initially and your taking the post-test. Tear off this sheet and bring it with you to the post-test.

APPENDIX E

SAMPLE QUIZZES

Name________________________________

FOOD SCIENCE 301

Quiz No. 4

1. Why might a pressure saucepan be particularly useful at high altitudes?

2. Some recipes for crystalline candies recommend boiling for a short time with the pan covered. This is done early in the heating process for the purpose of washing down sugar crystals. What would be the effect of failing to remove the cover? Why?

3. When a thermometer is used for determination of the end-point in the cooking of candy or jelly, why is it important that the mixture be boiling?

4. If in heating a fudge mixture you suddenly discovered that you had exceeded the desired boiling point by 4°C., what would you do? Why would your solution to the problem be preferable to any alternatives?

Name________________________________

FOOD SCIENCE 301

Quiz No. 5

1. Why does the addition of gelatin not raise the boiling point of water as does the addition of sucrose?

2. Why is underbeaten egg white an unstable foam?

3. Fill in the spaces in the following comparison of foams and emulsions:

	Foams	Emulsions
a. state of matter of dispersed phase		
b. common example of dispersed phase		
c. state of matter of the dispersion medium		
d. common example of a dispersion medium		
e. general term for a substance that confers stability on the dispersion		
f. an example of <u>e</u>		
g. evidence of instability		

APPENDIX F

STUDENT EVALUATION OF PROGRAMED INSTRUCTION

Name________________________________

Date________________________________

FOOD SCIENCE 301

Student Evaluation of Programed Instruction

Were the frames clearly stated?

_____ always
_____ usually
_____ sometimes
_____ never

Was the program content presented in a logical manner?

_____ always
_____ usually
_____ sometimes
_____ never

Did you find the program content interesting?

_____ always
_____ usually
_____ sometimes
_____ never

Was there sufficient variety in the manner in which the program content was presented?

_____ always
_____ usually
_____ sometimes
_____ never

Considering the time you spent in relation to what you learned, do you feel that this method in general was

_____ more efficient than
_____ about as efficient as
_____ less efficient than

the usual methods of presenting this type of material?

From your experience with programed instruction in this course would you prefer

_____ programed instruction alone
_____ programed instruction as a supplement to lectures
_____ programed instruction as a supplement to lectures and a conventional text
_____ conventional text as a supplement to lectures

Comments: