DEVELOPMENT AND EVALUATION OF PROGRAMED INSTRUCTION MODULES IN FOOD FOR THE COLLEGE LEVEL

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

DESCRIPTION OF THE PROBLEM

The importance of method in the teaching-learning process cannot be overlooked. The use of a variety of methods makes the process more interesting at the least. At the most, learning may be improved because one method may be better for one type of learning while some other method may be better for another. The effective teacher continually studies and experiments to try to improve teaching and facilitate learning. There is no standing still in this profession; the teacher goes either forward or backward. The progressing teacher is always a learner and his enthusiasm for learning brings a joy to teaching that inspires students to learn.

Reading about programed instruction (hereafter called PI) and experience with a few programs convinced the writer that this is a method that has much to contribute to the teaching-learning process. A search revealed very few programs in the field of home economics and it became necessary to develop some programs if the method was to be tried in the writer's classes. Further reading revealed that it might be well for the neophite programer to develop small units or modules rather than attempt to program a whole course. There was the possibility, also, that some parts of a course might lend themselves to programing more readily than other parts; that is, PI might be more successful with some types of learning than with others.

The purpose of the study was to develop and evaluate three modules of PI to supplement class and laboratory experiences in food at the college level and to discover through their use how they might facilitate learning and the attitudes of students toward PI as a means of learning.

Significance of the Study

More is expected of education, and especially of higher education, in the United States today than ever before. Americans have come to believe that education is responsible for improving economic and social conditions at home as well as for our position of world leadership. A larger percentage of high school students are graduating and more parents and students feel it is necessary for the high school graduate to go on to college. There is an "intensive democratization of education," the purpose of which is to educate every individual as far as ability will permit, according to Bowles.[1] It is becoming more nearly possible for each person to get as much education as he can profit from and desires. There is continued need for retraining and re-educating adults as available jobs and situations change and as more people live longer. The concept of continuing education from the cradle to the grave is being accepted.

Many factors are forcing educators at the college level to find ways to improve the teaching-learning process. Increase in enrollments is one such factor. The increase has been brought about in part by

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[1]Frank H. Bowles, "The Dual Purpose of Revolution," Higher Education Reflects on Itself and on the Larger Society: Current Issues in Higher Education, ed. Kerry G. Smith (Washington, D. C., 1966), p. 17.

expanding population. Also, more high-school graduates go on to college. Provisions for qualified young men and women of low-income families to pursue a higher education adds to the number of college students. More college students go on to graduate school. Many adults return to college. An ever-expanding curriculum which meets the needs of more people as well as technological advances, such as modernization of communication and transportation, are other factors helping to swell the college population.

Another is the "astounding proliferation of learning" discussed by Downing. He reminds us that the sum total of human knowledge doubled between 1940 and the late 1950's and will double again by 1970. Ninety percent of all the scientists that ever lived are living and working today. His logical conclusion is that "students must learn more and they must learn it faster."[2]

The new breed of student certainly must be considered. Educators have tried to teach this generation to "make decisions" and to "solve problems." These "thinking" students are raising questions in regard to their rights and desires and about contributions they can make to society. Students come to college knowing more than the students did a few years ago. At a national conference on student stress, students agreed that it is hard to define a "good" education, but the consensus was that lack of a "really good education" is the central source of student stress.[3] Increasing numbers of students from more varied

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[2] C. B. Downing, "What is Programed Instruction? Values and Uses," J. Amer. Dietet. Assoc., Vol. 46 (1965), p. 39.

[3] Edward Joseph Schoben, Jr., Student Stress and the College Experience. Report of National Conference on Student Stress sponsored by the U. S. National Student Assoc. (Washington, D. C., 1966), p. 15.

backgrounds with a broader range of ages results in students with a wider range of abilities, thus complicating the teaching-learning process.

Much has been written about the shortage of qualified teachers. Swope reports that the shortage of home economics personnel in higher education is increasing and critical and is qualitative as well as quantitative.[4] Accelerating technological advances in business and industry as well as automation in education itself are creating pressures for improved quality in education. An increasing understanding of the learning process is another challenge to educators.

Improving quality amidst quantity of both students and knowledge poses some real problems. It is being recognized anew that learning is indeed a personal and individual process. Teachers are faced with the dilemma of educating the masses and at the same time fitting instruction to the needs of the individual learner.

Some possible contributions of PI to the teaching-learning process are: (1) providing ways to individualize instruction; (2) making learning more effective and efficient; (3) making learning more controllable and predictable; (4) developing the habit of self-teaching and learning; (5) increasing understanding of the way in which people learn; and (6) releasing some of the teacher's time for more effective and individual work with students. In spite of these potentials, little PI has been developed and used in home economics, with even less produced for use at the college level.

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[4] Mary Ruth Swope, "How Short is the Shortage?," J. of Home Economics, 59 (1967), pp. 765-768.

The major effort in programing for home economics in higher education has been at Cornell in teacher education. Under the guidance of Nelson[5] eight different programs for use with student teachers during their professional semester were developed and validated through extensive field testing. Six program units were developed, four of which were evaluated in a small class, for teaching food science at the University of Tennessee, Knoxville, by Marovich under the supervision of Campbell.[6] These include energy transfer, heating media, dispersions, proteins, carbohydrates and lipids. Vantrease reports that John Wiley and Sons "has a program under contract called Understanding Foods by Kotschevar and McWilliams that should be published by Spring of 1969."[7] A programed unit in electricity for an introductory class in household equipment at the college level has been developed by Sundling at Iowa State University, Ames.[8] A programed unit at the beginning level in nutrition has been developed and evaluated by Richards at the University of Wisconsin, Madison, and six units of PI

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[5]Helen Y. Nelson, Development of Programed Instruction for Home Economics Education and Study of Attitudes Toward its Use at the Undergraduate Level, Research Report Number 6, Cornell University (Ithica, 1966), pp. 1-27.

[6]Patricia Ervin Marovich and Ada Marie Campbell, "Programmed Instruction in Teaching Food Science," J. Amer. Dietet. Assoc., Vol. 52 (1968), p. 407.

[7]Arlene Otto and Judy Vantrease, "Programmed Instruction: Its Possibilities for Home Economics," Focus (New York, Feb. 1968), p. 13.

[8]"Title of Theses: Home Economics and Related Fields, 1965-1966," J. of Home Economics, Vol. 59 (1967), p. 207.

on French Canadian Furniture by Gaudreau have been developed and evaluated at Cornell.[9]

As far as the writer has been able to ascertain, none of the programs mentioned are available for regular classroom use at this time.

Nelson writes, "Automated instruction seems to have much to offer in home economics as well as in other fields of education" and suggests that "continued experimentation with programed materials is needed at all levels of instruction in all areas of home economics."[10]

Controlled experiments have shown that students learn at least as well and often in less time through PI as through the more conventional methods. Surely, then, PI offers some exciting possibilities to the field of home economics.

The writer was challenged to develop some programed modules for use in food classes because of the contributions to learning it seemed to afford and because of the paucity of PI in home economics in higher education. It was believed that there were some concepts and generalizations in food that would lend themselves to programing and that such instructional materials might be used to the advantage of both students and teachers. It was hoped that development of the programed modules would increase the writer's understanding of the learning process and improve her teaching.

Statement of the Problem

The primary purpose of this study was to develop and evaluate some

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[9]"Title of Theses: Home Economics and Related Fields, 1966-1967," J. of Home Economics, Vol. 60 (1968), pp. 203 and 212.

[10]Nelson, p. 27.

modules of PI for use in selected food units at the college level with which students could learn effectively without direct instructor participation. The goal was to produce modules with an error rate of less than the "ten percent maximum usually considered acceptable."[11] The feasibility of using such program modules to supplement regular class and laboratory experiences was to be explored. It was hoped that indications of other ways to use the modules would be discovered. This phase of the study was initiated to seek answers to the following questions:

1. Is it feasible for the subject matter specialist in home economics to develop PI modules?
2. What benefits accrue to such a programer?
3. What are some ways such PI might be used to aid learning?

The secondary purpose was to find answers to questions through the use of those programed modules as follows:

1. What is the relationship between the mental ability of the students involved and their learning through the PI modules?
2. What is the attitude of those students toward PI as a means of learning in a food class?
3. What is the relationship of the attitude of those students toward learning through PI and their learning through its use?
4. What is the relationship between the mental ability of those students and their attitude toward PI as a means of learning?

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[11] Nelson, p. 7.

5. What percentage of the learning through combined PI, class and laboratory experiences was retained at the end of the semester?

6. What is the relationship between mental ability and percentage of retention and between attitude toward PI and percentage of retention?

A thorough search of the literature led the writer to assume at the beginning of the study that:

1. Students can and do learn effectively and efficiently from PI.

2. Students can learn equally well from several types of PI.

3. Several methods of frame construction can be equally effective.

Delimitation of the Study

This study was limited to:

1. The development of programed modules in selected areas of one food course.

2. Evaluation through use in two classes of approximately fifteen members each.

3. Concepts and their related generalizations in selected areas of food which were considered amenable to programing.

No statistical predictions were made since the two classes involved were not assumed to be samples of any population. For this study, they were considered to be the population.

Definition of Terms

Concepts and generalizations are words that do not always convey the same meaning to educators. For this study these terms were used as defined by Hoover:[12]

Concept: "the mental configurations, meaningful ideas or patterns, held by the student. They are the basic ideas which give structure and unity to knowledge."

Generalizations: "statements supported by fact that have an element of universality and usually indicate relationships. They may be expressed as conclusions, understandings, or principles. A generalization is not clearly distinguishable from a concept."

As PI has developed, so has a vocabulary which is unique to this method. In this study, PI is defined as a method of auto-instruction which attempts to make learning controllable and predictable. The material to be learned is presented in steps, the learner is required to participate and respond at each step, he receives feedback sometime after responding and is allowed to proceed at his own pace. Requisites for good programing include precisely stated terminal objectives that can be measured, careful definition of where the learner is, logical ordering of subject matter and elimination of the irrelevant.

Working definitions of other terms used in this study are:

Branch: a critical point in an intrinsic program at which students are sent to alternative frames, depending upon response to a multiple-

[12] Helene Perry Hoover, "Concept Development of College Students Exposed to Systematic, Organized Learning Experiences in Family Relationships" (unpub. Ed.D. dissertation, Oklahoma State University, 1966) p. 14.

choice item. A correct choice sends the learner to the next mainstream frame, but if his choice is not right he is directed to a loop or subsequence and then back to the original frame for another try.

Concepts amenable to programing: any concept, together with the related generalizations, which can be stated in measurable behavioral objectives.

Developmental testing: product improvement through student editing to obtain information for revising the program. Revision is continued until further editing produces little change.

Error: any response which is considered incorrect by the programer.

Error rate: the percentage of responses that are incorrect in a program or a programed module.

Feedback: knowledge of results as to whether the answer or choice is correct or incorrect. In case of error, information may be given as to why the response was not right.

Frame or item: the amount of material presented to a student at one time.

Gain score: the difference between the pretest and posttest scores given before and after PI.

Intrinsic or branching programing: "a programing technique developed by Norman Crowder, characterized by relatively lengthy items, multiple-choice responses, and consistent use of branching."[13] The response controls the next material the student will see. There is usually from two to four fixed sequences that a student may follow--a

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[13] Susan Meyer Markle, Good Frames and Bad: A Grammar of Frame Writing (New York, 1964), p. 273.

branched rather than a linear path. The printed format is the scrambled book.

Linear programing: a method of programing attributed to B. J. Skinner which stresses small steps that usually consist of no more than a sentence or two and requires overt responses and immediate confirmation of the right answer. Right answers are essential in shaping the learner's behavior and they are assured through sufficient cues to guide the student to the correct response. Each student proceeds through a fixed set of items--along a linear path.

Mainstream frames: frames in an intrinsic program that present new information and the multiple-choice responses that determine the route the student will take next. Together they form the main sequence of the program. All students see all the mainstream frames. Which remedial frames each sees is determined by the responses he makes.

Panel: a section of material to be used in conjunction with the program which the learner uses as he works through a number of frames. A panel could, for example, consist of written directions and materials for doing an experiment, textual material, problem situations, pictures or maps.

Programed module: a segment or small part of a course; a small but significant area of subject-matter material.

Remedial loop: a frame that explains to the erring student why his choice was incorrect, gives him no new information, but sends him back to the mainstream frame in which the error was made to try again.

Scrambled book: a book in which the learner does not proceed sequentially from one page to the next. Each response is followed by the page number to be read next and the learner proceeds from page to page as directed by his responses. Students who make few errors may read no more than one-third or so of the book, while others may read most or all of it.

Subsequence: a series of frames to which the student is shunted when he makes an error and which present remedial material and questions designed to help him reach the learning objective. At some point he will be returned to the mainstream.

Validation or field testing: describable and controlled testing with student samples of the target population in order to develop an accurate and detailed product description.

Procedure

Before beginning the PI modules, it was necessary to select the units of food to be programed. Units chosen were considered to be some of the problem areas for the students. Concepts and generalizations in these areas were identified. Intended learners were defined.

Frame construction was not limited to any one method. The choice of method depended upon the type of learning sought in each frame. Steps were as large as possible to permit students to proceed with a minimum of error. Overt responses were required and immediate confirmation of correct responses was given. Students were allowed to proceed at their own pace.

The actual development of each program module involved the following steps:

1. Writing terminal behavioral objectives that could be measured.
2. Constructing an extensive and comprehensive criterion test

based on those objectives.

3. Tentatively determining sequence of subject matter based on objectives.
4. Writing a rough draft of the program.
5. Developing the module through use with students not enrolled in either of the food classes in which the programs were to be used. The student volunteer took the pretest, worked through the module and took the posttest. Frame and posttest errors were tabulated and the results used to revise the program. This process was repeated with other students until such editing produced no appreciable change. The criterion test was revised for clarity and understanding and it was made shorter.
6. A colleague and/or a graduate student worked through the PI module to make suggestions in regard to clarity and accuracy of statements.
7. One of the food classes was then given the pretest, allowed to work through the PI module and given the posttest. Again an analysis of posttest and frame errors was made and the module revised according to findings. This procedure was then repeated in the second class.
8. One of the programs was tried with high school students in Homemaking III and two were tried with more advanced college food students to check on the ability level of the programs.
9. Specifications for each PI module, as indicated by the limited validation in this study, were determined.

There was no control group nor comparison of results from PI with the results from any other method. The class which did a PI module first was alternated with each module in order to increase the likelihood that any reduction in error rate on the second trial was due to improvement in the program rather than to differences in the two classes.

The writer developed tests for each PI module based on the terminal behavioral objectives. These tests were used for pretests, posttests and retention tests. The measure of the student's ability to learn was the percentile rank based on the mean standard score of the four tests (English, mathematics, social studies and natural sciences) of Form A of ACT.[14]

Error rate of an individual student on a PI module was the percentage of wrong responses he made. Error rate of a PI module was calculated by summing the error rates of all students doing the program, dividing by the number of students and multiplying by one hundred.

At the end of the semester, posttests on two of the modules were included in the final examination. The scores were used as retention scores and represented retention of learnings from all instructional methods; not those solely from PI. Percentage of retention was figured by dividing the retention score by the posttest score and multiplying by one hundred.

The writer revised "A Scale for Measuring Attitudes of Prospective Home Economics Teachers Toward Programed Instruction" developed by Nelson[15] to a similar scale to be used with food classes. The attitude scale was given to students after all the PI modules had been completed.

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[14] Using ACT on the Campus (Iowa City, 1965-66).

[15] Nelson, appendix.

Percentage distribution of total student attitude scores which fell in the extremely negative, negative, positive and extremely positive, categories were calculated.

The amount each student learned from a PI module was represented by a gain score, the difference between the pretest and posttest scores.

After a class had done the pretest, programed module and posttest, they proceeded with the regular class and laboratory work in that unit.

Coefficients of correlation between pairs of variables were calculated as follows:

1. Ability to learn, as represented by ACT percentile rank, and learning through PI, as represented by posttest scores for each module for each student.
2. Attitude toward PI as a means of learning, as represented by scores on an attitude scale, and learning through PI as represented by mean posttest scores on all modules for each student.
3. Ability and attitude.
4. Ability and percentage of retention at the end of the semester as represented by mean final test scores on all modules for each student.
5. Attitude and percentage of retention.

Since all research is of necessity based on previous work in the field, the history and theoretical background of PI was explored and reported. The next step was development and evaluation of the PI modules and using them in classes to ascertain results.

CHAPTER II

THEORETICAL BACKGROUND OF PROGRAMED INSTRUCTION

It could be argued that Mark Hopkins with his student on the other end of the log was a form of PI. The individual instruction through questioning by Professor Hopkins and answering by the student with immediate feedback as to correctness of answer do indeed parallel the tenets of PI. Perhaps the same could be said for Socrates and his students. But generally it is agreed that what is known as PI today had much more recent beginnings.

Development of PI

The origin of the PI movement usually is attributed to B. F. Skinner of Harvard with an article he published in 1954.[1] PI grew out of his attempt to apply certain psychological procedures of the animal experimental laboratory to human learning.

The use of teaching machines can be traced to the "testing-teaching" machines designed by Sidney L. Pressey of Ohio State University in the 1920's.[2] Despite his reports that the machines helped students to learn and saved many man hours in grading papers,

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[1] B. F. Skinner, "The Science of Learning and the Art of Teaching," Harvard Educational Review, Vol. 24 (1954), pp. 86-97.

[2] S. L. Pressey, "A Simple Apparatus Which Gives Tests and Scores--and Teaches," Teaching Machines and Programmed Learning, ed. A. A. Lumsdaine and Robert Glaser (NEA, Washington, D. C., 1960), pp. 35-41.

they gained no widespread use. Apparently he was ahead of the times. The depression, no doubt discouraged expenditures of educational funds for machines, and teachers were cheap. At any rate, over a quarter of a century elapsed between Pressey's first experiments and the reintroduction of the teaching machine by Skinner.

Lumsdaine and Glaser report that an unpublished paper by Norman Crowder in 1955 gives a preliminary formulation of the concepts of intrinsic programing.[3] In 1959 a more complete explanation of Crowder's position in regard to programing was published.[4]

Crowder's early work with PI was done for the United States Air Force. Indeed, much of the work on PI that has been and is being done is under the auspices of some branch of the armed services. Much of Pressey's work was for the navy and some of Skinner's for the army. The focus of early military efforts was on devices for development and assessment of particular skills, but some was directed toward practical self-instruction and supporting research.

Downing reports that "probably the greatest strides that have been made in the development and use of programmed materials for teaching have been in the military services." Business and industry are second in the field, finding PI more economical and efficient than other methods in teaching necessary skills. The schools come in for a poor

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[3] Norman A. Crowder, "The Concept of Automatic Tutoring," Teaching Machines and Programmed Learning, ed. A. A. Lumsdaine and Robert Glaser (NEA, Washington, D. C., 1960), p. 608.

[4] Norman A. Crowder, "Automatic Tutoring by Means of Intrinsic Programming," Automatic Teaching: The State of the Art, ed. E. H. Galanter (New York, 1959), pp. 109-116.

third, indicates Downing.[5]

Little was published on PI during the 1950's. During the early 1960's momentum developed and the tempo of PI production increased rapidly. The writer guesses that in 1964 an average person could have read most of the important publications concerning PI in a couple of days or so. Now it would take three to four times as long.

Several teaching machines were produced for school use in the late 1950's and early 1960's, but about all they did was serve as a means of presenting learning material, informing the student of his progress and tabulating errors. It became obvious that this type of machine could be no better than the programs put into it, and there was a dearth of programs. It was discovered, also, that programs in book form could be very effective without benefit of a machine. As far as education is concerned, the emphasis since around 1965 has seemed to switch to production of the learning materials themselves and to studying the process of programing.

Early researchers centered their efforts on such issues as whether students learn as well from PI as from other methods, whether they learn better from teaching machines or from programed texts, whether linear or intrinsic programs are more effective, whether small steps are better than large steps and whether overt responses are essential

[5]Carlton B. Downing, "Programmed Instruction in Perspective," Trends in Programmed Instruction, ed. Gabriel Ofiesh and Wesley C. Meierhenry (NEA, Washington, D. C., 1964), p. 31.

to learning. Extensive reviews of this research are given by Evans, Garner, Holland, and Strong.[6]

It seems to be agreed that students learn at least as well and sometimes more efficiently from PI as from other methods. Lewis reports that:

> results released from Encyclopedia Britannica Films, Inc., through its Temac Division, indicate that high school students of average ability can master algebra, geometry, trigonometry and calculus in half the time ordinarily devoted to these subjects now. Accelerated students show even more impressive records.[7]

Comparisons of teaching machines and programed texts usually have reported no significant difference. This is not surprising since the texts can perform about the same functions as the present-day machines. Comparison studies have shown no clear advantage for either linear or branching programs. Step size in itself has not been shown to be a crucial point. Fry suggests that it may be better to begin with smaller steps and progress to larger steps toward the end of a program.[8] Continual responding by the student seems to facilitate learning, but the overt response may be of more value to the researcher than to the

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[6] James L. Evans, "Programing in Mathematics and Logic," Teaching Machines and Programed Learning, II, ed. Robert Glaser, (NEA, Washington, D. C., 1965), pp. 372-399; W. Lee Garner, Programed Instruction (The Center for Applied Research in Education, Inc., New York, 1966), pp. 42-49; James G. Holland, "Research on Programing Variables," Teaching Machines and Programed Learning, II, ed. Robert Glaser (NEA, Washington, D. C., 1965), pp. 66-110; Paschal N. Strong, Jr., "Research Accomplishments and Needs in Programmed Instruction," Trends in Programmed Instruction, ed. Gabriel Ofiesh and Wesley C. Meierhenry (NEA, Washington, D. C., 1964), pp. 224-230.

[7] Philip Lewis, "Teaching Machines: New Resources for the Teacher," J. of Home Economics, Vol. 53 (1961), p. 824.

[8] Edward B. Fry, Teaching Machines and Programmed Instruction: An Introduction, (New York, 1963), p. 144.

learning process.

Many authorities are questioning the value of results from much of the comparison research in relation to PI because of inability to measure variables accurately, incomplete definition of terms and collection of data under poorly controlled conditions. At the present time many programers are pragmatic. They use whatever techniques seem to be best for the particular learning situation. Linear and intrinsic techniques, small and large steps and overt and covert responses all may be used in a single program. Their main concern is with what a program will do, and the best measure of this is probably the gain score, the difference between the pretest and posttest scores. Other important factors in determining what a program will do are measures of retention and transfer of knowledge. There may be some danger in the pragmatic approach of getting too far away from any theory of learning.

Much research is in progress in regard to effective use of machines, to developing adaptive systems which will adjust to the learner's needs as he progresses and to developing materials for use in very complicated machines.

PI, then, is a rather new method. It is a method that has the potentiality of revolutionizing education. Although it is moving into education more slowly than into the military and business and industry, it has progressed from idea to classroom more rapidly than most educational innovations. The art of programing is in its infancy with much to be learned about it and the use of programed materials and teaching machines.

Theoretical Background

Watson's behaviorist theory of learning sowed the seeds for PI. Watson believed that a science of psychology must be based on the study of what is overtly observable. No introspection was allowed. Behaviorists know that other events intervene between observable stimuli and responses. Since these intervening events cannot be observed--can be conjectured only--they have no place in a true science. The conditioned response was central to learning because it was the unit out of which habits are built. The appearance or strengthening of a conditioned response was said to take place through reinforcement.

The idea of operant conditioning developed within the behaviorist theory. Garner defines operant conditioning as

> a process whereby animals or human subjects are stimulated to behave toward predetermined goals through a series of small actions and consequent reinforcements. These small steps of action form a chain of successive approximations of behavior until the desired end behavior is displayed by the subject.[9]

Learning has occurred when a desired behavior has been reinforced long enough that the behavior becomes established in the organism.

Skinner is a psychologist of the behaviorist school. The paradigm for his linear programing is the operant-conditioning theory of learning. Learning is accomplished through reinforcement of desired behavior; therefore behavior, or doing something, is an essential part of learning. Emphasis is placed upon the response. The student must actively respond and the correct response must be reinforced. Wrong responses can be learned as well as correct ones. Therefore it is

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[9] Garner, p. 9.

necessary to keep wrong responses to a minimum and to never reinforce them. The response is the thing that is learned. It is not surprising that programs based on this theory are often referred to as response-centered programs.

In a Skinnerian program, it is necessary, therefore, that the learner actively, or overtly, respond. Correct responses are reinforced immediately by knowledge of results, feedback or confirmation of the right answer. It is essential that the student make very few errors as he traverses the program. Cues or prompts are used to insure correct responses, but the cues are faded gradually until the learner is on his own. Small steps serve two purposes. They help to insure that the ordinary student can do the program with a minimum of errors and make possible maximum frequency of reinforcement. All learners receive the same stimuli--they follow the same linear path, but each student can progress at a pace that is suitable for him.

Markle summarizes linear programing by listing three basic principles as follows: (1) active responding; (2) minimal errors (because the student learns the responses he makes); and (3) knowledge of results (confirmation of correct responses and correction of any errors that do occur).[10]

Skinner has very effectively translated a learning theory into a teaching method. Much of his laboratory work has been with pigeons, and there are those who argue that people are not pigeons. Linear programs do work with people, however. It just might be that much of the way in which man learns is shared with the lower animals.

[10] Markle, p. 21.

Crowder lays no claim to a specific theory of learning as the basis of his intrinsic programing. However, the techniques of his method can be traced to the assumptions of the cognitive theorists. Cognitive theories are stimulus centered rather than response centered. Environmental stimuli are perceived in an organized and structured manner. Which stimuli are perceived by the organism and the manner in which they are organized depend on the characteristics of the stimuli and on the previous experience of the organism. What is learned is a consequence of the dynamic perceptual organization and reorganization of these stimuli, which may continue long after the original stimuli have disappeared. Learning is a result of relating stimuli to each other in a meaningful way. Facilitation of learning, then, is accomplished by grouping and presenting stimuli in such a way that they form new cognitive relationships. Sudden insights may result as the new cognitive relationships are formed. Performance is not essential to learning. What the organism does is what he has already learned.

The basic assumption in intrinsic, or branching, programing is that learning takes place during exposure to materials. The materials are the environmental stimuli referred to by the cognitivists. Stress is placed on quality and variety of stimuli. Larger units of material, or longer frames, are presented in each step in the intrinsic than in linear programs. It is feared that too much fragmenting of material may result in loss of the main idea and in making difficult or impossible the development of creative insights.

A unit of material is followed by multiple choice questions which are designed to determine whether the learner understood the material read. Questions also serve to keep the student active, make clear to him what he is to learn, keep him informed as to his progress and encourage him to practice.

The purpose of the response is not to learn by doing, but to determine what material the student will see next. If his response is correct, he will go to the next mainstream frame and be told that he is correct. A wrong response sends him either to a loop which tells him he is wrong and directs him to try again or through a subsequence which presents the needed remedial work indicated by his response. At the end of the subsequence he is returned to the mainstream frame from which he was sidetracked and directed to choose another answer. Since the student does not learn through responding, he may simply "think" the answer, responding covertly. The overt response is not essential to the learning process.

A low error rate is not so important in the intrinsic as in the linear program. Crowder believes the student may even learn through errors. At any rate wrong responses are corrected before the learner proceeds to the next step.

Intrinsic and linear programs differ in many techniques and at many points in theory. Crowder insists that it is not the difference in techniques that really make them different. He wrote:

> The crucial and identifying feature of intrinsic programing is that the material presented to each student is continuously and directly controlled by the student's performance in answering questions. To permit this step-by-step control of the program by the student, the questions are put in multiple-choice form.
>
> A program with multiple-choice questions is not an intrinsic program unless each separate answer choice in each question leads the student to material prepared

especially for the student who has made that particular choice.[11]

These two main types of programs do have some common characteristics. Each is an attempt to make learning controllable and predictable and to make it more efficient. Each is concerned with a very careful sequencing of materials to minimize learning difficulties. Each presents the material to be learned in units, although step size differs. Each requires active responding by the student, although the response serves different purposes and may be made by writing the answer in one case and by "thinking" it in the other. Errors are of concern in both types of programs, although a wrong answer is thought detrimental to learning in the linear and is used to explain misunderstandings and increase learning in the intrinsic. Feedback is viewed as reinforcement which increases the probability of the response recurring in the linear, while its purpose is to supply the learner with information in the intrinsic.

Although there is an attempt in the intrinsic program to adjust to individual differences by providing a branch for each of the possible answers in the multiple-choice question, there are seldom more than four paths that a student may take in the programs that have been written to date. Therefore, there are four or fewer fixed paths that may be traversed by the student in the intrinsic program as compared to only one in the linear. Each type of PI is individualized to the extent that the student is allowed to progress at his own pace.

Linear and intrinsic programing are the two main types of pro-

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[11] Norman A. Crowder, "The Rationale of Intrinsic Programing," Programed Instruction, I (April, 1962), p. 3.

graming, although there are variations of each. Each is based on one of the two main schools of psychology: linear being developed from behaviorism and intrinsic from cognitivism.

Mathetics, a method of programing developed by Thomas S. Gilbert, probably should be mentioned. The program begins with the presentation of the completed task or the total material to be learned. Thus a Gestalt, or the "whole" is seen. For this reason Chidester indicates that "mathetic programming proceeds from a Gestalt learning-theory base."[12] Gestalt learning theory belongs to the cognitivist school. Markle insists that Gilbert is a Skinnerian psychologist and that his methods bear many similarities to linear programing.[13]

In a mathetics program, the student learns the last step of a task first. His correct response is confirmed and he then repeats the last step and goes on to the next to last step. This process is repeated until the beginning step is reached. Mastery of each step before going to the preceding step is stressed. For example, explains Mechner, if a child were learning to play a musical selection on the piano, the whole selection would be presented and the student would master the last bar. Only then would he go to the second to last bar. Each time he played the next to the last bar, the last bar would be repeated. When the next to the last bar was mastered, he would play the third to last bar, the next to last, and the last until the third to last bar was mastered. This process would be repeated until the

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[12]Franklin H. Chidester, "Programmed Instruction: Past Present, and Future," J. Amer. Dietet. Assoc., Vol. 51 (1967), pp. 50-51.

[13]Markle, p. 169.

first bar--and the total musical selection--was mastered.[14]

The student always finishes the problem, and this reinforces his learning. A mathetics program is response centered; the response is what is learned. Provision is made for "routing students to remedial materials if their performance indicates they cannot handle the lessons in front of them."[15]

The writer believes that linear programing works better for some kinds of learning, and intrinsic better for other kinds. This belief is supported by Chidester who reports that linear programs have worked best when used to present subjects such as mathematics and languages in which the sequence of learning steps is dictated by the logic inherent in the subject matter or by usage and in which there is only one possible correct understanding or application. According to Chidester, intrinsic programs have worked best in presenting subjects such as sociology, executive practices and politics in which "understanding may be obtained from a number of different starting points" and in which "there are a variety of tenable, though often incompatible, understandings and applications."[16]

Many of the objectives in home economics have to do with values rather than behaviors. No doubt values can be and are learned through PI. More must be known about how values are learned and testing

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[14]Francis Mechner, "Behavioral Analysis and Instructional Sequencing," Programed Instruction, Sixty-Sixth Yearbook of the National Society for the Study of Education, Part II, ed. Phil C. Lange (Chicago, 1967), p. 89.

[15]Markle, p. 169.

[16]Chidester, p. 50-51.

devices must be developed that will measure to what extent values have been learned before there can be any certainty about teaching values by any method.

There is no complete theory of learning. No theory takes into account all types of learning. It has been amply demonstrated that PI is a useful and efficient method of learning. The full potential of PI to control and predict learning cannot be achieved, however, until more is understood about the learning process itself. It just may be that PI, through the use of computers and other complicated machines, may be the means through which a more complete theory of learning may be developed.

The Future of PI

Teaching machines now in use in schools are in disrepute and the general belief is that the "program" is the important thing and can be quite successful without a machine. However, very complex teaching machines are now in experimental use which can adjust to the individual learner. They can change the learning situation to fit the needs of the student while the learning is in progress. Such machines as Socrates, Plato, IBM and CLASS are computer-based systems which utilize slides, films, film strips, and audio tapes and punched tapes or coded cards. Details about these machines and others are given by Stolurow and Davis and by Garner.[17]

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[17] Lawrence M. Stolurow and Daniel Davis, "Teaching Machines and Computer-Based Systems," Teaching Machines and Programed Learning, II, ed. Robert Glaser (NEA, Washington, D. C., 1965), pp. 162-207; Garner, pp. 86-96.

The new machines make both our present machines and programs seem primitive indeed and offer exciting and unbelievable possibilities for learning in the future.

More must be discovered about the learning process if teaching machines are to be used most effectively. One of the potentialities of PI is that more may be learned about learning through the use of teaching machines. Stolurow and Davis write:

> The most apparent application of computer-based teaching machines systems is to study the relative effectiveness of particular teaching programs. In spite of all the research on teaching, the critical variables in instruction are not well analyzed. Consequently, the use of teaching machine systems to determine the relative effectiveness of the variables in teaching is both a basic and high priority. The results of this research should contribute materially to a theory of teaching.[18]

Even these marvelous machine systems will be no better than what man puts into them.

Linear PI is an educational method that is based directly on learning theory and has been translated from the experimental laboratory for classroom use. Other programing techniques, although not so well defined theoretically, can be traced to learning theory. Although a complete theory of learning on which to build PI is lacking, it is probable that PI and teaching machines will contribute much to a more complete theory of how human learning takes place.

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[18] Stolurow and Davis, p. 202.

CHAPTER III

DEVELOPMENT AND EVALUATION OF PI MODULES

The writer was intrigued by the exciting potentialities of PI as a means of learning. The shortage of available programs in the field of home economics and their virtual non-existence at the college level led to the decision to develop some programed materials for use in the area of food. It seemed advisable to begin with a few modules or units of PI because it would be easier for the beginning programer and would take less time than programing a whole course and because some units might program to better advantage than others. The PI modules could be evaluated to a limited extent through validation testing in two classes. The writer wished to investigate the feasibility of such an adventure and the advantages that might accure to both instructor and students.

Preliminary Steps

Before any actual writing could begin it was necessary to choose units of material to be programed. From several years of experience, the writer knew of some areas with which students had difficulty. It was believed that the use of PI could help students toward a better understanding in those areas and make it possible for the whole class to have a more common background of knowledge before the regular class and laboratory work was begun.

The PI modules were to be tried out with two beginning food classes. The primary objective of the course in beginning food is that the students discover and understand the basic principles of cooking for each type of food included. In order to do this the student must develop many new concepts and understand relationships among them. Developing concepts and generalizations is facilitated by experiencing their use in as many ways as possible. Such activities as reading about concepts, seeing pictures and illustrations of the objects and the actual objects themselves, touching, smelling, hearing and experimenting to see what happens in different situations help the student to develop concepts and generalizations.

The course in beginning food is taught from an experimental standpoint in order to provide as many opportunities as possible for the student to experience use of the concepts and generalizations involved. A wide variety of visual aids is used. Students are given reading assignments in the textbook and other pertinent sources. Class discussion of concepts and generalizations involved is followed by laboratory experiments designed to demonstrate what happens when different processes of preparation and cooking are employed. Students are expected to draw conclusions from laboratory experiments and to state the basic principles involved.

The areas that seemed more difficult for students were listed, together with related concepts and generalizations that were usually taught. Recent textbooks were reviewed to ascertain the amount and kinds of information given in these areas. It seemed that insufficient information and explanation for the purposes of the course involved were given in some cases.

Considering the areas with which students had difficulty, the information available in textbooks and the writer's interests, units selected to be programed were:

1. Emulsions
2. Solutions, colloidal dispersions and suspensions
3. Gelatin

They were programed in the order given.

Students in the beginning food course are usually first semester freshmen, although a few upper classmen are enrolled. Most are majoring in home economics education, but non-majors are admitted. Most have had some home economics in high school. Chemistry is not a prerequisite, but some take beginning chemistry concurrently. Since the writer has been teaching the food course no students have had organic chemistry prior to enrollment. The programs were to be developed, then, for first semester freshmen majoring in home economics education with some background in high school home economics and practically none in chemistry.

Development of the PI Modules

The first step in the development of a program, as in planning for any other learning situation, is the formulation of instructional objectives. The objectives need to be so clearly defined that they provide a basis for selecting and arranging material in the program. It is essential that objectives be so stated and described that it is possible to obtain evidence of their accomplishment. They must be measurable. Evidence of accomplishment, or lack of accomplishment, can be used to revise and improve the program. Therefore, objectives must be stated in terms of the terminal behavior expected. Dale believes the detailed specifications of objectives of instruction in behavioral terms is a key factor in programing. He indicates, also, that such authorities as Franklin Bobbit, W. W. Charters and Ralph Tyler are among those who have emphasized activity analysis and behavioral specifications.[1]

Mager's programed book on preparation of instructional objectives was most helpful. Mager defines terminal behavior as what the person will be doing as a result of the program or other means of instruction. He suggests that terminal behavioral objectives should do three things: (1) describe what the learner will be doing when demonstrating his achievement of the objective; (2) define the important conditions under which the behavior is to occur; and (3) define the criterion of acceptable performance. Mager agrees that although each of these items may help an objective to be more specific, it is not necessary to include all three in every objective.[2]

Mager suggests using such words as to write, to recite, to identify, to differentiate, to solve, to construct and to compare in writing specific terminal behavioral objectives. Such words as to know, to understand, to really understand, to fully appreciate and to enjoy are open to too many interpretations.[3]

The writer formulated general objectives and then identified specific behavioral terminal objectives related to each of the general objectives. A sample objective together with related program frames and criterion test items is included in Appendix A.

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[1]Edgar Dale, "Historical Setting of Programed Instruction," Programed Instruction, Sixty-Sixth Yearbook of the National Society for the Study of Education, Part II, ed. Phil C. Lange (Chicago, 1967), p. 33.

[2]Robert F. Mager, Preparing Instructional Objectives (Palo Alto, 1962), pp. 13-53.

[3]Ibid., p. 11.

Formulating terminal behavioral objectives that can be measured is not only the first step in developing a program, it is also the most important step. Objectives that specifically describe measurable terminal behavior certainly facilitate the writing of items for the criterion test. When the objectives are formulated, the test is practically written. The more clearly the objectives indicate the behavior expected, the better guide they are for selecting program content, or the learning experience.

It was found that most of the objectives of the units the writer selected to program were written in a more general form than was required for programing. Regardless of the stated objectives of a unit or course, it was suspected that the "true" objectives were likely to be revealed by tests. Referring to unit tests did prove to be helpful in converting rather general objectives to measurable behavioral terms. If program objectives determine program content, a program can be no better than its objectives. Therefore, colleagues evaluated the objectives for each PI module as to whether they represented material the student needed to know.

The second step in developing each PI module was the construction of the criterion test. The purpose of the criterion test is to evaluate whether the program has taught the learner to do what was specified in the objectives. In PI the test always evaluates the program and the programer--never the student. It is always assumed that the program has failed when the student has failed to learn.

Since an effective program leads to almost perfect results on the criterion posttest, the analysis of test items to determine discrimination and difficulty do not apply to PI. This position is confirmed by

Green as he refers to "the inappropriateness of the classical concepts of evaluation as they come from testing theory to the technology of programed instruction."[4]

Since the program teaches the criterion test, the criterion test may be used for both pretest and posttest. The pretest scores indicate entry behavior of students, but pretests can do more. A careful analysis of errors on pretest items may reveal proposed objectives that need not be included in the program because students demonstrate particular behaviors set forth on those objectives. Test item errors may indicate where an individual student needs to enter a program or where branch points are needed in the program. The difference in pretest and posttest scores represents the gain score for students.

The criterion test must be valid in the sense that it measures the terminal behaviors set forth in the program objectives. Opdycke believes that "a developmental test should be so comprehensive and saturated that more time will be spent in testing than teaching." Such a comprehensive test requires one or more test items related to the terminal behavior set forth in each and every objective, according to Opdycke.[5]

Strong has shown the relationships among objectives, program and criterion test in the following statement:

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[4]Edward J. Green, "The Process of Instructional Programing," Programed Instruction, Sixty-Sixth Yearbook of the National Society for the Study of Education, Part II, ed. Phil C. Lange (Chicago, 1967), p. 65.

[5]Robert M. Opdycke, "Development of Measuring Devices for Programmed Instruction," Trends in Programed Instruction, ed. Gabriel Ofiesh and Wesley C. Meierhenry (NEA, Washington, D. C., 1964), pp. 172-173.

> Indeed, the criterion test is merely a restatement of the set of detailed objectives and should completely represent that population of facts or knowledge. The trial objectives-program-criterion test should be essentially identical, with nothing present in one that is not present in all. As one member of the triad is revised, all must be checked to see if this congruency is maintained.[6]

In developing each of the criterion tests the writer constructed at least one test item for each objective. These items were revised for clarity and made more objective and easier to grade during developmental testing. All items were retained on the validating pretests and posttests used with classes because the PI modules, and consequently the criterion tests, were relatively short. In a long program the validating criterion test might have to be shortened by some means of selecting an adequate sample of items. An example of a behavioral objective and of the test item designed to measure its achievement are:

Objective:

Selecting the more viscous of given pairs of liquids.

Test items:

(1) Which is the more viscous, milk or cream? ________________

(2) Which is the more viscous, corn syrup or milk?

____

(3) Which is the more viscous, cold honey or warm honey?

____

This example is taken from the objectives and criterion test for the PI module on emulsions. See Appendix A for another example.

The programer must continually remind himself that the purpose of

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[6] Strong, p. 226.

testing in PI is not the same as most kinds of testing and that different test results are to be expected. The purpose of the PI posttest is to indicate whether the program objectives have been achieved and not whether the student has succeeded or failed. Nor is it the purpose of the posttest to determine how students rank with one another.

Once the behavioral objectives have been stated in measurable terms and the criterion test for measuring the accomplishment of those objectives has been constructed, the programer must tentatively determine the sequence in which the learning materials will be presented. A thorough knowledge of the subject matter and experience with teaching certainly are very helpful. The programer may have to rely mostly on his own intuition for the first draft of the program, especially in an area such as home economics in which there is little inherent logical ordering of learning sequence.

The program on emulsions was the first developed by the writer. It seemed easier to begin the module around something the students could do and see, and it was thought that a little experiment at the beginning of the module might make the PI more interesting to the students. A simple experiment was planned in which each student added a drop of food coloring to water and was guided by frames in the program to observe what happened. Next the student added a drop of food coloring to oil and observed the results. Then the student mixed the oil and water and food coloring together and shook them vigorously. Again the program guided them to observe accurately what happened and to draw some conclusions, or to generalize, about the results. The directions for the experiment were included in Panel I, which was included with the program. Panel I for "Emulsions" is given in Appendix B. A small tray holding all the materials needed was prepared for each student prior to beginning the program. This technique helped the writer to get started writing frames and it did interest the students when they did the program.

The writer began by writing each criterion test item on a three-by-five-inch index card. Such cards could be rearranged as desired in determining the tentative sequence of the criterion frames.

The next step was to write the first draft of the program. The writer began by composing a teaching frame to go on the side of the card opposite to the test item. Thus, there was one teaching frame for each test item and at least one test item for each objective. There were only thirty-six frames at that point. A few more frames were added to explain, to give examples, and to promote discrimination. It was felt that the program would be too difficult when tried by the first student, and it was. Markle points out that students will make mistakes if they do not know what the programer has assumed they know. This feedback will show the programer where revisions need to be made. On the other hand, the programer "will never find out by looking at the errors that he has taught something that he did not need to teach."[7]

Brethower and his coworkers have suggested that criterion frames, based on criterion test items, be constructed and then arranged in some logical sequence. The criterion frames form an outline for the program. The programer then constructs the teaching frames necessary to answer the criterion frames.[8] A criterion frame is one that contains

[7]Markle, p. 13.

[8]Dale M. Brethower et al., Programmed Learning: A Practicum, (Ann Arbor, 1966), pp. 159.

no prompts and is placed far enough from the sequence of teaching frames that it will measure more than immediate memory. The writer's procedure of using the objectives to outline the program did not differ much from that suggested by Brethower.

The PI module, "Emulsions," was written primarily in the Skinnerian linear format, although the learner was often asked to choose between two alternatives. Steps varied in size and overt responses were required. Immediate confirmation of correct responses was given.

Teaching frames contain information which enables the student to perform correctly on the criterion frames. In linear programing, a teaching frame must contain sufficient prompts to insure that the learner will respond correctly. Underlining, rhyming, indicating the number of letters in a word, giving the initial letter of a word, and the grammatical structure of a sentence are examples of formal prompts. It is the form of the prompt itself which increases the probability of the desired response. When a prompt has a theme designed to bring about the desired response it is called a thematic prompt. The thematic response provides information about the meaning of the response. Meaningful associations encourage the correct response.

An example from "Emulsions" illustrating the behavioral objective-program-criterion test item follows:

Objective:

B-6. Selecting the more viscous of given pairs of liquids.

PI module frames:

60. The viscosity of a liquid is measured by comparing the speed with which it will pour or flow to the speed with which water will pour or flow. Viscosity is a measure of the resistance of a liquid to flowing or pouring. Molasses, then, is more viscous than water.

Cold molasses would be _____ __________ than warm molasses.

61. Correct response to frame 60: more viscous.

The measure of the resistance of a liquid to flow is (a) _ _ _ _ _ _ _ _ _.

Milk is less (b) ______________ than honey.

Mayonnaise is (c) _____________ _______________ than homemade French dressing.

62. Correct responses to frame 61: (a) v i s c o s i t y

(b) viscous; (c) more viscous.

Criterion test items:

27. Which is the more viscous: milk or cream? (cream)

28. Which is the more viscous: corn syrup or milk?

(corn syrup).

29. Which the more viscous: cold honey or warm honey?

(cold honey).

See Appendix A for another example of behavioral objective-program-criterion test items.

Frames 60 and 61 are both teaching frames. The underlining and the two blanks in frame 60 are formal prompts. The underline for each letter in viscosity in frame 61 is a formal prompt to force the student to spell viscosity correctly. The word "less" preceding blank (b) is a thematic prompt.

Response (a) in frame 61 could be considered a copying response since the definition is the same as one in frame 60. As a general rule copying frames should be avoided becasue they do not require the student to think. The case in point is one exception because the underlines for each letter prompt the student to think how to spell viscosity.

In some cases formal prompts are stronger and in others thematic prompts are stronger. The programer needs to be aware of the strength of the prompts he is using. At the beginning of a program or a sequence of frames teaching a concept, strong prompts are used. As the program or series of frames progresses prompting is gradually reduced or faded until there are no prompts in the criterion frame.

Comparison of the responses to frame 61 and responses (b) and (c) in frame 62 with responses to the test items reveal that frame responses and test responses require the same behavior. Each requires the learner to be able to identify the more viscous liquid in a pair of liquids. Yet the frame examples and test examples are different. The use of different examples causes the student to think of the meaning of viscosity rather than to memorize examples.

Discriminating and generalizing are two of the main elements of learning. In frames 60 and 61 the student must discriminate between examples of more viscous and less viscous liquids. If he can make this discrimination he has the concept of viscosity.

Discrimination can be taught by giving examples and non-examples of a concept. Frame 9 in "Emulsions" gives the definition of an emulsion as, "When water (one liquid) is dispersed in tiny droplets in another liquid with which it is immiscible, an emulsion is formed." Frame 10 points out that food coloring and water do not form an emulsion because they are liquids that are miscible. This is a non-example. The learner is asked if sugar and water can form an emulsion. Sugar and water would be another non-example of an emulsion because sugar dissolves in water and because sugar is not a liquid. Frame 11 presents another non-example: meringue made by dispersing air (a nonliquid) in egg whites. Mayonnaise and French dressing are two examples of emulsions that are given later in the program.

Students can be taught to generalize by helping them to see relationships between or among concepts and generalizations. Several frames in "Emulsions" represent efforts of the programer to prompt students to see relationships and to generalize. One example of this effort is found in frame 52, which follows:

> 52. . . . Some boughten French dressings are more permanent emulsions than the homemade. One reason is because more efficient (b) ___(emulsifying)___ agents are used.
>
> One reason mayonnaise is more permanent than homemade French dressing is because it contains a more efficient emulsifier.
>
> We could generalize by saying, other things being equal, the more efficient the emulsifier, the (c) ___(more)___ permanent the emulsion.

One approach to structuring the sequence of information presented to students in PI is the RULEG system suggested by Homme and Glaser. In this system a RU (concept) is presented and followed by an EG (example). A RU plus an EG gives a RULEG frame. $\widetilde{\mathrm{RU}}$ represents a partial rule and $\widetilde{\mathrm{EG}}$ a partial example. RU + EG, RU + $\widetilde{\mathrm{EG}}$ + $\widetilde{\mathrm{EG}}$ and $\widetilde{\mathrm{RU}}$ + EG are but a few examples of possible arrangements under the RULEG system.[9] Information presented proceeds from the abstract to the concrete. The EGRUL ordering of information was not long in appearing. As might be guessed, one or more examples is given first, then followed by the rule. This arrangement proceeds from the concrete to the

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[9] Lloyd Homme and Robert Glaser, "Problems in Programming Verbal Sequences," Teaching Machines and Programmed Learning, ed. A. A. Lumsdaine and Robert Glaser (NEA, Washington, D. C., 1960), pp. 486-496.

abstract. Which works best, RULEG or EGRUL, probably depends on the concepts involved. For example, a difficult concept that the student may not be able to understand in its most abstract form may be learned more easily if presented in the EGRUL order.

Frames 60 and 61, presented on pages 39 and 40, are examples of the RULEG system. Together they present RU + EG + $\widetilde{EG}$ + $\widetilde{EG}$ + $\widetilde{RU}$ + $\widetilde{EG}$ + $\widetilde{EG}$. Frame 52, presented on page 42, is an example of EGRUL, the sequence being $\widetilde{EG}$ + EG + $\widetilde{RU}$.

After a rough draft of "Emulsions" was written and edited, it was tried with a single student volunteer. The student took the pretest and then worked through the program in the presence of the writer. The student was encouraged to make comments, ask questions and report any difficulties. After the program was completed, the student took the posttest. It was noted where errors were made on program frames and on posttest items. Error-producing frames were checked for clarity and revised. This process was repeated with three other students. Two colleagues did the program and made suggestions. At this point in revision, the first twenty frames were traversed and criticized by nine members of a graduate class in PI. This led to more revisions. After further trials with three more students, followed by minor revisions, the PI module seemed to be doing what it was supposed to do.

The criterion test was revised during the developmental testing also. Revisions were concerned with increasing clarity and making the test more objective and easier to grade.

Each trial student was given a typed copy of the program to work with out of respect to him and to prevent errors from inability to read the writer's handwriting. This meant retyping some pages after each student trial and, of course, required a great deal of time and effort.

It is an humbling experience to put one's best into a program and find it does not work with a student. One would like to lay the blame on the inability or inattentiveness or carelessness of the student. But programing philosophy will not permit the student to be blamed. The writer must admit that it is he who has not done a good enough job and he must keep trying until he succeeds. When the program does succeed, however, it is most rewarding and reinforcing for the programer.

The problem in the actual writing of the program is one of communication. Statements must be precise enough that the student gets the exact meaning that was intended. Early drafts of "Emulsions" contained many ambiguous statements that had to be clarified.

Evaluation of the Modules

After developmental testing was completed the module was given to one food class. The class was given the criterion test before traversing the program and after the program was completed. Frame and post-test errors were tabulated and the program revised accordingly. This procedure was repeated with the second class.

About the same procedures were followed for the other PI modules. They were written primarily in the intrinsic style in scrambled book format. However each contains several linear frames. Whichever type of frame seemed best for the situation and was easiest to write was used. Each intrinsic frame begins with the response chosen on the previous frame which is followed by an explanation as to why the response is right or wrong. Then new information is presented followed by a problem or question and alternative responses. The student is directed to the next frame on the basis of the response he chose.

The writer found it helpful to list concepts and generalizations in the units to be programed prior to formulating the behavioral objectives. This procedure seemed to facilitate objective writing and sequencing of material.

The small index cards proved to be too small for many frames. The writer found that the clean side of dittoed "scratch" paper cut half in two was quite satisfactory for frame writing.

Because these modules were longer than "Emulsions" they were each divided into parts. The students seemed to do better and become less bored when the modules were not too long. One of these modules is entitled, "Solutions, Colloidal Dispersions and Suspensions" and is divided into three parts. The first part is on solutions, the second on dispersions, and the third on suspensions. The other module is entitled "Gelatin." Part one is "Nature and Nurture" and part two is "Sols, Gels, and Foams."

The PI module on emulsions was tried with high school students in third year homemaking classes under the supervision of their classroom teacher. A few students in an Oklahoma State University food class did "Emulsions" outside of class. The students in the food class at Oklahoma State University were either sophomores or more advanced students. Organic chemistry is prerequisite. Students in one of these food classes at Oklahoma State University did the PI Module on solutions colloidal dispersions and suspensions during class time. Both the writer and regular class instructor were present while the students did the programs. These extra trials were helpful in verifying the level of students for which the PI modules were suitable.

The consumer always needs to know what he can expect a program to do. Therefore specifications for each PI module were formulated. It must be emphasized that these sepcifications were based on limited evaluation. The specifications indicated the number of frames, number of pages and number of parts. The target population, average total amount of time needed to complete the module and error rate were given. Formats were described. Production of teacher's manual, separate answer sheets, statement of objectives, pretests and posttests were indicated. The number of student trials conducted with student groups by group size were given. Test results were given. PI module specifications will be found in Appendix C.

Posttests were repeated at the end of the semester for "Emulsions" and "Solutions, Colloidal Dispersions and Suspension" to ascertain retention of learning. Students had done regular classroom and laboratory work in addition to the programs; therefore retention was a result of all the methods of learning. Retention tests were given to one class for "Gelatin" but not to the second class because it was quite near the end of the semester when the second class did the program.

Nelson developed a student attitude inventory to assess the attitude of students toward PI as means of instruction in professional home economics education. "Attitudinal items were developed according to the Likert method of scale construction." Nelson reports that "a reliability coefficient of .91 was found, indicating a considerable degree of accuracy in measuring student attitude."[10]

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[10]Nelson, pp. 8-13.

Permission to adapt the scale for use in food classes was granted by Dr. Nelson. (See letters, Appendix D). The title of the inventory was changed, one item was omitted and the emphasis in five items was changed from professional education to food. The attitude inventory was given to students after all programs were completed.

Summary

Preliminary to the actual writing of the programs intended learners had to be defined and units to be programed had to be selected. PI module development included formulation of measurable behavioral objectives and construction of a comprehensive criterion test. A first draft of the PI module was written, tested with a student and revised. This process was continued until the program worked with an individual student.

Each module was evaluated through use in two classes. One class did the program and it was revised on the basis of frame and posttest errors. The process was repeated with the second class. Some of the modules were tried with third-year homemaking high school classes and with college students more advanced than those in the writer's food classes. Specifications were formulated from the limited evaluation of the PI modules. Other data needed for the study were collected. Retention tests for two of the modules were given at the end of the semester. An attitude inventory was adapted for use in food classes to determine attitude of students toward PI as a means of learning. The inventory was given to students after all programs were completed.

CHAPTER IV

DISCUSSION OF FINDINGS

The primary purpose of this study was to develop some modules of PI for food units at the college level and to evaluate the modules through use with two classes. It was hoped that students would be able to learn effectively from the modules without direct instructor participation and that modules with less than ten percent error rates could be produced.

Findings from Development of the Modules

Developing and writing a PI module requires a great deal of time and patience. The writer is convinced that several revision are required to produce any good program. The first effort may require more revisions than subsequent ones. Much paper, hours of typing, and reproduction in quantity of at least two revisions of the module are required; therefore some expense is always involved.

A neophite programer must make some emotional and philosophical adjustments. When he tries a program with a student or a group of students and sufficient learning does not occur, the programer has no excuse behind which to hide. He, the teacher, has to accept the responsibility for failure of students to learn. Educators have said rather glibly that "if the student has not learned the teacher has not taught," but there is little evidence to show that teachers have really blamed themselves when students failed to learn. Many times the teacher-programer must accept the fact that what he has written is not good enough. He must be willing to revise and revise and revise. It might be said in passing that if other methods of teaching were subjected to the rigors of programing philosophy they might teach ninety percent of the subject matter to ninety percent of the students as well as PI.

The programer is forced to develop the learning situation with students. Students actually help to write the program. The teacher has to give more than token indulgence to "pupil-teacher planning." The programer must be humble enough to profit by statements of students such as, "I don't get it--you just don't make sense." The teacher must truly realize that he is not on one side of the contest with the students on the opposing side. Both teachers and students must be on the same team with the teacher committed to do everything in his power to help the student to learn. Of course a little commitment on the part of the students would help, too.

One of the greatest difficulties in programing is precision and clarity in writing. The student cannot learn what the program intends unless the meaning is the same to the student as it was to the writer. Of course this principle applies to other methods of teaching as well as to PI, but programing forces the teacher to face the issue.

The writer found that a new concept had to be presented seven or more times in a variety of ways before most of the students got it. How often a concept is presented once in a hurried lecture, perhaps lacking in clarity, and the student is expected to show mastery of the concept on a subsequent test. A concept is not gained by passively listening and reading alone; it grows out of a variety of experiences.

Effective teachers play to an audience. They continually watch their students for expressions of understanding, puzzlement or boredom. They ask questions to determine if students have understood. They give tests not only to assign grades, but to evaluate the teaching. PI is a method where the teacher can get feedback from every student on every point to be learned. The teacher is continually informed as to how each student and the program is performing.

Programing is not easy, but as with most difficult tasks, the reward is great and well worth the effort. It is feasible for the individual who knows the subject matter to develop a program that will teach, although there might be times when a team of subject-matter expert and writer-programer specialist would work to advantage. There are many benefits that accrue to the teacher who develops a program with his students, that cannot be overlooked. For one thing, the programer actually sees learning theories at work and his knowledge of the teaching-learning process gains greater breadth and depth than can be obtained from lectures and books.

Developing a program increases the ability of the teacher to evaluate his methods and his teaching objectively. As ability to evaluate objectively increases, his teaching and the students' learning can be improved.

One benefit from developing a program is learning to write precisely what one means. This knowledge is transferrable to other methods and other teaching-learning situations.

Programing is a cooperative adventure of both teacher and students. The objectives are specific and measurable and both teacher and students know what the program is supposed to teach. Teacher and students work together to insure that the program does teach the objectives. The tests are honest--they do measure what is supposed to be learned. The programer develops perseverance, patience and humility. He must realize anew that he can learn from students.

The writer would advise any teacher who plans to do some programing to begin with a very short unit or module. The feedback and reinforcement from success with a short module can make possible its development before enthusiasm and patience wane.

Facts are the lowest objectives in Bloom's taxonomy but he does insist that they are essential.[1] Facts are the tools for conceptualization and generalization. The problem in education is that the teaching-learning process often does not get beyond the facts. The neophite programer probably would find it easier to begin with a unit primarily concerned with facts because behavioral objectives and learning experiences of a factual nature likely are easier to write. However, any objective that can be stated in measurable behavioral terms can be programed. The beginning programer should experiment early with objectives that go beyond the facts.

Linear type programing was easier for the writer than intrinsic programing. It must be for others, too, since the majority of published programs are of this type. A major difficulty in intrinsic programing is formulating sufficient plausible alternatives. For this study, the first criterion test used with individual students in developing

[1]Benjamin S. Bloom, ed., Taxonomy of Educational Objectives: Cognitive Domain (New York, 1956), pp. 18-43.

intrinsic frames contained essay items. Responses on these items were helpful in discovering misunderstandings and plausible answers to multiple-choice questions.

The programer must watch for boredom. Humor in the program may help. However effects of attempted humor should be evaluated during developmental testing since teachers and students may not agree on what is humorous.

PI modules developed by the writer were used during class time in order to control experimental conditions. Traversal of a module by all class members helps to insure a common background from which to begin other learning experiences. When all students obtain specific information through their own efforts by doing a program, there can be no doubt that the class will have a common starting point. However, many other possible uses of programs could be suggested. Out-of-class study of a PI module could serve many of the same purposes of in-class use. PI modules could be developed and used as remedial learning for poorer students. PI modules might be produced for the purpose of offering challenge and enrichment to the very good student. PI offers an ideal method of instruction by correspondence. How convenient it would be to have a PI module to give to a returning student to help him catch up after an absnece. The writer plans to try to develop a programed laboratory for food which will allow the student to work independently of the instructor. PI modules might be used to broaden the curriculum. If a student chose a few objectives in a food course, or any other course, and developed a program from them himself he probably would learn a great deal.

As a result of this study, it was concluded that it is feasible for the classroom teacher to develop and use modules of PI. The development of a PI module is far from easy, but it is a rewarding experience. The programer learns to work with the student in developing the program and in the educative process. Clarity and precision of expression are developed. Programing increases the teacher's understanding of the teaching-learning process and helps the teacher to detect and utilize feedback from students to improve teaching. In short, development of a program is likely to improve a teacher's teaching.

Findings from Use of the Modules

After each module of PI was developed through individual student trials and subsequent revisions it was used in one class, revised, used in a second class and revised again.

Emulsions

Table I, page 54, lists data concerning the results from use of "Emulsions." The ACT composite percentile rank, used as a measure of ability in this study, ranged from 12 to 87 among this group of students, the average being 42. Percentage pretest scores ranged from 0 to 19, with an average of 5, indicating this group of students had little prior knowledge of the material presented in the module. At this stage, "Emulsions" contained 66 frames and it took the students an average time of 53 minutes to complete the program. Error rates for individuals on frame responses ranged from 2% to 17%. The error rate for the module, which is the average of individual error rates, was 9.9%. This error rate was within the limit of 10% set by the writer

TABLE I

DATA ON USE OF EMULSION PI MODULE WITH
FIRST FOOD CLASS

Student Group A	ACT Comp. %	Time Required Minutes	PI Module Responses Missed Number	%	Pretest Score	%	Posttest Score	%	Gain Score %	Final Test Score	%
1	21	49	10	9	0	0	32	74	74	39	91
2	21	63	8	7	2	5	35	81	76	40	93
3	21	67	10	9	0	0	32	74	74	41	95
4	76	50	10	9	0	0	37	86	86	42	98
5	69	45	17	15	0	0	38	88	88	43	100
7	16	58	14	12	5	12	29	67	55	37	86
8	12	59	11	10	0	0	29	67	67	41	95
9	47	44	17	15	1	2	37	86	84	42	98
10	69	50	2	2	2	5	39	91	86	42	98
11	62	42	17	15	0	0	32	74	74	37	86
12	47	41	9	8	3	7	43	100	93	43	100
13	21	69	6	5	8	19	41	95	76	42	98
14	54	64	15	13	0	0	37	86	86	43	100
15	12	55	19	17	2	5	31	74	69	38	88
16	87	44	3	3	5	12	39	91	79	42	98
Average	42	53		9.91*		5		82	77		95

*Error rate of PI module.

in planning of the study, but since this was a linear program it was desirable to reduce it to 5% or less. The average posttest score was 82%, with scores ranging from 67% to 100%.

The writer hoped to revise the program so that no student would make less than 90% on the posttest score. Gain scores are probably the best indicators of what students learn from programs. The percentage of gain ranged from 55 to 93 and averaged 77. Therefore students did learn from the program.

Responses that were missed on the module were marked and tabulated. Any response that was missed more than twice was analyzed to try to determine what caused the misses. Posttest errors were tabulated and analyzed, also. Program frames were revised on the bases of analysis of frame and test errors.

Table II, page 56, contains data from use of the revised emulsions module. The revision contained 83 frames and required an average of 70 minutes for completion. The average ACT composite percentile rank of students in Group B was 52 which is 10 percentiles higher than for the first group of students. Students in Group B made a slightly higher average on the pretest. The second group had a higher average gain score, which was 84%. The average posttest score was 92%, which is a high average, but there were three scores that fell below 90%. The error rate on the revised module was reduced to 2.6%. It was hoped the revision would reduce the error rate to 5%, but it was reduced even more--to almost half that amount.

On the final test, given to measure retention at the end of the semester, Group A did better than Group B. Yet Group A had less ability, as indicated by the measure used, made an average of more

TABLE II

DATA ON USE OF REVISED EMULSION PI MODULE WITH SECOND FOOD CLASS

Student Group B	ACT Comp. %	Time Required Minutes	PI Module Responses Missed Number	PI Module Responses Missed %	Pretest Score	Pretest %	Posttest Score	Posttest %	Gain Score %	Final Test Score	Final Test %
6	26	78	7	4	2	5	35	81	76	38	88
17	76	71	8	5	7	16	42	98	82	40	93
18	47	73	4	2	4	9	30	70	61	37	86
19	39	70	2	1	1	2	39	91	79	30	70
20	95	70	1	1	3	7	41	95	88	34	79
21	54	80	2	1	1	2	42	98	96	42	98
22	3	60	2	1	7	16	38	88	72	29	67
23	33	72	0	0	2	5	40	93	88	39	91
24	82	67	8	5	1	2	43	100	98	39	91
25	73	65	10	6	6	14	40	93	79	37	86
26	39	67	7	4	5	12	43	100	88	33	77
Average	52	70		2.6*		8		92	84		84

*Error rate of PI module.

errors on the program and made a lower average score on the posttest. This may be explained in part by the fact that there were fewer students in Group B than in Group A. Perhaps this result supports the fact that the teacher is still necessary and may be able to accomplish some things a program cannot do. In Group A one student made 100% on both posttest and final test scores. Every other student showed a gain in the final test score over the posttest score. About half of the students in Group B showed a gain on the final test and the other half showed a loss.

Solutions, Colloidal Dispersions and Suspensions

Tables III and IV, pages 58 and 59, show data on the two groups who did the PI module, "Solutions, Colloidal Dispersions and Suspensions." Entry knowledge was low for both groups. Group A, the class which did the program first, ranged from 0 to 37% on the pretest with an average of 10%. Program response errors ranged from 1% to 13%, with a program error rate of 4.26%. This module contained many intrinsic frames and a low error rate is not considered so essential in this type of program as in the strictly linear type. Posttest scores indicated, however, that some revisions were needed. With the exception of one student, posttest scores ranged from 69% to 97%. The student who made 54% on the posttest ranked in the third percentile on the ACT composite score.

The program was revised on the bases of program response and posttest item errors. The primary purposes of the revisions were to clarify meanings and to include more comparisons and discriminations. Revision increased the program from 76 frames to 87 frames. The

TABLE III

DATA ON USE OF SOLUTIONS, COLLOIDAL DISPERSIONS AND SUSPENSIONS
PI MODULE WITH FIRST FOOD CLASS

Student Group A	ACT Comp. %	Time Required Minutes	PI Module Responses Missed Number	PI Module Responses Missed %	Pretest Score	Pretest %	Posttest Score	Posttest %	Gain Score %	Final Test Score	Final Test %
17	76	74	8	7	6	17	26	75	58	22	63
18	47	65	4	3	4	11	24	69	58	27	77
19	39	75	2	2	2	6	33	94	88	19	54
20	95	78	3	3	0	0	34	97	97	23	66
21	54	81	4	3	4	11	33	94	83	23	66
22	3	75	4	3	0	0	19	54	54	16	46
23	33	75	2	2	4	11	32	91	80	28	80
24	82	75	1	1	13	37	32	91	54	30	86
25	73	70	15	13	0	0	28	80	80	18	51
26	39	60	6	5	1	3	29	83	80	23	66
Average	54	73		4.26*		10		83	73		65

*Error rate of PI module.

TABLE IV

DATA ON USE OF REVISED SOLUTIONS, COLLOIDAL DISPERSIONS AND SUSPENSIONS PI MODULE WITH SECOND FOOD CLASS

Student Group B	ACT Comp. %	Time Required Minutes	PI Module Responses Missed Number	PI Module Responses Missed %	Pretest Score	Pretest %	Posttest Score	Posttest %	Gain Score %	Final Test Score	Final Test %
1	21	87	3	2	4	11	32	91	80	24	69
2	21	115	10	6	6	17	27	77	60	28	80
3	21	105	0	0	13	37	33	94	57	28	80
4	76	97	1	1	0	0	34	97	97	32	91
5	69	75	4	2	10	29	32	91	62	31	89
6	26	80	8	5	3	9	27	77	68	22	63
8	12	90	5	3	2	6	31	89	83	21	60
9	47	65	17	10	5	14	28	80	66	18	51
10	69	64	3	2	0	0	33	94	94	34	97
11	62	87	8	5	4	11	33	94	83	27	77
12	47	71	7	4	8	23	33	94	71	31	89
13	21	85	3	2	11	31	33	94	63	28	80
14	54	87	29	18	1	3	30	86	83	33	94
15	12	80	5	3	4	11	27	77	66	26	74
16	87	80	3	2	7	20	34	97	77	32	91
Average	43	85		4.28*		15		89	74		79

*Error rate of PI module.

average time required to do the program increased from 73 minutes for Group A to 85 minutes for Group B. Because of this, the program was divided into three parts providing shorter working periods to minimize fatigue and boredom.

Pretest scores for Group B ranged from 0 to 37%, the same as for Group A, but the average score of 15% was somewhat higher for Group B. Gain scores were practically the same for both groups, the average score for Group A being 73% and for Group B being 74%. Average post-test scores were increased from 83% for Group A to 89% for Group B. Posttest scores for Group B ranged from 77% to 97%. This average score and range of extreme scores might be considered quite satisfactory with most methods of teaching, but it is not as effective as PI should be.

The module on solutions, colloidal dispersions and suspensions was harder for the students than the one on emulsions. Many of the concepts in the former were new to most of the students. The area has been a "trouble spot" with other methods of teaching. The writer hopes that an additional revision will increase the posttest scores and raise the average score. Little research has been done regarding the effect of PI on retention. However, it was felt that final test scores were too low. Review of the program by students before the final test might help. Perhaps revisions which stress basic principles and applications as well as discrimination and comparison of concepts will improve retention.

Gelatin

Tables V and VI, pages 61 and 62, give data concerning the two class trials of the PI module on gelatin. This was the longest of the

TABLE V

DATA ON USE OF GELATIN PI MODULE WITH FIRST FOOD CLASS

Student Group A	ACT Comp. %	Time Required Minutes	PI Module Responses Missed Number	%	Pretest Score	%	Posttest Score	%	Gain Score %	Final Test Score	%
17	76	88	8	7	10	18	47	84	66	48	86
18	47	81	3	3	12	21	38	68	47	28	50
19	39	70	3	3	5	9	53	95	86	46	82
20	95	78	3	3	5	9	49	88	79	49	88
21	54	113	2	2	2	4	54	96	92	48	86
22	3	85	2	2	2	4	35	63	59	31	55
23	33	75	3	3	11	20	51	91	71	46	82
24	82	77	3	3	9	16	55	98	82	53	94
25	73	73	13	12	10	18	42	75	57	46	82
26	39	102	9	8	5	9	49	88	70	50	89
Average	54	84		4.49*		13		84	71		79

*Error rate of PI module.

TABLE VI

DATA ON USE OF REVISED GELATIN PI MODULE WITH SECOND FOOD CLASS

Student Group A	ACT Comp. %	Time Required Minutes	PI Module Responses Missed Number	%	Pretest Score	%	Posttest Score	%	Gain Score %	Final Test** Score	%
1	21	116	6	4	9	16	53	95	79		
2	21	100	8	5	5	9	46	82	73		
3	21	102	5	3	9	16	54	96	80		
4	76	95	2	1	5	9	54	96	87		
5	69	60	4	3	1	2	56	100	98		
6	26	95	1	1	0	0	52	93	93		
8	12	95	13	9	1	2	48	86	84		
9	47	74	9	6	6	11	47	84	73		
10	69	105	10	7	4	7	47	84	77		
11	62	104	4	3	4	7	45	80	73		
12	47	80	9	6	11	20	55	98	78		
13	21	70	1	1	14	25	52	93	68		
14	54	98	17	12	7	13	44	79	66		
15	12	88	6	4	11	20	44	79	59		
16	87	90	2	1	12	21	51	91	70		
Average	43	91		4.4*		12		89	77		

* Error rate of PI module.
**No final test given to this class.

three modules requiring an average of 91 minutes for the second class to do the revised version. It was divided into two parts for both classes. "Gelatin" was a combination of linear and intrinsic frames.

Entry knowledge was low and similar for both groups. Pretest scores ranged from 4% to 21% for Group A and from 0 to 25% for Group B. The average pretest score for Group A was 13% and for Group B was 12%. The error rate of 4.49% for the first group was satisfacoty and was not changed appreciably in the revision for Group B. The average posttest score was increased from 84% for Group A to 89% for Group B. The criterion test for "Gelatin" was not given to Group B at the end of the semester to estimate retention because that group completed the gelatin PI module next to the last week of the semester. Gain scores of 71% for Group A and 77% for Group B indicated considerable learning had taken place.

Further revision of the gelatin module may lead to improved posttest scores. At any rate, the writer is convinced that effective PI modules can be developed by the classroom teacher. The three modules really grew to six when "Solutions, Colloidal Dispersions, and Suspensions" was divided into three parts and "Gelatin" into two parts. These modules were at least as effective as other methods of teaching. They proved to be a very useful tool in the teaching-learning process.

Relationship Between Ability and Learning Through PI

Coefficients of correlation were computed between ability, as indicated by the ACT composite percentile rank, and posttest percentage scores on each of the modules for Group B students. It was Group B who used the revised version of each module in the limited field testing in the writer's classes. The correlation value for each module is given in Table VII below. The r values indicate there is little relationship between ability of participating students and achievement on these PI modules. If the r value comparing ability of students with posttest percentage scores on "Emulsions" is squared and multiplied by 100 the relationship between the two variables is shown to be slightly over 16%. The same process reveals an association of a little over 25% between the two variables for "Solutions, Colloidal Dispersions, and Suspensions." There is practically no relationship between the two variables for "Gelatin."

TABLE VII

CORRELATION COEFFICIENTS BETWEEN ABILITY AND LEARNING THROUGH PI FOR GROUP B STUDENTS

	r
ACT Composite Percentile Rank and Posttest Percentage Score on "Emulsions"	+.410
ACT Composite Percentile Rank and Posttest Percentage Score on "Solutions, Colloidal Dispersions and Suspensions"	+.559*
ACT Composite Percentile Rank and Posttest Percentage Score in "Gelatin"	+.216

*Significant at the 5% level.

Students with higher percentile ranks on the ACT battery of tests performed somewhat better on the first two modules than those with less ability. This agrees with findings by Nelson, Marovich and Campbell and others.[2] Better students learn more through PI than do poorer students.

Student Attitude Toward PI

Student attitudes toward PI in food classes were assessed on a scale adapted from Nelson. Procedures reported by Nelson were followed whereby "reactions to each item were scored on a zero to four range depending on the degree of favorability expressed. Values were assigned in reverse order for negatively stated items."[3] There were 38 items on the attitude scale and the range of possible scores was 0 to 152. The scale was divided into four parts as follows:

1. Extremely negative: 0 through 38.
2. Negative: 39 through 76.
3. Positive: 77 through 114.
4. Extremely positive: 115 through 152.

Actual scores on the student attitude scale ranged from 87 to 147. All scores fell within the positive and extremely positive categories with 46% in the positive and 54% in the extremely positive. This compares to 64% of the attitude inventory scores in the positive and extremely positive categories in the Nelson study. She reported 35% in the negative and 1% in the extremely negative categories.[4] The

[2]Nelson, p. 13; Marovich and Campbell, p. 407.

[3]Nelson, p. 10.

[4]Nelson, p. 18.

favorable attitude toward PI in this study can be explained in part by the fact that PI was a new experience for nearly all of the participating students. Only 2 of the 26 students in the two classes indicated they had used PI before. The novelty of participating in research also appealed to them.

Relationships Between Other Variables

Coefficients of correlation were determined between attitude and learning, between ability and attitude, between ability and retention and between attitude and retention for all of the 26 participating students. The r values of these variables are shown in Table VIII.

TABLE VIII

CORRELATION COEFFICIENTS BETWEEN ATTITUDE AND LEARNING, BETWEEN ABILITY AND ATTITUDE, BETWEEN ABILITY AND RETENTION AND BETWEEN ATTITUDE AND RETENTION

Attitude Score and Average Posttest Percentage Score on Three PI Modules for All Students	r +.075
ACT Composite Percentile Rank and Attitude Score for All Students	r +.378
ACT Composite Percentile Rank and Average Final Percentage Score for All Students	r +.670*
Attitude Score and Average Final Percentage Score for All Students	r +.123

*Significant at the 5% level.

The percentage posttest scores on all three modules were averaged to obtain the score representing the learning or achievement of the student through PI. The r value of .075 between achievement scores and attitude scores reveals that there was practically no relationship between these variables. This lack of relationship may be explained in part by the fact that the attitude of all participating students toward PI either was positive or extremely positive.

An r value of .378 between ability, as represented by the ACT composite percentile ranks, and attitude scores represents an association of about 14% between these two variables. This suggests that ability had little effect on attitude toward PI as a means of learning in this study.

There was a stronger relationship between ability and average final test scores on the modules when PI was one means of learning. An association of nearly 45% between these two variables is shown by an r value of .670. Ability did affect retention when PI was a means of learning.

There was less than 2% association between attitude scores and final test score averages. Attitude toward PI as a means of learning had little effect on retention when PI was one of the methods used. Again, the fact that attitudes of all students were quite favorable toward PI as a means of learning would explain part of the low relationship between these two variables.

Results with High School Students

There were 13 high school students in third-year homemaking who completed the emulsions module and for whom ability scores were available. Table IX, page 69, shows data resulting from the use of "Emulsions" with this group of high school students. Otis intelligence test scores were the measure used to indicate ability. All Otis scores for the participating high school students were below 100 except one, which was 102. The scores below 100 ranged from 80 to 98 indicating those students had below average ability. Responses missed on the program ranged from 0 to 83% and averaged 15.04%. Pretest scores averaged 16%. Posttest scores averaged 62%. The lowest posttest score was 19% and the highest was 86%. The average gain score was 46%.

The program responses missed by the high school students were quite high compared to responses missed by the experimental Group B class (15.0% and 2.6%). Posttest scores and gain scores were low, also for the high school students. The average time required for the high school students to do this program was 91 minutes compared to 70 required by Group B. The relatively high percentage of response errors and posttest errors and longer time required to traverse the program indicate that the PI module on emulsions was too difficult for the participating high school students.

Results with Advanced College Students

Only 5 of the advanced food students completed the emulsions module. Data concerning this group is given in Table X. These students required only 57 minutes to complete the module. The average of program responses missed was 1.68%. Their pretest score average was 43%, indicating they knew nearly half of the material in the program before they started it. Posttest scores averaged 96%. The low error

TABLE IX

DATA ON USE OF REVISED EMULSION PI MODULE
WITH HIGH SCHOOL STUDENTS

Student	Otis Intelligence Score	Time Required Minutes	PI Module Responses Missed Number	%	Pretest Score	%	Posttest Score	%	Gain Score %
1	94	78	10	6	6	14	29	67	53
2	80	85	10	6	10	23	28	65	42
3	94	65	22	12	11	26	27	63	37
4	86	110	63	35	7	16	21	49	33
5	94	85	28	16	6	14	30	70	56
6	96	70	21	12	6	14	34	79	65
7	92	87	4	2	14	33	31	72	39
8	96	97	0	0	9	21	37	86	67
9	83	125	6	3	1	2	17	40	38
10	102	65	148	83	1	2	8	19	17
11	92	80	12	7	3	7	28	65	58
12	81	99	1	1	10	23	36	84	61
13	98	122	8	4	3	7	23	53	46
Average	91	90		15.04*		16		62	46

*Error rate in PI module.

TABLE X

DATA ON USE OF REVISED EMULSION PI MODULE WITH ADVANCED COLLEGE STUDENTS

Student	ACT Comp. %	Time Required Minutes	PI Module Responses Missed Number	PI Module Responses Missed %	Pretest Score	Pretest %	Posttest Score	Posttest %	Gain Score %
2	69	53	3	2	7	16	40	93	77
3	76	50	5	3	21	49	41	95	46
4	82	45	3	2	26	60	43	100	40
5	82	70	0	0	18	42	43	100	58
13	16	70	4	2	21	49	41	95	46
Average		57		1.68*		43		96	53

*Error rate on PI module.

rate on the module and on posttest items, the short time required to do the program and high pretest scores indicate the emulsions PI module was too easy for these students.

There were 12 of the advanced food students who completed "Solutions, Colloidal Disperions, and Suspensions." Data concerning their use of this module are given in Table XI, page 72. The average time required to traverse the program was 71 minutes compared to 85 minutes required by the experimental Group B class. Program error rates were nearly the same for both groups: 4.19% for the advanced students and 4.28% for Group B. Pretest scores for the advanced students averaged 54%, indicating they knew over half of the material in the program before they traversed it. One posttest score was 74%, but others ranged from a low of 89% to 100%, averaging 91%. Although this program was harder for the advanced students than the one on emulsions, the high pretest scores indicate much material could be omitted from "Solutions, Colloidal Dispersions and Suspensions" for this group of advanced food students.

Summary

The primary purpose of this study was to develop and evaluate some PI modules for use in food at the college level with which students could learn effectively without direct instructor participation. It was found that it is feasible for the classroom teacher to develop PI modules. Benefits accruing to the programer and some possible uses for PI modules have been suggested.

The secondary purpose of the study was to find answers to questions listed on pages 7 and 8 concerning relationships between several

TABLE XI

DATA ON USE OF REVISED SOLUTIONS, COLLOIDAL DISPERSIONS AND SUSPENSIONS PI MODULE WITH ADVANCED COLLEGE STUDENTS

Student	ACT Comp. %	Time Required Minutes	PI Module Responses Missed Number	PI Module Responses Missed %	Pretest Score	Pretest %	Posttest Score	Posttest %	Gain Score %
1	75	50	2	1	23	66	35	100	77
2	69	74	3	2	17	49	31	89	72
3	76	70	1	1	16	46	33	94	78
4	82	67	2	1	22	63	34	97	75
5	82	88	0	0	22	63	32	91	69
6	33	78	3	2	24	69	35	100	31
7	12	92	1	1	17	49	32	91	42
8	54	76	18	11	18	51	29	83	32
9	54	61	16	10	18	51	31	89	38
10	69	54	14	8	16	46	31	89	43
11	31	54	11	7	18	51	26	74	23
12	54	88	12	7	15	43	32	91	76
Average		71		4.19*		54		91	54

*Error rate on PI module.

pairs of variables, concerning student attitude toward PI as a means of learning, and concerning the amount of knowledge retained at the end of the semester from all methods of learning in the subject matter covered by the program modules. Answers to these questions, as found in this study, have been reported.

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS

This study resulted in the development of three modules of PI in food for the college level: (1) Emulsions, (2) Solutions, Colloidal Dispersions and Suspensions; and (3) Gelatin. The three modules were tried in two food classes.

Summary

"Emulsions" was written in the linear style. The other two modules contained both linear and intrinsic frames and were arranged in the scrambled book format. The module on solutions, colloidal dispersions and suspensions was divided into three parts and the one on gelatin into two parts.

The three PI modules were developed for first semester freshmen majoring in home economics education with some background in high school home economics but practically none in chemistry. The first step in developing each module was to formulate instructional objectives in measurable, behavioral terms. The second step was to construct a comprehensive criterion test which included at least one item for each objective. Then frames were written to teach the objectives and the criterion test. The first rough draft of each module and the criterion test were tried with one student and revised on the bases of program response errors, posttest errors and comments by the student. The process of student trial and revision was repeated until there seemed to be little need for change in the program. The criterion test was used for both pretest and posttest.

Each module was subjected to limited field testing by using with one class, analyzing program response and posttest errors and revising and then repeating the whole process with a second class.

The final version of the program on emulsions was tried with some high school students in third-year homemaking. It was traversed, also, by a few students more advanced in college and with more background in chemistry than in the experimental classes. The program on solutions, colloidal dispersions and suspensions was tried by the more advanced college students.

Posttests were given near the end of the semester to ascertain the retention of learning from all methods of instruction. A scale for measuring student attitude toward PI was given to students in the experimental classes after all three PI modules had been completed. Correlation coefficients were computed between ability to learn and learning through PI, between attitude toward PI and learning through PI, between ability to learn and attitude toward PI, between ability to learn and percent of retention at the end of the semester and between attitude toward PI and percent of retention at the end of the semester.

It was decided that it is feasible for the classroom teacher to develop PI modules, although the task is a difficult one which requires perseverence and patience. The basic philosophy that the student cannot be blamed for program errors--that errors are always the fault of the programer and the program--requires some emotional and philosophical adjustment on the part of the neophite programer. The teacher must change his attitude toward tests because in PI tests are used to evaluate how well the program teaches rather than how well the student does. Developing a module through student trial and error requires time and patience, but is a necessary procedure in producing an effective program. Precision and clarity in writing is one of the greatest difficulties in programing. Continual feed back from each student is one of the advantages of PI.

Although programing is difficult, it is very rewarding. The programer-teacher develops a better understanding of the learning process and improves his own teaching. He learns to express himself more clearly. He is forced to plan the learning situation with students and to base learning experiences and tests on measurable behavioral objectives. He and the students all know what they are trying to accomplish.

It seemed important that the first attempt at programing should be confined to a short module. A unit concerned primarily with factual material and a linear type program probably would be easier for the beginner.

The PI modules developed for this study were used in classes, but several other possible uses were suggested. PI modules might be used for out-of-class assignments, for remedial work, for challenging the good student, for correspondence instruction, for make-up work, and for laboratory work. Students might learn through programing short units themselves.

The PI modules developed in this study were at least as effective as other methods of teaching. The error rate on the final revision for

"Emulsions" was 2.6%, for "Solutions, Colloidal Dispersions and Suspensions" was 4.28%, and for "Gelatin" was 4.4%. The average posttest score for "Emulsions" was 92%, for "Solutions, Colloidal Dispersions and Suspensions" was 89% and for "Gelatin" was 89%. It was felt that the last two modules needed further revision to bring up some of the lower posttest scores. Final average scores at the end of the semester for "Emulsions" were 95% for the first class who did the program, Group A, and 84% for the second class who did the revised version, Group B, and were considered satisfactory. It is hoped that further revision will increase final scores for "Solutions, Colloidal Dispersions and Suspensions" from the 65% average for Group A and 79% average for Group B and from a 79% average for Group A on "Gelatin."

Students in the experimental classes were quite favorable to PI as a means of learning. There was practically no association between attitude toward PI and learning through PI. The students ability to learn had little effect on attitude toward PI. There was little relationship between attitude toward PI and retention at the end of the semester. There was a significant relationship between ability to learn and retention when PI is one means of learning. The better students learned more from the program on emulsions and the one on solutions, colloidal dispersions and suspensions than did the poorer students, but good and poor students learned equally well from "Gelatin."

Conclusions

The primary purpose of this study was to develop some PI modules with which students could learn efficiently. The study was initiated to find whether it was feasible for the classroom teacher to develop such modules, what benefits might accrue to the programer and some ways in which PI might be used to aid learning. Development of the modules led to the following conclusions:

1. It is feasible for the subject matter specialist in home economics, the classroom teacher, to develop PI modules. Modules can be developed from which students learn effectively and efficiently. The task is difficult, requires time and patience but is very rewarding.
2. Some benefits accruing to the teacher-programer are:
    a. Actual experiencing of applied theories of learning and an increased understanding of the learning process.
    b. An increased ability to objectively evaluate teaching methods.
    c. Improvement in communication.
    d. A new insight into the role of objectives in the learning process.
    e. An increased awareness of the need to plan learning experiences with students.
    f. Improvement in total teaching ability.
3. PI modules might be used for the following:
    a. In-class study.
    b. Out-of-class study.
    c. Remedial learning.
    d. Accelerated learning.
    e. Correspondence instruction.
    f. Make-up work.
    g. Laboratory work independent of the instructor.

h. Broadening the curriculum.

i. Teaching students by having them program short units.

The secondary purpose of the study was to answer questions listed on pages 7 and 8. Use of the modules in two food classes resulted in answers to those questions as follows:

1. Students learned at least as effectively through the PI modules as through other methods of instruction. There was not much relationship between mental ability and learning through PI. The better students learned more through two of the modules than the poorer students, but the good and poor students learned almost equally well from the module on gelatin.

2. Students in the experimental classes had quite favorable attitudes toward PI as a means of learning.

3. There was very little relationship between attitude of participating students toward PI as a means of learning and the amount they learned through the PI modules.

4. The ability of students to learn did not affect their attitude toward PI as a means of learning.

5. Retention at the end of the semester from all methods of learning was very good for the PI module on emulsions but was not considered high enough in the areas covered by the other two modules.

6. There was a significant relationship between ability to learn and retention at the end of the semester when PI was one means of learning. There was practically no relationship between attitude toward PI as a means of learning and

retention at the end of the semester.

Implications

This study indicates that programing is a valuable experience for the teacher. Some experience with programing should be a part of all teacher training programs. More programs are needed in home economics. Further experimentation will be necessary to:

1. Develop quality programs and modules for use in home economics.
2. Explore efficient uses of PI modules in food classes and other areas of home economics.
3. Develop PI modules that improve retention of learning.
4. Learn if and how PI might be used to teach values in home economics.

PI is not magic, but it is a useful method. It is well worth the classroom teacher's time to explore its use and to experiment with developing PI modules.

SELECTED BIBLIOGRAPHY

Basescu, Bernard and Robert E. Horn. "A Response Analysis System." Programed Instruction, IV (Dec., 1964), 6-11.

Bloom, Benjamin S. (ed.) Taxonomy of Educational Objectives: Cognitive Domain. New York: David McKay Company, Inc., 1956.

Bowles, Frank H. "The Dual Purpose Revolution." Higher Education Reflects on Itself and on the Larger Society: Current Issues in Higher Education, pp. 17-23. Washington, D. C.: Association for Higher Education, A Dept. of the NEA, 1966.

Brethower, Dale M. Programed Instruction: A Manual of Programing Techniques. Chicago: Educational Methods, Inc., 1963.

Brethower, Dale M., et al. Programmed Learning: A Practicum. Ann Arbor: Ann Arbor Publishers, 1965.

Childester, Franklin H. "Programmed Instruction: Past, Present and Future." J. American Dietet. Assoc., Vol. 51 (1967), 413-419.

Crowder, Norman A. "Automatic Tutoring by Means of Intrinsic Programing." Automatic Teaching: The State of the Art, pp. 109-116. Ed. E. H. Galanter. New York: John Wiley and Sons, Inc., 1959.

Crowder, Norman A. "The Rationale of Intrinsic Programing." Programed Instruction, I (April, 1962), 3-6.

Dale, Edgar. "Historical Setting of Programed Instruction." Programed Instruction, pp. 28-54. Sixty-Sixth Yearbook of the National Society for the Study of Education, Part II. Ed. Phil C. Lange. Chicago: The University of Chicago Press, 1967.

Downing, Carlton B. "Programmed Instruction in Perspective." Trends in Programmed Instruction, pp. 31-32. Ed. Gabriel Ofiesh and Wesley C. Meierhenry, Washington, D. C.: NEA, 1964.

Downing, C. B. "What is Programmed Instruction? Values and Uses." J. Amer. Dietet. Assoc., Vol. 46 (1965), 39-42.

Evans, James L. "Programing in Mathematics and Logic." Teaching Machines and Programed Learning, II, pp. 372-399. Ed. Robert Glaser. Washington, D. C.: NEA, 1965.

Filip, Robert T. (ed.). Prospectives in Programing. The MacMillan Co., N. Y., 1963.

Fry, Edward B. Teaching Machines and Programed Instruction: An Introduction. New York: McGraw Hill Book Co., Inc., 1963.

Gagne, Robert M. "An Analysis of Instruction." Teaching Machines and Programed Learning, II, pp. 21-65. Ed. Robert Glaser. Washington, D. C.: NEA, 1965.

Garner, W. Lee. Programed Instruction. New York: The Center for Applied Research in Education, Inc., 1966.

Green, Edward J. The Learning Process and Programmed Instruction. N. Y.: Holt, Rinehart and Winston, Inc., 1962.

Green, Edward J. "The Process of Instructional Programing." Programed Instruction, pp. 61-80. Sixty-Sixth Yearbook of the National Society for the Study of Education, Part II. Ed. Phil C. Lange. Chicago: The University of Chicago Press, 1967.

Gilbert, Thomas F. "On the Relevance of Laboratory Investigation of Learning to Self-Instructional Programing," Teaching Machine and Programed Learning, II, pp. 475-485. Ed. Robert Glaser. Washington, D. C.: NEA, 1965.

Holland, James G. "Research on Programing Variables." Teaching Machines and Programed Learning, II, pp. 66-117. Ed. Robert Glaser. Washington, D. C.: NEA, 1965.

Homme, Lloyd and Robert Glaser. "Problems in Programming Verbal Sequences." Teaching Machines and Programmed Learning, pp. 486-496. Ed. A. A. Lumsdaine and Robert Glaser. Washington, D. C.: NEA, 1960.

Hoover, Helen Perry. "Concept Development of College Students Exposed to Systematic, Organized Learning Experiences in Family Relationships." (unpub. Ed.D. Dissertation, Oklahoma State University, 1966).

Hughes, J. L. Programed Instruction for Schools and Industry. Chicago: Science Research Associates, Inc., 1962.

Krathwohl, David R. "Stating Objectives Appropriately for Programing, for Curriculum and for Instructional Materials Development." Journal of Teacher Education, Vol. 16 (March, 1965), 83-92.

Lewis, Philip. "Teaching Machines: New Resources for the Teacher." J. of Home Economics, Vol. 53 (1961), 820-824.

Lysaught, Jerome P. and Clarence M. Williams. A Guide to Programmed Instruction. N. Y.: John Wiley and Sons Inc., 1963.

Mager, Robert F. Preparing Instructional Objectives. Palo Alto: Fearon Publishers, Inc., 1962.

Margulies, Stuart and Lewis D. Eigen. Applied Programed Instruction. N. Y.: John Wiley and Sons, Inc., 1962.

Margulies, Stuart. "Some General Rules of Frame Construction." Programed Instruction, IV (October, 1964), 6-8.

Markle, Susan Meyer. Good Frames and Bad: A Grammar of Frame Writing. N. Y.: John Wiley and Sons, Inc., 1964.

Markle, Susan Meyer, Lewis D. Eigen and P. Kenneth Komuski. A Programed Primer on Programing. New York: The Center of Programed Instruction, 1961.

Marovich, Patricia Ervin and Ada Marie Campbell. "Programmed Instruction in Teaching Food Science." J. Amer. Dietet. Assoc., Vol. 52. (1968), 407.

Mechner, Francis. "Behavioral Analysis and Instructional Sequencing." Programed Instruction, pp. 81-103. Sixty-Sixth Yearbook of the National Society for the Study of Education, Part II. Ed. Phil C. Lange. Chicago: University of Chicago Press, 1967.

Moore, Aimee N. and Hanna W. Klachko. "Problems in Producing Programs for Auto-Instruction." J. Amer. Dietet. Assoc., Vol. 51 (1943), 420-425.

Nelson, Helen Y. Development of Programed Instruction for Home Economics Education and Study of Attitudes Toward its Use at the Undergraduate Level. Research Report No. 5. Ithica: Cornell University, 1966.

Opdycke, Robert M. "Development of Measuring Devices for Programmed Instruction." Trends in Programmed Instruction, pp. 172-174. Ed. Gabriel Ofiesh and Wesley C. Meierhenry. Washington, D. C.: NEA, 1964.

Otto, Arlene and Judy Vantrease. "Programmed Instruction: Its Possibilities for Home Economics." Focus. New York: John Wiley and Sons, Inc., Feb., 1968.

Pressey, S. L. "A Simple Apparatus Which Gives Tests and Scores--and Teaches." Teaching Machines and Programmed Learning, pp. 35-41. Ed. A. A. Lumsdaine and Robert Glaser. Washington, D. C.: NEA, 1960.

Schoben, Edward Joseph. Student Stress and the College Experience. Report of Nat'l. Conf. on Student Stress sponsored by U. S. National Student Assoc. Washington, D. C.: Council Press for the USNSA, 1966.

Stolurow, Lawrence M. and Daniel Davis. "Teaching Machines and Computer-Based Systems." Teaching Machines and Programed Learning, II, pp. 162-207. Ed. Robert Glaser. Washington, D. C.: NEA, 1965.

Strong, Paschal N., Jr. "Research Accomplishments and Needs in Programmed Instruction." Trends in Programmed Instruction, pp. 224-230. Ed. Gabriel Ofiesh and Wesley C. Meierhenry. Washington, D. C.: NEA, 1964.

Swope, Mary Ruth, "How Short is the Shortage?" J. of Home Economics, Vol. 59 (1967), 765-768.

"Title of Theses: Home Economics and Related Fields, 1965-1966," J. of Home Economics, Vol. 59 (1967), 191-218.

"Title of Theses: Home Economics and Related Fields, 1966-1967," J. of Home Economics, Vol. 60 (1968), 193-221.

Unwin, Derick and John Leedham (ed.). Aspects of Educational Technology. London: Methuen and Co. Ltd., 1967.

Using ACT on the Campus. Iowa City: The American College Testing Program, Inc., 1965-1966.

APPENDIX A

EXAMPLE OF BEHAVIORAL OBJECTIVE-
PROGRAM-CRITERION TEST ITEMS

Emulsions

The PI module on emulsions is essentially the linear type. An example of a terminal behavioral objective, frames developed to teach the objective and two test items to determine if the objective was achieved by the teaching frames is included. The number to the left indicates the frame number in the program.

Objective: Upon completion of this PI Module the student will demonstrate on a paper and pencil test that he understands how emulsions are formed by indicating the relationship between the vigor of agitation and the viscosity and permanence of an emulsion.

Program Frames: (The concepts of coalescing and temporary and permanent emulsions were developed earlier in the program.)

Correct responses, frame 32: (a) coalesce; (b) continuous; (c) merge, join, blend.

33. In the experiment you did, you divided the oil into tiny droplets by shaking the jar. What else might you have done to break the oil into tiny droplets and disperse it?

Correct response, frame 33: beat, stir, agitate.

34. As agitation is increased, the oil droplets would be divided into (smaller/larger) (a) ________________ droplets.

    The smaller the oil droplets, the (shorter/longer) (b) ________________ time it would take for them to coalesce into a continuous phase.

Correct responses, frame 34: (a) smaller; (b) longer.

35. It would take longer for many tiny droplets to merge together, or to (a) ____________, than for fewer larger ones to do so.

Mayonnaise is a food emulsion that is considered a permanent emulsion. This means that it lasts; it does not break of its own accord.

An emulsion that lasts--does not break--is a (b) ______________ emulsion.

Correct responses, frame 35: (a) coalesce; (b) permanent.

Correct responses, frame 38: (a) one that breaks in a short time. (b) permanent.

39. To merge together means to (a) __________________.

Forming an emulsion requires some kind of (a) ________________.

Correct responses, frame 39: (a) coalesce; (b) agitation.

40. One thing that helps to make mayonnaise a permanent emulsion is very vigorous (a) ______________ which divides the oil into droplets tiny enough to retard their (b) ________________.

Correct responses, frame 40: (a) agitation; (b) coalescence.

41. In fact, shaking by hand would not provide sufficient agitation. A rotary beater, an electric mixer, a blender, or some other form of mechanical agitation would have to be used in order to divide the oil into tiny enough droplets to form an emulsion with any degree of (a) ________________.

One reason, they why mayonnaise is a more permanent emulsion than homemade French dressing is because much more vigorous (b) ________________ is employed.

Correct responses, frame 41: (a) permanence; (b) agitation.

Correct responses, frame 54: (a) quantity, amount; (b) 3 eggs.

55. So far, three factors have been mentioned which affect the permanence of an emulsion. They are:

(a) _________________ of agitation.

Quality or strength of the (b) ________________.

(c) ______________ of the emulsifier.

Correct responses, frame 55: (a) amount, vigor degree; (b) emulsifier; (c) quantity, amount.

56. We can generalize; other conditions being the same, the more vigorously agitated, the ________ permanent the emulsion.

Correct response, frame 56: more.

Correct response, frame 59: permanent.

60. The <u>viscosity</u> of a liquid is measured by comparing the speed with which it will pour or flow to the speed with which water will pour or flow. Viscosity is a measure of the resistance of a liquid to flowing or pouring. Molasses, then, is <u>more</u> viscous than water.

Cold molasses would be ________ ______________ than warm molasses.

Correct response, frame 60: more viscous.

61. The measure of the resistance of a liquid to flow is (a) _ _ _ _ _ _ _ _ _.

Milk is less (b) _______________ than honey.

Mayonnaise is (c) _____________ _______________ than home-made French dressing.

Correct responses frame 61: (a) v i s c o s i t y; (b) viscous; (c) more viscous.

66. Try to recall a difference in making these two dressings other than in the ingredients. Mayonnaise was agitated more than the French dressing. The mayonnaise was more viscous than the French dressing. You've got it! Other things being equal, the greater the agitation, up to the breaking point, the more _____________ the emulsion.

Correct response, frame 66: viscous.

Correct responses, frame 68: (a) agitation; (b) oil.

69. Mayonnaise is more viscous than French dressing. It is also more permanent.

Another generalization, then, is:

Other things being equal, the more viscous the emulsion, the more ________________________ it will be.

Correct response, frame 69: permanent.

70. In fact, anything we can do to increase the viscosity of an emulsion will increase its ________________________.

Correct response, frame 70: permanence.

Correct responses, frame 82: (a) oil; (b) rapidly, fast, quickly, soon; (c) agitating, beating.

83. Let's review some generalizations about emulsions. Other conditions being the same:

a. The smaller the oil droplets, the ____________ time it would take for them to coalesce into a continuous phase.

b. The more vigorous the agitation, the ________________ viscous the emulsion.

c. The more viscous the emulsion, the _______________ permanent the emulsion.

Correct responses, frame 83: (a) longer, more; (b) more; (c) more.

Test Items: (Directions: You are to fill in the blank in each item on this test. Please write your response in the blank to the left of the number every time a blank is placed there.)

____(less)____ 31. Other conditions being the same, the less vigorous the agitation, the _____ permanent the emulsion.

____(more)____ 32. Other conditions being the same, the more viscous the emulsion the _____ permanent the emulsion.

APPENDIX B

EXAMPLE OF A PANEL

A panel is any material that the learner uses with a program as he works through a number of frames. (See definition, page 11.) The module on emulsions began around an experiment the student was to do. Program frames indicated what he should observe as he did the experiment, asked questions to guide him and led him to draw some conclusions. This panel is given below:

EMULSIONS, PANEL I

On a tray, you will see the following items:

1. One glass container with oil in it.
2. A small jar with a tight-fitting lid with water in it.
3. A bottle of food coloring.
4. One spoon.
5. A paper towel.

Very carefully follow the procedures outlined below:

1. Add a drop of food coloring to the water. What happens? Take a spoon and stir the water and food coloring. What happens?
2. Add a drop of food coloring to the oil. What happens? Stir the oil and food coloring. What happens?
3. Pour the oil and food coloring combination in the water. What happens?
4. Tightly screw the lid onto the jar. Shake the jar gently to be sure there is no leak, then
5. Shake the jar vigorously. What happens?
6. Put the jar down and let it stay still for a few minutes. What happens?

APPENDIX C

SPECIFICATIONS FOR THE PROGRAM MODULES DEVELOPED

Program title: Emulsions.

Target population: First semester freshmen majoring in home economics education with some background in high school home economics and practically none in chemistry.

No. of frames: 86 ; No. of pages: 25 ; Error rate: 2.6% .

Total average time required to complete: 70 minutes .

Formats available: Textbook only .

Teacher's manual available? No .

Statement of terminal behavioral objectives? Yes .

Pretest available? Yes ; Posttest available? Yes .

No. of trials with student groups: Four .

Size of student trial groups: 15, 11, 13, 5 .

Mean posttest score: 92% ; Mean gain score: 84% .

Program title: Solutions, Colloidal Dispersions and Suspensions.

Target population: First semester freshmen majoring in home economics education with some background in high school home economics and practically none in chemistry.

No. of frames: 87 ; No. of pages: 93 ; Error rate: 4.28%.

Total average time required to complete: 85 minutes .

Formats available: Textbook only .

Teacher's manual available? No .

Statement of terminal behavioral objectives? Yes .

Pretest available? Yes ; Posttest available: Yes .

No. of trials with student groups: Three .

Size of student trial groups: 10, 15, 12 .

Mean posttest score: 89% ; Mean gain score: 74% .

Program title: Gelatin.

Target population: First semester freshmen majoring in home economics education with some background in high school home economics and practically none in chemistry.

No. of frames: 125 ; No. of pages: 124 ; Error rate: 4.4%.

Total average time required to complete: 91 minutes .

Formats available: Textbook only .

Teacher's manual available? No .

Statement of terminal behavioral objectives? Yes .

Pretest available? Yes ; Posttest available: Yes .

No. of trials with student groups: Two .

Size of student trial groups: 10, 15 .

Mean posttest score: 89% ; Mean gain score: 77% .

APPENDIX D

COMMUNICATIONS

215 South Monroe
Stillwater, Okla. 74074
April 15, 1968

Helen Y. Nelson, Assoc. Prof.
Dept. of Home Economics Education
New York State College of Home Ec.
Cornell University
Ithica, New York 14850

Dear Miss Nelson:

I teach the food, nutrition and education courses at Eastern New Mexico University, Portales, New Mexico. I am on sabbatical leave this semester to work toward an Ed.D. degree here at Oklahoma State University.

I wrote three programed modules for food courses and used them with my classes in the fall and we are using them with some classes here this spring. Could I have your permission to adapt "A Scale for Measuring Attitudes of Prospective Home Economics Teachers Toward Programed Instruction" from your Research Report Number 6, "Development of Programed Instruction for Home Economics Education and Study of Attitudes Toward its Use at the Undergraduate Level," for use with my research? I believe that with a few changes it could be used as a scale for measuring student attitudes toward programed instruction in food classes.

A self-addressed, stamped envelope is enclosed for your reply. Thank you so much for your consideration of this matter.

Sincerely,

(Mrs.) Vera Murphey,
Assoc. Prof. in Home Ec.
Acting Head, H. E. Dept.

VRM/vrm

April 19, 1968

Mrs. Vera Murphey
215 South Monroe
Stillwater, Oklahoma 74074

Dear Mrs. Murphey:

I would be pleased to have you adapt the "Scale for Measuring Attitudes of Prospective Home Economics Teachers Toward Programed Instruction" and use it in your doctoral research. If you prepare an abstract from your dissertation, I would be glad to have such a report.

Sincerely,

Helen Y. Nelson
Associate Professor
Department of Home Economics
Education

HYN/odf

VITA

Vera Randle Murphey

Candidate for the Degree of

Doctor of Education

Thesis: DEVELOPMENT AND EVALUATION OF PROGRAMED INSTRUCTION MODULES IN FOOD FOR THE COLLEGE LEVEL

Major Field: Home Economics Education

Minor Field: Food, Nutrition and Institution Administration

Biographical:

Personal Data: Born in O'Donnell, Texas, November 5, 1919, the daughter of Mr. and Mrs. John P. Randle; married to Paul B. Murphey, 1941.

Education: Graduated from Portales High School, Portales, New Mexico, in May, 1937; attended Eastern New Mexico Junior College in fall, 1937, through spring, 1939; received the Bachelor of Science degree from New Mexico College of Agriculture and Mechanic Arts in 1941, with a major in Home Economics; attended Eastern New Mexico University part time 1955 through 1959; attended Colorado State University in the summers of 1959 and 1961; received the Master of Arts degree from Eastern New Mexico University in 1960, with a major in Home Economics and Education; completed requirements for the Doctor of Education degree at Oklahoma State University in July, 1968.

Professional Experience: Statistician, War Department, Washington, D. C., and Detroit in 1941 through 1946; kindergarten teacher, Eastern New Mexico University, fall, 1954, through January, 1956; home economics teacher, Portales Junior High School, January 1956, through spring, 1959; faculty member, Eastern New Mexico University, fall, 1959, through spring, 1968; Acting Chairman, Department of Home Economics, Eastern New Mexico University, 1967 and 1968.

Professional Organizations: American Home Economics Association, New Mexico Home Economics Association, National Education Association, New Mexico Education Association, Omicron Nu, Phi Upsilon Omicron, Delta Kappa Gamma, American Association of University Women, American Association of University Professors.