The Development of Validated Metric Teaching Materials: Length

Joanne Parry Dankey

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THE DEVELOPMENT OF VALIDATED METRIC TEACHING MATERIALS: LENGTH

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

[Signature] Thesis/Adviser

[Signature] Date

[Signature] Dean, College of Home Economics

[Signature] Date
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JPD
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Chapter 1

INTRODUCTION

The consumers of this nation are being confronted with a new measurement system. President Gerald Ford signed the Metric Conversion Act of 1975 and the wheels of transition are turning. This Act (Metric Conversion Act of 1975, p. 1)

... declared that the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system.

According to the Act (Metric Conversion Act of 1975, p. 1) the President will appoint the 17 members of the United States Metric Board.

Section six of the Metric Conversion Act of 1975 (p. 4) stated that the Board will conduct public information programs relating metric terms and units to daily life. Newspapers, magazines, radio, television and other media will be used to inform consumers. For example, the public needs to know that metric measurement offers the following advantages: easier, faster, and more logical to use than the present system.

With the coming of the metric system, the consumer must learn a new method of selecting clothing and equipment sizes, selecting quantity of foods, and expressing temperature and distance. The transition to the metric system will be more difficult for adult consumers than school-age children. Mathematics
teachers throughout the nation are presently using the new units in their classrooms. Adults will need to learn the new system on their own.

BACKGROUND FOR THE STUDY

Every major nation except the United States is already using the metric system. In 1971, the U.S. Metric Study Interim Report--The Consumer (1971, p. 6) reported the results of a personal interview survey of 1400 family units. The survey found that consumers knew very little about metric measures.

Only 40 percent of the respondents were able to name even a single metric measure. Less than 20 percent were familiar with either the relationships within the metric system or the relationship of metric measures to measures in the current system. Much resistance to conversion seems to stem from this lack of information. The objectives to conversion mentioned most were inconvenience and confusion.

The survey findings indicated that our nation faces an immense task; millions of adult consumers must be educated to think metric.

The U.S. Metric Study Interim Report--The Consumer, (1971, p. 14) also indicated that more than half of the individuals who answered correctly all metric questions on the survey definitely favored our country's adoption of the new system. These findings suggest that an educational program to help the consumer learn the new system will reduce the resistance to the conversion.

This study (1971, p. 45) reported that "... a change to the metric system would require extensive emphasis on consumer education." Not only do consumers need to learn a new language
of measurements but they must apply this knowledge in the marketplace as they make purchases based on the new metric units.

PURPOSE OF THE STUDY

The purpose of the present study was to develop a Metric Length self-instructional program to teach adult male and female consumers how to use the meter, the basic unit of length in the metric system. The goal of the project was to create a self-paced program containing instructional materials that were totally individualized. The researcher chose this approach because adult education programs have found individualized instruction to be very effective. Self-instructional programming has been found to be effective for mastery level learning. The goal of this program is to help consumers think metric and to use these units in their daily lives, a goal which consumers need to reach at the mastery level. The materials were empirically developed following the steps of development recommended for linear programs.

Field testing of the self-instructional program was another purpose. The results of the field test indicated how well the subjects had achieved the objectives of the self-instructional program.
DEFINITIONS OF TERMS USED

The writer has defined certain technical terms used in this research project.

**Behavioral objectives**: specified tasks performed by the learner which are desired outcomes of instruction.

**Criterion-referenced test**: a test the results of which indicate as precisely as possible whether the pupil has achieved the goals specified for the learning task.

**Empirical development**: the careful development of instructional materials employing the feedback of subjects in a test-revision cycle.

**Self-instructional program**: a sequence of frames empirically developed leading a student to mastery of a subject with a minimum number of errors.

**Target population**: the population of people for whom the self-instructional program was designed.
Chapter 2

REVIEW OF LITERATURE

Self-instructional programming developed within the last two decades and has had a great impact on classrooms in the nation. The future of this innovation continues to look promising. This method was chosen to teach consumers how to use metric length in their daily lives because programming is effective for adult education and lends itself to independent study in the home.

This review of literature describes current innovations in education that grew out of self-instructional programming. The chapter consists of four parts. First, early developments in self-instructional programming are presented. Second, the effect of self-instructional programming on classroom teaching is described. Third, current trends in education which developed from self-instructional programming and recent modifications are identified. The chapter concludes with the use of self-instructional programming for adult education.

EARLY DEVELOPMENTS IN SELF-INSTRUCTIONAL PROGRAMMING

According to Lysaught and Williams (1963, p. 5), the first teaching machine was developed by S. L. Pressey in 1926. Pressey, a psychologist, produced "... a testing machine that presented a series of questions to a student and informed him immediately whether his reply was right or wrong." He gave his students assignments and
then the students took teaching-machine tests. Pressey thought of his machine as a testing, rather than a teaching device. This machine did not catch on as Pressey had hoped because no one organized materials to use in the machine and the depression of the thirties delayed its development.

The behavioral psychologist, B. F. Skinner presented a new learning theory in 1954. This theory is now called operant conditioning and is a further development of the conditioned response. Skinner's theory grew out of many years of laboratory experimentation with animals. Lysaught and Williams (1963, p. 8) stated that "the Skinner theory supplied the ingredient missing from Pressey's experiments. It provided the idea of programming instructional materials that Pressey's machines needed."

Skinner discovered in the laboratory that animals can learn desired behavior by the use of reinforcers such as food and water. He reasoned that humans, too, learn by using reinforcements such as grades, gold stars, money or just knowing the correct answer.

Vantrease (Otto and Vantrease, 1968, p. 12) stated that "programmed instruction really came out of behavioral psychology ... with its principles of reward and reinforcement." B. F. Skinner is sometimes called the father of programmed instruction. In the words of Taber, Glaser and Schaefer (1965, p. v),

... the present interest in programmed instruction and teaching machines is specifically attributable to the writings of Professor B. F. Skinner in 1955 and 1958. It is Skinner's work which has captured the general imagination, and his transition from laboratory studies to practical application has encouraged a systematic basis for further research and
development in teaching. The language and technology of Skinner's laboratory provide the frame work for most recently published programmed materials.

Skinner in 1954 presented an article proposing the application of his theory of animal learning to human learning and suggested use of teaching-machines. Skinner (1954, pp. 94-95) stated that

In the experimental study of learning it has been found that the contingencies of reinforcement which are most efficient in controlling the organism cannot be arranged through the personal mediation of the experimenter. An organism is affected by subtle details of contingencies which are beyond the capacity of the human organism to arrange. Mechanical and electrical devices must be used. Mechanical help is also demanded by the sheer number of contingencies which may be used efficiently in a single experimental session. . . . Now, the human organism, is if anything, more sensitive to precise contingencies than the other organisms we have studied. We have every reason to expect, therefore, that the most effective control of human learning will require instrumental aid. The simple fact is that, as a mere reinforcing mechanism, the teacher is out of date. This would be true even if a single teacher devoted all her time to a single child, but her inadequacy is multiplied many-fold when she must serve as a reinforcing device to many children at once. If the teacher is to take advantage of recent advances in the study of learning, she must have the help of mechanical devices.

Lumsdaine (Lumsdaine and Glaser, 1960, pp. 6-7) pointed out that the United States Air Force began working on programmed instruction during the fifties. According to Downing, (Ofiesh and Meierhenry, 1964, p. 31) the military services made the largest contribution toward the development and use of self-instructional programs for teaching. The program developers at the Randolph and Lackland Air Force Bases were national leaders in the art of programming. In addition to the military services, business and industry were beginning in 1964 to produce and to use programmed materials to train new employees.
Skinner also emphasized the idea of validation of lessons, according to Barlow (Filep, 1963, pp. 10-11). Barlow said "programmed instruction is validated instruction, instruction which is criteria-centered and student screened." He continued to stress that a program should be designed so that the student can complete the steps and then demonstrate that he has reached mastery level of the skills within that objective. Programs that were not based on terminal criteria and not validated should not be called programmed instruction. Barlow recommended using the term validated instruction instead of programmed instruction. "In fact, the principle of lesson validation is applicable to any form of instruction: spoken, taped, printed, filmed, televised, or in the form of projects and field trips."

Lumsdaine (Lumsdaine and Glaser, 1960, pp. 12-14) indicated that Glaser and Homme developed the programmed textbook in 1959. This method was sometimes called the "paper machine"; it offered the advantage of being less costly than other devices. The above authors said that both Skinner's machine and their programmed textbook were based

... on Socratic question-and-answer or problem-and-solution methods of teaching. Typically, they proceed in small steps of graded difficulty, so that mastery of concepts, understanding, and skills are gradually built up as the student proceeds through the program.

It was apparent that the heart of the new method was reinforcement and sequencing of materials which led to mastery level learning.

According to Lumsdaine, (Lumsdaine and Glaser, 1960, p. 21) in 1959, Crowder introduced the idea of intrinsic programming; he
called it the "scrambled book." To use this "paper teaching machine," the student responded to a question and his answer determined to what page he would next turn. This type of programming offered the remedial loop for individuals who needed more practice to achieve mastery of a particular objective or a short route through the learning process for abler students.

During this early period, interest vacillated between the hardware, teaching machines, and the software, teaching materials, used in the machine. Lumsdaine (Lumsdaine, 1960, p. 146) said that the machine itself does not teach. "It simply brings the student into contact with the person who composed the material it presents." According to Lumsdaine, the machine acts as a tutor just as the teacher would do only on a one to one basis and a teacher must work with many students. Ofiesh (Ofiesh and Meierhenry, 1964, p. 5) stated that the program is the information or content that is to be presented and it can be prepared in several different styles, and therefore "... 'the program' is the heart of any teaching machine. The 'program,' for that matter, is the heart of any teacher--human or machine." A teaching machine is only the device used to provide the stimulus and an opportunity for student response. According to Glaser (Lumsdaine and Glaser, 1960, p. 29), Skinner stressed "... that the success of a teaching machine depends on the material used in it."
EFFECTS OF SELF-INSTRUCTIONAL PROGRAMMING
ON CLASSROOM TEACHING

There are three ways that programmed instruction may be used in the classroom. First, self-instructional programs may be the sole means of instruction for an entire course or for segments in a particular course. Well-designed programs are excellent learning devices for students at any age level. In this situation, the teacher's role is to give supplementary help where needed and to monitor the testing and progress of the student.

Briggs stated (Knirk and Childs, 1968, p. 127) that when self-instructional programs are used to teach segments of a course, the teacher's role includes:

- recognizing and rewarding creativity,
- administering achievement tests,
- answering the odd question not covered in the program,
- updating the information if necessary,
- and assigning units of work based on student abilities and goals.

An additional role of the teacher in this case is to integrate the programs into the total course.

Second, self-instructional programs may be used for special purposes in the classroom. For example, students with special problems may complete self-instructional programs while the remaining class members use another method. According to Briggs (Knirk and Childs, 1968, p. 128), programs may offer the following advantages: absent students may use them to catch-up, slow students may use them to keep up with other classmates, failing students may use them to help them attain passing grades, fast learners may use
the programs for enrichment, disturbed children who cannot learn in a group can use self-instructional programs in an environment conducive to their learning, handicapped students benefit from programs because the frames proceed with small steps, and students may use them for homework.

A third use of programmed instruction in the classroom is to combine it with a variety of methods. Briggs (Knirk and Childs, 1968, p. 128) favored this combined approach but stressed that the teacher must plan very carefully so that nothing is in conflict. Briggs (Knirk and Childs, 1968, pp. 128-29) pointed out that Goldbeck conducted a study and found that a combination of lecture-discussion methods with self-instructional programming produced better results than were achieved by either method alone.

As programs were used daily in schools, the teacher would spend less time telling and showing. Briggs (Knirk and Childs, 1968, pp. 130-31) said that the teacher would have more time to consider these roles: "The teacher may become counselor; tutor; an evaluator of progress; an encourager of initiative; a re rewarder of creativity; a designer of personal projects; a critic of student products; an aid in social development . . . ." Regardless of which way self-instructional programming was incorporated into the classroom, time was saved for the teacher to accomplish other tasks.

The question has been raised whether the teaching machine will replace the teacher. Authorities in the field tend to agree that a teaching machine will never replace the teacher. For example,
Stanchfield (1974, p. 46) stated that up to now there has been no research to indicate that computers or teaching machines will ever replace the classroom teacher. "Technology, rather than supplanting the teacher in the classroom, will supplement him in the teaching/learning process." According to Calvin (Calvin, 1969, p. 37), "the single most important factor bearing on the success of the programmed teaching situation is the teacher." The role of the teacher is expanded when programmed materials are used. However, the teaching machine does possess several advantages over a teacher. Stanchfield (1974, p. 46) stated that "a machine is tireless, objective, infinitely patient, non-punitive and non-judgmental instructor; and therefore does not demoralize the student or create any negative self-fulfilling prophecies." Because the machine gives the teacher more time, the teacher can work with individual students or in small groups. Tucker (1964, p. 62) stated that "teachers alone can provide the type of individualized instruction that auto-instructional and computer based lessons seem to promise but cannot possibly accomplish."

The use of programming is now a widely used procedure. Calvin (1969, p. 37) stated that "programmed textbooks are rapidly outdistancing any other educational innovation. The school not using programmed materials in one form or another will soon be the exception." Programmed textbooks in this case undoubtedly include the ever increasing textbooks in which text is interspersed with frames requiring the student to respond. After responding, the
student is given feedback on the frames and then he/she continues to read the textbook.

Extensive use of programmed materials in the classroom has resulted in a number of changes in conventional classroom teaching. The first of these changes is emphasis on behavioral objectives. Popham (1964, p. 65), Lumsdaine (1968, p. 77), Heinich (1968, p. 51), and Downing (1964, p. 32) all stated that by using self-instructional programs, public school personnel have come to realize that behavioral objectives are important. According to Popham (1964, p. 66), this first influence of programmed instruction on the classroom caused educators to begin to write instructional objectives. Mager deserves recognition because he developed a book on writing behavioral objectives which is used extensively.

A second influence of self-instructional programming on conventional teaching is that classroom teachers have come to recognize the need for active student involvement rather than a passive role for students. When using programs, students are actively involved as they respond to frames. In conventional teaching, students today are encouraged to discuss issues, role-play their feelings on various topics and use other techniques requiring active involvement.

A third change in teaching which grew out of programmed instruction is the use of continuous reinforcement of student learning. In programming, this reinforcement comes in the form of immediate knowledge of results. Reinforcement makes learning more
permanent and sets the emotional stage for further learning. In conventional classrooms, the teacher is increasingly using verbal or written reinforcement.

The fourth influence of programming according to Popham (1964, pp. 66-67) is the emphasis on self-pacing. Self-pacing is essential for all students because each person is an individual. Each student learns and works at his own particular rate.

The fifth change created by self-instructional programming is the use of student feedback to improve instruction. In the process of developing programs, feedback from subjects is used to make changes during the test-revision cycle; it is an integral part of the process. Popham (1964, p. 67) said that teachers are beginning to see that if students fail to reach certain instructional objectives it is not the students' fault but a failure in the teachers' methods. Therefore, teachers are finding many ways to secure feedback from students in order to improve instruction. This approach has recently been called formative evaluation.

The final contribution of self-instructional programming to the conventional classroom is "curriculum concern." Popham (1964, p. 67) explained that "as instructional methods, both programmed and conventional, become more capable of achieving their objectives, we shall see an even greater concern regarding the appropriateness of the curriculum."
CURRENT TRENDS IN EDUCATION DEVELOPED FROM SELF-INSTRUCTIONAL PROGRAMMING

Two major trends currently growing in education are computer-assisted instruction (CAI) and the systems approach. In this section the similarities of these major trends to self-instructional programming are identified. Several other innovations which have been somewhat influenced by self-instructional programming are also described.

The early emphasis in self-instructional programming was on hardware, teaching machines; this emphasis resulted in the sophisticated teaching machines used today for CAI-computer-assisted instruction. Hicks and Hunka (1972, p. 1) stated that "the term CAI covers teaching and learning activities aided directly by a digital computer. More particularly, CAI refers to instruction actually performed by the computer and its associated consoles for the students." Meierhenry (Margolin and Misch, 1970, p. 145) pointed out that there are two different kinds of computer-assisted instruction being used in the nation. In one method, content is presented in the traditional manner and the computer provides drill and instruction. The other method requires the student himself to do the programming. Using this method the "student discusses a problem by the Socratic method with the computer." Thus the student actively shapes the direction of an instructional sequence.

Bunderson (Holtzman, 1970, p. 45) stated that "CAI can be viewed as a compound resulting primarily from a union of
programmed instruction and the use of time-shared, interactive computer systems . . . ."

There are six similarities between self-instructional programming and CAI: self-pacing, drill for reinforcement, criterion-referenced tests, feedback, flowcharts, and behavioral objectives. Both CAI and self-instructional programs are developed so the student works at his own pace. According to Margolin and Misch (1970, p. 68) and Suppes and Morningstar (1972, p. 2) most computerized instructional programs are designed to provide highly individualized instruction. A second similarity is that both of the methods under consideration contain material to read, and drill is provided to reinforce what has been taught. Tests given in CAI are similar to the criterion frames and a criterion-referenced post-test in a program. Feedback is used often as a reinforcement in both systems.

Flow charts are another similarity between CAI and self-instructional programs; but the types of flow charts used for the two methods look very different. Bunderson (Holtzman, 1970, p. 48) said that flow charts describing intrinsic self-instructional programs are very simple. In contrast, a flow chart indicating the conditional branching capabilities of the computer are extremely complex.

Behavioral objectives are written for both self-instructional programs and CAI but at different stages of development. In programming, behavioral objectives are written after the
needs of the learner have been established. Bunderson (Holtzman, 1970, pp. 53-55) stated that in CAI, program goals are first written in nonbehavioral language and translated into behavioral objectives in the second stage of CAI development, instructional design.

Computer-assisted instruction is effective in today’s schools. Stanchfield (1974, p. 48) described a computerized reading instruction program being used in three junior high and three senior high schools in Los Angeles. Eighty percent of the computer time was spent on remedial exercises and 20 percent for enrichment exercises. In the high schools, computerized reading instruction was used for 16-18-year-olds who could not attend the regular high school program. According to Stanchfield, (1974, p. 48) the teachers agreed that CAI offers the following advantages for teaching at the secondary level.

1. The computer program provided drill and practice, reinforcement and specific physical involvement. The lessons taught students to follow directions, to be precise and to check errors.

2. The computerized approach was keenly motivating. Students shared the status of technology in our society. They also enjoyed the novel 'human touch' of being addressed by name by an impersonal machine.

3. Computerized instruction proved to be an effective instrument in helping students attend. Students were more alert and able to attend for 30 to 40 minutes, as compared to 10 to 15 minutes in class.

4. To the students, computers seemed to be non-threatening. The tireless machines tolerated mistakes and repetition without human reactions of impatience or irritation.
The teaching computer offers the aforementioned advantages. Scriven (Calvin, 1969, p. 15) pointed out an important disadvantage however, it is very costly. This cost can be minimized by making it available to many students, by good scheduling and by arranging for its use by other groups such as administrators and researchers.

According to Suppes\(^1\) (1973) a computer can talk, it can listen with some difficulty, it can store and retrieve information, and it can know both cognitively and affectively what the student can do. The hindering factor in teaching computer development is that today's men and women do not know how to use all the information that a computer can store and obtain. The present day knowledge of theories of learning and instruction do not equip educators to use the teaching computer to its fullest capacity. Obviously, teachers need to be trained to make greater use of the teaching computer.

The second major trend related to programmed instruction is the systems approach to education. Kaufman (1972, p. 2) explained the systems approach as follows:

A process by which needs are identified, problems selected, requirements for problem solution identified, solutions are chosen from alternatives, methods and means are obtained and implemented, results are evaluated, and required revisions to all or part of the system are made so that the needs are eliminated.

\(^1\)Opinion expressed by Patrick Suppes, author, in an address ("The Schools of the Future: Technological Possibilities") at Alternative Futures for Education and Learning: Symposium '73.
Palmer (1973, p. 55) stated that there are several similarities between programmed learning and the systems approach, see Figure 1. A task analysis is the first step for both methods. The educational needs are discovered in this step. The second step for both methods is that the behavioral objectives are defined. The third step involves consideration of the subject's present knowledge because this knowledge determines the direction to proceed. The fourth step in the systems approach is the post-test construction and in programmed learning, it is development of a criterion-referenced test. Although Palmer differentiated between post-test used in systems approach model and criterion test used in the programming process, this is an unnecessary distinction; the criterion test accompanying a self-instructional program is a post-test. The fifth step of the systems approach involves determining what skills need to be learned. This process is similar to the fifth step of programmed learning involving sequencing of the instructional materials.

A difference in the two methods may occur in the sixth step. In the systems approach, a variety of methods which have potential for helping learners to reach the objectives are considered; sometimes programmed learning is chosen as the method to be used. In the programming process, the sixth step is always frame construction involving development of both criterion and teaching frames.
Figure 1

Palmer's Figure Comparing Systems and Programming Processes

A Systems Approach Model

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What does he DO? (Job/Task Analysis)</td>
</tr>
<tr>
<td>2</td>
<td>What do we teach? (Define Objectives)</td>
</tr>
<tr>
<td>3</td>
<td>What does he know already? (Course Prerequisites)</td>
</tr>
<tr>
<td>4</td>
<td>How do we know he has finished? (Posttest Construction)</td>
</tr>
<tr>
<td>5</td>
<td>What does he need to know? (Skill/Knowledge Requirements)</td>
</tr>
<tr>
<td>6</td>
<td>How do we teach him? (Decide Methodology)</td>
</tr>
<tr>
<td>7</td>
<td>Try out the course (Pilot Course)</td>
</tr>
<tr>
<td>8</td>
<td>Check with the user (Evaluation and Revision)</td>
</tr>
</tbody>
</table>

The Programming Process

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What does he DO? (Task Analysis)</td>
</tr>
<tr>
<td>2</td>
<td>What do we teach? (Define Objectives)</td>
</tr>
<tr>
<td>3</td>
<td>What does he know already? (Target Population)</td>
</tr>
<tr>
<td>4</td>
<td>How do we know he has finished? (Criterion Test)</td>
</tr>
<tr>
<td>5</td>
<td>What does he need to know? (Sequence Material)</td>
</tr>
<tr>
<td>6</td>
<td>How do we teach him? (Frame Construction)</td>
</tr>
<tr>
<td>7</td>
<td>Try out the course (Validation)</td>
</tr>
<tr>
<td>8</td>
<td>Check with the user (On-job Assessment)</td>
</tr>
</tbody>
</table>

The seventh step involves a try-out of the course. The systems approach model uses a pilot course and programmed learning employs a test-revision cycle in the empirical development of teaching materials. The final step for both methods requires the materials to be field tested. The subjects use the materials and complete the evaluation devices. Both methods are revised on the basis of the data results.

Several other innovations have been somewhat influenced in their development by self-instructional programming. These innovations are: mastery learning, formative evaluation and the learning packet.

Block and Airasian (1971, pp. 64-72) described six similarities between programmed instruction and mastery learning. First, the responsibility for achieving the objectives is on the school system or program not on the student. Second, both methods emphasize the need to specify the objectives of instruction in terms of skills the student is expected to learn. Third, mastery learning is readily accomplished in courses where the material is learned sequentially. In self-instructional programs, the importance of sequencing frames in a step-by-step process is always stressed. Fourth, Block believes the most important step in mastery learning is the summative evaluation, a type of evaluation which is consistently used in self-instructional programs. In both mastery learning and self-instructional programs, the device used for summative evaluation is developed from the objectives. Fifth, Airasian
(Block, 1971, p. 79) stated that "formative evaluation provides the information necessary to individualize instruction within a mastery strategy." Learning weaknesses in a particular segment of the course are discovered. Formative evaluation is similar to criterion frames in self-instructional programs, since the response to a criterion frame indicates whether or not the subject has learned that segment of the program. The sixth similarity is that programmed instruction may be one of several alternatives leading to mastery learning whereas it is the sole method in self-instructional programming.

Formative evaluation is another current trend in education which developed with self-instructional programming. Carroll (Block, 1971, p. 36) said that according to Scriven, formative evaluation measures how much students have learned in a specific unit of the course and checks whether the student has problems or questions concerning that unit. The programmer also uses formative evaluation during the test-revision cycle as the self-instructional program frames are written, tested, and rewritten according to the feedback gained from individuals testing the program. Cronback (1963, p. 675) stated that "... evaluation, used to improve the course while it is still fluid, contributes more to improvement of education than evaluation used to appraise a product already placed on the market." Formative evaluation plays a significant role in education today.

The learning packet is a current trend in education which is similar to self-instructional programming. In both methods
behavioral objectives are developed. A pretest is given in both approaches to determine present understanding of the concept.

Sequenced learning activities are essential in both methods. Sepede (1972, p. 290) stated that in the learning packet "immediate responses must be provided to promote learning." Immediate responses to frames is a key principle of programming. If a student has done poorly on the learning packet as indicated by the final evaluation, the student may retake the packet. A student may also retake a program or portions of it. An important difference is that self-instructional programs are empirically developed and learning packets are not.

Strictly linear programs are not used in education today except for an occasional short unit within a course. Modified forms of programs are, however, widely used. Some of the program modifications include: combination of linear and intrinsic styles into one program, adjunct programs, Personalized System of Instruction (PSI), audio-tutorial system for laboratory instruction and the Guided Design Systems Approach.

Downing (1964, p. 32) stated that more recently program developers are using several forms in one program. Better programs should result from the combined forms. When linear and intrinsic styles are combined, the student may proceed more rapidly through a portion of the program by omitting frames that teach an objective he has already mastered. In strictly linear programs, no frames
can be skipped; the subject is required to respond to every frame in the entire program.

The second change in program writing is to include adjunct materials with the program. Espich and Williams (1967, pp. 83-84) explained that adjunct in programming means "'subordinate to and in support of.'" Espich and Williams added that there are two types of adjunct programs. In one type, "the text itself is kept intact and the program is supplied as a separate unit." Criterion frames may be interspersed throughout a text to help the learner assess his progress rather than the frames being bound in a separate unit.

In the second type of adjunct programming, "... sections of the textbook are extracted verbatim and used in the program as the basic information." These authors said that leaving the textbook intact is the most popular type. According to Downing (1964, p. 32), "this inclusion of reading material with frames provides extraordinary flexibility for introducing technical and unusual material with which the trainee has had little or no acquaintance."

Popham and Baker (1970, pp. 1-3) have written several books using the adjunct programming form. For example, Planning An Instructional Sequence contains five self-instructional programs that a person completes on his own. Each program begins with instructional objectives and presents tangible competencies. After completion of a program, the student takes a mastery test and he/she obtains feedback on his performance from the answers to the mastery test.
The third current modification of self-instructional programming is the Personalized System of Instruction (PSI), developed by Fred S. Keller at Columbia University. According to Born and Zlutnick (1972, p. 30), PSI involves having the student spend a lot of time taking tests over small portions of the material and then giving him immediate feedback concerning his progress toward mastery level learning. Under this system, the student progresses at his own rate and may take several tests before he achieves mastery level of a particular concept.

Another current modification of self-instructional programming is the audio-tutorial system to personalize laboratory instruction. Postlethwait, (Doty, 1974, p. 36) a Purdue University biology professor, introduced this system in 1961 to supplement his botany course for freshmen. Doty (1974, p. 37) then introduced the audio-tutorial approach to a microbiology course at Pennsylvania State University to personalize laboratory instruction. Doty (1974, p. 37) explained that the audio-tutorial system involves "... listening through earphones to tape-recorded laboratory instruction ...". He pointed out several advantages of the audio-tutorial system for laboratory instruction. First, the student can work at his own pace. Second, the student continues to a new experiment according to his ability. Third, the student starts the tape player to hear instructions only when he is prepared for it. Since the adoption of this approach many schools
and colleges are using the audio-tutorial system to improve instruction in a variety of subject matter courses.

Self-instructional programming has recently been incorporated into a new educational innovation called the Guided Design Systems Approach. Wales developed this teaching method for the Exxon Education Foundation. Wales (p. 16) stated that Guided Design is a new approach "... in course design and operation which focuses on developing student's decision-making skills as well as teaching specific principles and concepts." The four main parts of the Guided Design System are: introduction to decision-making and Guided Design, Guided Design projects, subject matter materials and examinations.

The second part of the Guided Design process is the completion of projects. Every project a student does involves the fundamentals of programmed learning, securing information, responding to questions, and securing feedback. The information and questions are not as highly structured as in a traditional program. The students are working in groups to solve an open-ended problem rather than individually as in self-instructional programs.

The third part of the Guided Design is the subject matter material. Every student works outside of class studying subject matter to aid him in his decision-making. For a freshman student, his out of class work involves working on programmed, self-study materials. The programmed materials include content-performance objectives and a homework assignment. Dr. Wales (p. 20) stated
that a programmed text is very good for self-study but it is not a
good source for review. For this reason, "Reference Book" pages
were added to the programmed materials. Although the programmed
materials are modified, it is obvious that their role in the
Guided Design Systems Approach is significant.

SELF-INSTRUCTIONAL PROGRAMMING
FOR ADULT EDUCATION

Educators in our country are using programmed instruction
as an important tool in adult education programs. In the past,
business, industry, and the armed forces frequently used programmed
instruction. Hathaway (1969, p. 207) described a study conducted
in the Cincinnati Public schools which used programmed instruction
for adults. The results showed that programmed instruction was
"superior for teaching both facts and concepts." These findings
were true for both immediate and retention tests. The students
were asked about programmed instruction in comparison to conventional
methods. Hathaway reported that "... 82 percent felt that they
learned more; 92 percent reported that they enjoyed learning with
programmed texts as much as or more than with conventional instruc-
tion." Hathaway (1969, p. 203) further stated that in his research
he found that students learn equally well using inexpensive pro-
grammed texts as when expensive hardware with costly upkeep is
used.

According to Hathaway (1969, pp. 210-11), there are six
reasons why self-instructional programming is successful in adult
education. These reasons are: (1) the student actively works with the program on an individual basis, (2) the student works step-by-step through the program and this helps to give him success, (3) the program is organized logically with explicit directions and explanations, (4) the student responds and immediately gets feedback on his response, (5) the student can work at his own pace, and (6) the student finds the program interesting. Because self-instructional programs are successful for adult education and adult consumers may complete the program at home, the researcher chose this method of instruction to teach consumers to use metric length in their daily lives.
Chapter 3

DEVELOPMENT OF THE SELF-INSTRUCTIONAL PROGRAM AND FIELD TESTING

The purpose of this study was to develop a self-instructional program to teach consumers to use the meter, the basic unit of length in the metric system. A field test was necessary to evaluate how well the objectives of the program were achieved and to determine if consumers like to learn the metric system using this type of instruction.

INITIAL DRAFT OF THE MATERIALS

Consumers are urged to learn to think metric; to make this transition men and women must experience working with the new units. Measuring the length of a variety of objects and converting lengths from English to metric units provides the background that consumers need to achieve a feeling for metric length. Many men and women will be using metric units for household and avocational purposes in which they do not need precise measures as would be secured by using conversion tables or mathematical formulas. As consumers think about the distance between two cities in miles, they can mentally convert the miles to kilometers if they have a simple rule to apply. It is unrealistic to expect that consumers could function smoothly in the new system if they are totally dependent upon metric conversion charts or formulas.
Behavioral Objectives for the Program

Before objectives could be written, the researcher analyzed what competencies consumers, as contrasted with scientists or industrialists, would need to acquire if they are to use metric units in their daily lives. These competencies provided the basis for the development of the behavioral objectives for the self-instructional program and the criterion-referenced pretest and post-test.

The following behavioral objectives for the Metric Length Program were formulated.

1. The subject uses the most appropriate metric unit to express the length of various objects and distances.
2. The subject states the five rules of thumb taught in the program.
3. The subject applies the rules of thumb to mentally convert English units to metric units or the reverse.
4. The subject estimates the length of objects in the appropriate metric units.

The subject achieved mastery level if he/she could perform the tasks specified in these four metric length objectives. The self-instructional program was designed to teach the subject to achieve mastery level learning. Block (Gronlund, 1973, p. 12) recommended a level of 80 percent correct on short-answer test items as a realistic goal for mastery learning. For this reason, achievement of mastery level for the Metric Length Program was specified as
80 percent correct or higher on the criterion-referenced post-test. Subjects attaining a score of 80 or higher on the post-test were said to have attained the mastery level goal for the program.

**Development of Pretest and Post-test**

The writer developed a pretest to measure the subjects' understanding of metric length before going through the program and a post-test to measure understanding after completing the program. Both the pre- and post-test were criterion-referenced tests; they were developed to measure how well the subjects achieved the objectives of the self-instructional program. Since the objectives were strictly performance objectives, they were logical criteria for use in a criterion-referenced test.

The pretest used for the pilot study contained 70 items and the post-test 75. It was decided to lengthen the tests and make them contain the same number of items. These tests were revised and lengthened to contain 100 items each. Since length of the test could have affected reliability, this change hopefully improved accuracy of measurement. Although both tests had the same eight subscales, items were different. The subscales were: Comprehension, Rules of Thumb, Centimeters, Kilometers, Miles, Meters, Yards, and Estimation.

**Opinion Sheet**

The opinion sheet (see Appendix B, p. 86) was developed to secure expressions of attitude toward the self-instructional
program. The opinion sheet was anonymous so that honest responses could be secured. It was given to the subjects after they had completed the program and post-test.

The one-page form asked the subjects to check the item(s) that described their feelings about the program. The subjects indicated how much they expected to use metric length in their daily lives. In addition, they were asked to rank instructional methods, thus indicating their preferences for ways to learn the metric system. Space was provided for the subjects to check the appropriate sex, age range, and educational background.

**Criterion and Teaching Frames**

After analyzing the objectives, it was obvious that they could be broken down into smaller parts, for example, the subjects had to learn five rules of thumb to convert lengths or distances from English to metric units or the reverse. The rules of thumb were to be used to change inches to centimeters, miles to kilometers, kilometers to miles, yards to meters, and meters to yards. No rule of thumb to change centimeters to inches was developed because consumers were less likely to need this conversion in their daily lives. The researcher's goal was for consumers to think metric and to use the new units instead of always converting to English units. In addition, the subjects learned when it was appropriate to use a particular unit of metric length: millimeter, centimeter, meter and kilometer were frequently used metric units.
A full set of criterion frames was written from the behavioral objectives. Criterion frames were like test items, each one measured the achievement on one aspect of an objective. The criterion frames measured what had been previously learned from the teaching frames. The teaching frames were written in a step-by-step process to insure the subject's ability to respond correctly to each criterion frame.

Previously a Basic Metric Program had been developed by Hoff (1975). It was assumed that consumers needed a general background on the metric system. Therefore, the researcher believed that her subjects should go through Hoff's program before proceeding to the Metric Length Program. Two homemakers followed this sequence and took Hoff's post-test.

**TEST-REVISION CYCLE**

**Individual Testing**

The first draft of the self-instructional program was tested with individuals. After two homemakers completed Hoff's post-test these subjects were given the Metric Length Program. Each subject was observed as she went through the frames and the researcher took notes on problems encountered with various frames. One homemaker who was in her mid-thirties completed the booklet with relative ease and made several suggestions. The other, an older homemaker who had not attended high school, had difficulty remembering the rules of thumb and using decimals. The 70 item
post-test was given to both homemakers. The first subject required one hour and 45 minutes to complete the program and post-test and the second subject required three hours and 45 minutes. These subjects obviously spent considerable time doing this researcher's program and had previously used several hours completing Hoff's program.

Society today creates many demands on the consumers' time and therefore it was unrealistic to ask all subjects to donate four to six hours to complete two metric self-instructional programs. The decision was made to develop a self-contained program on metric length and omit the first step of taking Hoff's program.

Two boys at the Brookings High School also participated in the individual testing. Each subject was observed and the writer took notes on problems encountered with various frames. One subject suggested making a rules of thumb card to help him remember the rules; this suggestion was used later.

**Pilot Study**

Revisions were made in the program and copies duplicated in preparation for conducting a pilot study. Sixteen secretaries in the Home Economics-Nursing Building at South Dakota State University participated at this stage in the development of the program. The pretest was administered by the researcher; each secretary then took a program booklet and accompanying materials home to complete at her convenience. A week later the secretaries took the post-test in the presence of the researcher.
After analyzing the results of the post-tests from the pilot study, both the pre- and post-tests were lengthened to 100 items. The number of items requiring conversion from English to metric units or the reverse was increased from 38 to 51. In addition, the number of items requiring estimation of the length of objects or lines was decreased from 17 to 10 in each of the tests.

Results of the pilot study indicated that the program needed to be lengthened to achieve the objectives of the program. Frames were revised and additional ones added until the program contained 90 frames.

The opinion sheet was completed by each secretary; results indicated that these subjects preferred learning metric length using a self-instructional program to other instructional methods. In addition, their attitudes toward the program were positive. The format of the opinion sheet was revised slightly before the field test.

Instructional Package for Field Testing

The format of the revised booklet (see Appendix A, pp. 70-73) followed that of the booklet used in the pilot study. Three frames were typed on each stencil; drawings were added and the stencils were duplicated. Each page was cut into three frames, the answer portion of the page was folded back, and two holes were punched in the left
side of each frame. The 90 frames were assembled into a Metric Length booklet with manila covers and rings.

A two-page answer sheet was developed with numbers and charts corresponding to frame numbers in the program. Space was provided for the subject's name and the time spent working on the program. The subject was asked to not write in the program booklet.

A manila folder accompanied each program booklet. Panel A was attached to one side of the manila folder. This panel illustrated the units of millimeter, centimeter, and decimeter. A paper clip wire the diameter of which represented one millimeter and straws cut to the length of one centimeter and one decimeter were attached to panel A. Panel B, a mileage chart of South Dakota, was attached to the other side of the folder. Several frames required the subjects to use information from the mileage diagram to make conversions to kilometers. A centimeter tape measure was included in the manila folder so that subjects would have the experience of measuring a number of objects in metric units.1

Attached to the manila folder was a three by five inch card listing the five rules of thumb taught in the program. These rules were developed to teach the subjects how to mentally convert lengths or distances from one system to the other. Subjects were permitted

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1Purchased from the Sterling Forest Research Center, Union Carbide Corporation in New York.
to keep this card and encouraged to display it in their office or kitchen for daily use.

FIELD TESTING

Subjects for Field Test

The subjects for the field test lived within a forty mile radius of Brookings, South Dakota. Forty-three female subjects and 27 male subjects completed the entire program. A variety of ages were represented by the participants:

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Number of Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 - 25</td>
<td>19</td>
</tr>
<tr>
<td>26 - 35</td>
<td>18</td>
</tr>
<tr>
<td>36 - 45</td>
<td>19</td>
</tr>
<tr>
<td>46 and above</td>
<td>14</td>
</tr>
</tbody>
</table>

The educational background of the subjects was also varied:

<table>
<thead>
<tr>
<th>Educational Background</th>
<th>Number of Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade school graduate</td>
<td>3</td>
</tr>
<tr>
<td>High school graduate</td>
<td>18</td>
</tr>
<tr>
<td>High school plus</td>
<td>26</td>
</tr>
<tr>
<td>College graduate</td>
<td>23</td>
</tr>
</tbody>
</table>

Testing of Adult Subjects

The Brookings County Home Extension Agent arranged for participation of members of four extension clubs in the field test. Each club allowed 25 minutes for the researcher to give the pre-test and pass out the program and supplementary materials to the
club members who were willing to participate. A month later the
members who had completed the program turned in all the materials
and proceeded to complete the post-test and opinion sheet. A total
of 33 extension club members completed all steps of the project.

Thirteen male subjects for the field test came from the
Veterans Agricultural Education night classes held at the Brookings
High School. The Brookings Optimist Club was also contacted and
seven men completed the field testing process.

The remaining subjects were contacted individually, some of
them through the college algebra classes held at South Dakota State
University. The algebra students took the pretest in the researcher's
office, completed the program in their dormitory rooms and later
returned the materials and responded to the post-test and opinion
sheet.

The amount of time that elapsed between completing the
program and taking the post-test varied considerably. Some subjects
took the post-test within a few hours of completing the program.
For some of the extension club members several weeks passed between
completion of the self-instructional program and an opportunity to
complete the post-test. This time variable was impossible to
control.

The pretest was given to 95 subjects; 70 subjects completed
the program, post-test, and opinion sheet. Subjects that did not
complete the entire 90 frames of the program were dropped and their
pre- and post-test results eliminated. The 25 subjects who took
the pretest but did not follow through the sequence had a variety of reasons for dropping out of the field test. Several male subjects at the Optimist Club meeting took the program materials home and later returned them because their job responsibilities prevented their completing the booklet. Several extension club members dropped out because they were too busy. Five of 12 ladies in one extension club were older women who did not want to take the program booklets home because they were not interested in learning about metric length and believed they would not need to know how to use the new units of length.
Chapter 4

SUMMATIVE EVALUATION OF FIELD TESTING

Data collected from the field test of the Metric Length Program are described in this chapter. The information collected include pre- and post-test scores and responses to an attitude sheet. Data were used to compute or describe (1) reliabilities of the criterion-referenced tests; (2) frequency distributions of the criterion-referenced test scores; (3) factors affecting post-test scores and (4) summary of attitudes of the adult consumers toward this method of instruction.

DESCRIPTION OF TESTS

Criterion-referenced pre- and post-tests (see Appendix B p. 75 and 81) were based on the four objectives (see p. 30) for the metric length self-instructional program. The tests were divided into eight subscales. The first subscale, Comprehension, required the subject to determine which metric unit was most appropriate in a variety of situations. The second subscale, Rules of Thumb, contained items which required the consumer to state the five rules of thumb taught in the Metric Length Program. The third subscale, Centimeters, contained items in which the consumer applied the appropriate rule of thumb to change inches to centimeters. The fourth subscale, Kilometers, required the subject to apply the appropriate rule of thumb to convert miles to kilometers. The fifth
subscale, Miles, contained items in which the consumer changed kilometers to miles by applying the appropriate rule of thumb. The sixth subscale, Meters, required the subject to apply the appropriate rule of thumb to change yards to meters. The seventh subscale, Yards, contained items which required conversion from meters to yards. The eighth subscale, Estimation, posed problems in which the subject estimated the length of objects and lines in the most appropriate metric unit of length.

The criterion-referenced pre- and post-tests contained the same number of items and the maximum score for each test was 100. The test items for both tests were short-answer type questions.

Popham and Husek (Popham, 1971, pp. 17-37) stated that validity and reliability coefficients for criterion-referenced tests are not as appropriate as are these data for norm-referenced tests because there is usually very little variability in the scores. The reliability coefficients of these criterion-referenced tests were, however, computed using Cronbach's (1951, pp. 297-334) coefficient alpha which provided an index of internal consistency. The pretest had an unusually high coefficient of reliability, .97.

Subscales of the post-test were analyzed separately; the reliability, index of internal consistency in this case, for each of these subscales is given in Table 1.

Five of the eight subscales had reliabilities above .90 and the reliability for the total post-test was .96. The lowest coefficient of reliability, .80, was found in the Rules of Thumb.
Table 1
Post-test Reliability

<table>
<thead>
<tr>
<th>Subscales</th>
<th>Alpha (reliability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Comprehension</td>
<td>.83</td>
</tr>
<tr>
<td>2. Rules of Thumb</td>
<td>.80</td>
</tr>
<tr>
<td>3. Centimeters</td>
<td>.97</td>
</tr>
<tr>
<td>4. Kilometers</td>
<td>.95</td>
</tr>
<tr>
<td>5. Miles</td>
<td>.93</td>
</tr>
<tr>
<td>6. Meters</td>
<td>.97</td>
</tr>
<tr>
<td>7. Yards</td>
<td>.94</td>
</tr>
<tr>
<td>8. Estimation</td>
<td>.89</td>
</tr>
<tr>
<td>9. Total</td>
<td>.96</td>
</tr>
</tbody>
</table>
subscales. Items in this subscale required the consumer to state the five rules of thumb taught in the program. Gronlund (1973, p. 49) pointed out that it was very difficult to measure reliability accurately in a section of a criterion-referenced test containing less than ten items. There were only five items in this subscale.

FIELD TEST DATA

Distributions of Scores

From the field test data, histograms were developed to illustrate the frequency distributions of scores for the adult subjects on the pre- and post-tests.

The frequency distribution of the pre-test scores is shown in Figure 2. The range of scores was from zero to 77; and the mean was 16.97. It is interesting to note that 27 subjects, 38.6 percent, scored between zero and five on the pretest. The distribution is skewed to the left which was expected because the subjects were assumed to have a minimal understanding of metric length before taking the self-instructional program.

The frequency distribution of post-test scores is illustrated in Figure 3. The range of scores was from 37 to 100; the mean was 82.47. Mastery level learning was specified as 80 percent or higher on the post-test; 67.1 percent of the subjects earned 80 percent or higher; and 42.9 percent of the subjects scored 90 percent or higher on the post-test. The distribution was skewed to
Figure 2

Histogram of Pretest Scores
Figure 3
Histogram of Post-test Scores
the right. Scores increased an average of 65.5 percentage points between pre- and post-tests.

The fact that 32.9 percent of the subjects earned scores below mastery level may be related to the problem that it was impossible to regulate the time lapse between completion of the program and taking the criterion-referenced post-test. For example, a month passed between giving the extension club members the self-instructional program and their taking the criterion-referenced post-test. Given this situation, a subject may have completed the program a few hours earlier or several weeks may have passed since completion of the program booklet. In the later case, scores on the post-test were more likely to be lower.

Factors Affecting Post-test Scores

Mean post-test subscale and total scores of the population were compared by sex, age, educational background, and number of minutes spent completing the self-instructional program.

An analysis of variance was computed to compare the post-test means of the population by sex, see Table 2. The means of male consumers were consistently higher than the means of female consumers in all eight subscales and also the total score. The F-value of the Kilometers subscale was significant beyond the .05 level. The reason for the higher performance of male subjects on this subscale may be due to the fact that 13 of the 27 male subjects tested were members of a Veterans Agricultural Education night class.
Table 2

Post-test Means by Sex

<table>
<thead>
<tr>
<th>Subscales</th>
<th>Maximum Score</th>
<th>Females</th>
<th>Males</th>
<th>F-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension</td>
<td>34</td>
<td>31.79</td>
<td>31.81</td>
<td>&lt; 1.00</td>
</tr>
<tr>
<td>Rules of Thumb</td>
<td>5</td>
<td>4.09</td>
<td>4.15</td>
<td>&lt; 1.00</td>
</tr>
<tr>
<td>Centimeters</td>
<td>20</td>
<td>16.51</td>
<td>18.52</td>
<td>2.28</td>
</tr>
<tr>
<td>Kilometers</td>
<td>8</td>
<td>5.74</td>
<td>7.26</td>
<td>4.97&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Miles</td>
<td>7</td>
<td>6.07</td>
<td>6.56</td>
<td>1.19</td>
</tr>
<tr>
<td>Meters</td>
<td>8</td>
<td>5.44</td>
<td>6.33</td>
<td>1.23</td>
</tr>
<tr>
<td>Yards</td>
<td>8</td>
<td>5.70</td>
<td>6.52</td>
<td>1.32</td>
</tr>
<tr>
<td>Estimation</td>
<td>10</td>
<td>4.42</td>
<td>5.63</td>
<td>1.99</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>79.76</td>
<td>86.78</td>
<td>3.54</td>
</tr>
</tbody>
</table>

<sup>a</sup>Significant beyond the .05 level
These veterans were likely to have experienced working with kilometers during their military service, particularly if they were on military duty outside the United States. The difference between the total mean scores for males and females approached significance at the .05 level. The researcher believes it is possible that male consumers are adjusting more rapidly to the use of metric units than are females.

Subjects were divided into four age groups and an analysis of variance was computed to compare the post-test means, see Table 3. Subjects in the 46 years and above category scored lower than subjects in other groups in every subscale except Kilometers, where the 36-45 year old subjects had a lower mean.

Subjects in the age category of 26-35 years had the highest mean more frequently than subjects in the other age categories. This group had the highest mean in the Comprehension, Kilometers, Meters, Yards and total scales. The highest mean for the total post-test was 86.16, earned by the 26-35 year old subjects. The lowest mean for the total post-test was 74.00; it was earned by the 46 years and above subjects. There were no significant differences among the age categories on the post-test scores. Any differences in the scores may be due to chance.

The educational background of the consumers was divided into the following categories: grade school graduate, high school graduate, high school plus junior college or vocational school training, and four year college graduate. An analysis of variance
Table 3

Post-test Means by Age Categories

<table>
<thead>
<tr>
<th>Subscales</th>
<th>Maximum Score</th>
<th>Age of Respondent</th>
<th>F-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Score</td>
<td>16-25</td>
<td>26-35</td>
</tr>
<tr>
<td>Comprehension</td>
<td>34</td>
<td>31.89</td>
<td>32.66</td>
</tr>
<tr>
<td>Rules of Thumb</td>
<td>5</td>
<td>4.39</td>
<td>4.28</td>
</tr>
<tr>
<td>Centimeters</td>
<td>20</td>
<td>18.22</td>
<td>17.16</td>
</tr>
<tr>
<td>Kilometers</td>
<td>8</td>
<td>6.44</td>
<td>7.33</td>
</tr>
<tr>
<td>Miles</td>
<td>7</td>
<td>6.50</td>
<td>6.45</td>
</tr>
<tr>
<td>Meters</td>
<td>8</td>
<td>5.95</td>
<td>6.45</td>
</tr>
<tr>
<td>Yards</td>
<td>8</td>
<td>6.56</td>
<td>6.89</td>
</tr>
<tr>
<td>Estimation</td>
<td>10</td>
<td>5.50</td>
<td>4.94</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>85.45</td>
<td>86.16</td>
</tr>
</tbody>
</table>
was performed to compare the post-test means of these four groups, see Table 4.

As evidenced by Table 4, the means of college graduates are higher for every subscale except Rules of Thumb. The means for the grade school graduates were the lowest for each of the eight subscales and for the total score. The $F$ Value for the Estimation subscale was significant beyond the .05 level. Differences among the educational categories on this subscale were not attributed to chance. The mean of the grade school graduates was 1.33 for the estimation subscale as compared to the mean of the college graduates of 5.95 with the other means falling between these two groups. The researcher believes that it was possible that the subjects with only a grade school education lacked skill in estimating lengths of objects even in English units and needed more opportunity to estimate metric length than did the other subjects.

The means for the total post-test produced an interesting pattern. The lowest mean for the total test was 66.01; it was earned by the grade school graduate group. A mean of 79.00 for the total test was achieved by the high school graduates, 83.50 by the high school plus subjects and the highest mean, 86.43, by the college graduates. These means reflect a trend toward higher scores on the post-test by subjects with progressively more educational training.

Scores of subjects were also compared to the number of minutes spent completing the Metric Length Program. Each subject
Table 4
Post-test Means by Educational Background

<table>
<thead>
<tr>
<th>Subscales</th>
<th>Maximum Score</th>
<th>Educational Background</th>
<th>F-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grade School</td>
<td>High School</td>
</tr>
<tr>
<td>Comprehension</td>
<td>34</td>
<td>30.67</td>
<td>31.06</td>
</tr>
<tr>
<td>Rules of Thumb</td>
<td>5</td>
<td>3.33</td>
<td>3.94</td>
</tr>
<tr>
<td>Centimeters</td>
<td>20</td>
<td>13.00</td>
<td>17.34</td>
</tr>
<tr>
<td>Kilometers</td>
<td>8</td>
<td>5.00</td>
<td>6.05</td>
</tr>
<tr>
<td>Miles</td>
<td>7</td>
<td>4.34</td>
<td>6.00</td>
</tr>
<tr>
<td>Meters</td>
<td>8</td>
<td>4.34</td>
<td>5.45</td>
</tr>
<tr>
<td>Yards</td>
<td>8</td>
<td>4.00</td>
<td>5.61</td>
</tr>
<tr>
<td>Estimation</td>
<td>10</td>
<td>1.33</td>
<td>3.55</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>66.01</td>
<td>79.00</td>
</tr>
</tbody>
</table>

^aSignificant beyond the .05 level
recorded the number of minutes spent on the program booklet. The minutes were compared to the subjects' performance on each post-test subscale and to the total score. These comparisons were expressed as Pearson Correlation Coefficients, see Table 5. The correlation coefficients for the Kilometers, Estimation, and total scales were significant beyond the .05 level. In these particular subscales there was a significant relationship between number of minutes spent in responding to the program and post-test means but it was an inverse relationship. This relationship indicated that the greater the time spent completing the program the lower the post-test mean for the Kilometer, Estimation and total subscales. The writer thinks that it was possible that subjects with progressively more education completed the program more rapidly and also performed better on the post-test.

Sex and educational background seem to have a slight effect on the performance of subjects on the post-test. There was a tendency for males and subjects with progressively more education to do better on the post-test. For many of the subscales, these differences were not significant.

Data from the Opinion Sheet

The subjects involved in the field test were asked to express their feelings by completing the sheet, Your Opinions Please (see appendix B, p. 86), after completing the post-test. The following information was requested. First, the subjects indicated their feelings about the program. They were told to check one or
Table 5

Correlation between Scores on Subscales and Total Time Spent on Program

<table>
<thead>
<tr>
<th>Subscales</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension</td>
<td>-.10</td>
</tr>
<tr>
<td>Rules of Thumb</td>
<td>-.12</td>
</tr>
<tr>
<td>Centimeters</td>
<td>-.03</td>
</tr>
<tr>
<td>Kilometers</td>
<td>-.23&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Miles</td>
<td>-.11</td>
</tr>
<tr>
<td>Meters</td>
<td>-.19</td>
</tr>
<tr>
<td>Yards</td>
<td>-.14</td>
</tr>
<tr>
<td>Estimation</td>
<td>-.29&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total</td>
<td>-.23&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Significant beyond the .05 level
more words or phrases that best described their feelings. Second
the subjects were asked to check how much they wanted to use metric
length in their daily lives. Third, the subjects were asked to rank
according to their preferences certain methods that might be used
to learn the metric system.

The consumers' feelings about the self-instructional program
are shown in Table 6. The feeling which was checked by the largest
number of consumers was interesting; 82.9 percent checked this
feeling. In developing this self-instructional program, the main-
tenance of the subjects' interest was important. In addition, 81.4
percent of the respondents checked the feeling, beneficial. More
than half of the 70 subjects indicated that they would recommend
the Metric Length Program to a friend. None of the respondents
checked that they believed the program to be too difficult or boring.
Some self-instructional programs have been criticized for being
boring, especially some strictly linear programs. The Metric Length
Program was written in linear form but was evidently not boring for
the adult consumers in the sample.

The subjects' attitude toward wanting to use metric length
in their daily lives after completing this program varied, see
Table 7. The respondent had a choice of four levels of use: not
at all, a little, quite a bit, or a lot. Seven consumers checked
that they did not want to use metric length at all. Thirty-four
consumers, 48.6 percent of the sample, indicated that they wanted
<table>
<thead>
<tr>
<th>Feelings</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too much math</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>Interesting</td>
<td>58</td>
<td>82.9</td>
</tr>
<tr>
<td>Repetitious</td>
<td>6</td>
<td>8.6</td>
</tr>
<tr>
<td>Too difficult</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Beneficial</td>
<td>57</td>
<td>81.4</td>
</tr>
<tr>
<td>Frustrating</td>
<td>10</td>
<td>14.3</td>
</tr>
<tr>
<td>Recommend it to a friend</td>
<td>37</td>
<td>52.9</td>
</tr>
<tr>
<td>Too brief, need more help</td>
<td>4</td>
<td>5.7</td>
</tr>
<tr>
<td>Too long</td>
<td>2</td>
<td>2.9</td>
</tr>
<tr>
<td>Boring, too simple</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
to use metric length a little. This group is almost half of the sample which possibly means that these consumers will slowly begin to use the new units. Twenty-five consumers, 35.7 percent of the sample, answered that they will use metric units quite a bit. Three of the respondents want to use the units a lot. For example, one of the male consumers told the researcher that he wanted to learn the new units of length because he would be using them daily on the job. Eighty-eight percent of the total sample want to make some use of metric length.

Table 7

Desired Use of Metric Length in Daily Life

<table>
<thead>
<tr>
<th>Level of Use</th>
<th>Number of Subjects</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = No Response</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>1 = Not at all</td>
<td>7</td>
<td>10.0</td>
</tr>
<tr>
<td>2 = A little</td>
<td>34</td>
<td>48.6</td>
</tr>
<tr>
<td>3 = Quite a bit</td>
<td>25</td>
<td>35.7</td>
</tr>
<tr>
<td>4 = A lot</td>
<td>3</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Mean level 2.31

The subjects ranked their preferences of methods to learn the metric system; Table 8 indicates the subjects' first, second, and third choices. The method the consumers preferred for learning
the metric system was self-instructional programming. Sixty-five of the 70 subjects in the sample chose programming as their first, second or third choice.

Table 8

Ranking of Methods to Learn Metric System

<table>
<thead>
<tr>
<th>Method</th>
<th>First Choice N</th>
<th>Second Choice N</th>
<th>Third Choice N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-instructional program</td>
<td>41</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Television</td>
<td>3</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Newspaper</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Correspondence course</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Movies</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Classroom lecture and discussion</td>
<td>18</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>Lecture</td>
<td>0</td>
<td>4</td>
<td>13</td>
</tr>
</tbody>
</table>

The method of classroom lecture and discussion seemed to be second in popularity; 40 of the 70 subjects checked it as their first, second, or third choice. The least popular method for learning the metric system was movies.

The data from the opinion sheet indicated that 82.9 percent of the consumers found the Metric Length Program interesting and 81.4 percent of the consumers found it beneficial. Eighty-eight percent of the consumers plan to make some use of metric length in
their daily lives. Consumers' first, second or third choice of preferences of methods to learn the metric system was almost consistently a self-instructional program.
Chapter 5

SUMMARY AND RECOMMENDATIONS
FOR FURTHER STUDY

SUMMARY

The goal of this study was to develop a self-instructional program to teach metric length to adult consumers. The programmed materials were created to meet the following guidelines. First, the materials were designed to teach consumers rather than scientists or industrialists. Second, the materials were written to be beneficial and interesting for both male and female consumers. Third, the materials were developed for individualized instruction to permit consumers to complete the booklets at home at their convenience. Fourth, the materials were to be inexpensive.

The programmed materials were designed for mastery level learning. Mastery level was arbitrarily defined as a score of 80 percent or higher on the criterion-referenced post-test.

Subjects for the field test were males and females living within a forty mile radius of Brookings, South Dakota. All of the subjects were eighteen years or older. Seventy adult consumers completed all stages of the field testing process.

The first step in development of the linear program was to decide what consumers needed to know and the mental skills they needed in order to use metric length. Behavioral objectives appropriate for these needs were developed (see page 30). The four
behavioral objectives were the basis for the criterion-referenced pre- and post-tests and also for the criterion and teaching frames of the program.

The program underwent a test-revision cycle using two homemakers and two male high school students who were unfamiliar with the metric system. From feedback obtained in the individual testing, the program was lengthened and additional instructional materials were developed.

A pilot study was conducted using 16 secretaries employed at South Dakota State University. Analysis of the pilot study data indicated that the pre- and post-test should be lengthened. Additional items were added until each test contained 100 items. Based on the pilot study results, the program booklet underwent minor revisions.

A field test was conducted to evaluate the program. In addition to the program booklet, each subject was given a two-page answer sheet, a pre- and post-test, an opinion sheet, and a Manila folder containing the following: Panel A and B, a centimeter tape measure, and a rules of thumb card.

A primary interest in the analysis of field test data was the assessment of the effectiveness of these programmed materials. The reliabilities of the pre- and post-tests were computed. The frequency distributions of subjects' scores on the pre- and post-tests were plotted. Post-test scores were also analyzed to determine if the following factors affected the scores: sex, age,
educational background, and number of minutes spent completing the self-instructional program. A summary of consumers' attitudes was also reported.

The coefficient of reliability of the criterion-referenced pretest was .97 and for the post-test, it was .96. The range of scores on the pretest was zero to 77; and the mean was 16.97. Twenty-seven of the 70 subjects earned a score of zero to five on the pretest. The frequency distribution was skewed to the left.

The range of scores on the post-test was 37 to 100; the mean was 82.47. Mastery level learning, specified as 80 percent or higher, was achieved by 67.1 percent of the consumers. Scores increased an average of 65.5 percentage points between pre- and post-tests.

According to reactions expressed on the opinion sheet, 82.9 percent of the consumers found the self-instructional program to be interesting and 81.4 percent responded that it was beneficial. Sixty-five of 70 subjects in the sample chose self-instructional programs as their first, second, or third choice of method to learn the metric system.

RECOMMENDATIONS FOR FURTHER STUDY

Revising the Metric Length Program

The following revisions or suggestions are recommended for further improvement of the Metric Length Program:
1. Improve the wording on certain frames of the self-instructional program.

2. Change the name of the pre- and post-test to Pre-Program Knowledge and Post-Program Knowledge. The word "test" in any form threatens adults and reminds them of unpleasant memories of tests when they were in school.

3. Increase the number of frames in the program that teach subjects how to estimate length in metric units.

Recommendations for Further Research

The following areas are recommended for further study:

1. Develop similar self-instructional programs to teach other areas of metric measurement, such as volume, weight, and area. A self-instructional system to teach metric temperature was developed by Posey (1975).

2. Perform a follow-up study to determine how much knowledge of metric length is retained after a lapse of three months, six months, and one year.

3. Repeat this study and control the amount of time between completing the program and responding to the post-test.

4. Test the self-instructional program using ninth grade students as subjects and compare their performance and attitude with that of adult consumers.

5. Repeat this study in 1980 to determine if consumers are more highly motivated to learn to use metric length when they
are faced with the immediacy of the need to use the metric system. This recommendation is made with the assumption that five years after passage of the Metric Conversion Act of 1975 considerable progress will have been made toward the application of the metric system in daily life.
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BIBLIOGRAPHY


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APPENDIX A

SAMPLE FRAMES FROM METRIC LENGTH PROGRAM
Distances that we formerly measured in inches; we will now measure in centimeters.

\[
\begin{align*}
\text{1 centimeter} & \quad \text{1 inch} \\
\end{align*}
\]

Guess this fraction:

A centimeter is ___?___ of an inch

About \( \frac{1}{3} \) of an inch

Guess the length of each line and specify the symbol. Record your guesses for all of them before looking at the answers.

a. ___________________  
   a. 7 cm
b. 1.1 cm or 11 mm  
   b. 1.1 cm or 11 mm
c. 9 cm  
   c. 9 cm
d. 4 cm  
   d. 4 cm
e. 1.5 cm or 15 mm  
   e. 1.5 cm or 15 mm
f. 10 cm  
   f. 10 cm
g. 5 mm  
   g. 5 mm

Short lengths are measured in millimeters and longer lengths in centimeters.
This is a car speedometer, with numbers marked in miles per hour. What would be the approximate metric rate for 30 miles per hour?

If you go through a neighborhood and see a sign like this

What is the speed in miles per hour?

Estimate range: 45 km to 53 km

48 km is exact speed

Estimate range: 12 to 16.5 miles

Exact speed is 15 miles per hour
Apply the new rule of thumb to change these body measurements to metric units.

a. chest 34 inches, _____  a. 85 cm
b. waist 22 inches, _____  b. 55 cm
c. hips 36 inches, _____  c. 90 cm

New Rule of Thumb

To change yard to meter: Subtract 1/10

```
1 yard  0.9 meter
```

To change meter to yard: Add 1/10

```
1 meter  1.1 yard
```

An Olympic pool is 50 meters in length. Estimate this length in yards.
If a swim relay is 200 yards, how many meters will the relay team swim?  

180 m  
or  
180 meters

Which metric unit would be used to express the length of each of these objects?

a. Dimensions of room  
b. Thickness of a button  
c. Book  
d. Distance between cities  
e. Height of room  
f. Chest measurement  
g. Cake pan  
h. Thickness of pencil  
i. Shears  
j. Length of swimming pool

a. m  
b. mm  
c. cm  
d. km  
e. m  
f. cm  
g. cm  
h. mm  
i. cm  
j. m
APPENDIX B

EVALUATION DEVICES
PRETEST

DIRECTIONS: Blanks at the left correspond with numbered omissions in the text. Fill in each blank with one word which best completes the statement.

m-meter

1. As consumers you will soon be using metric length in your daily lives. The base unit in metric length is the ___ 1 __.

yard

2. The base unit is a little more than three inches longer than the ___ 2 ___ in our present system.

dm-decimeter

3. In addition to the base unit, the family of metric cm-centimeter

4. length includes several units that begin with mm-millimeter

5. prefixes. List the three units which are smaller than the base unit, ___ 3 ___, ___ 4 ___, and ___ 5 ___.

km-kilometer

6. The unit which is larger than the base unit is the ___ 6 ___.

DIRECTIONS: Write in the blank at the left the word and the symbol for the most appropriate unit of metric length for each item.

<table>
<thead>
<tr>
<th>WORD</th>
<th>SYMBOL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>meter</td>
<td>m</td>
<td>7. 8. dimensions of a room</td>
</tr>
<tr>
<td>millimeter</td>
<td>mm</td>
<td>9. 10. thickness of a pen</td>
</tr>
<tr>
<td>meter</td>
<td>m</td>
<td>11. 12. length of a basketball court</td>
</tr>
<tr>
<td>kilometer</td>
<td>km</td>
<td>13. 14. speed limit per hour</td>
</tr>
<tr>
<td>centimeter</td>
<td>cm</td>
<td>15. 16. length of pen</td>
</tr>
<tr>
<td>centimeter</td>
<td>cm</td>
<td>17. 18. waist measurement</td>
</tr>
<tr>
<td>millimeter</td>
<td>mm</td>
<td>19. 20. thickness of a coin</td>
</tr>
</tbody>
</table>
km 21. 22. distance between Sioux Falls and
     Minneapolis
m 23. 24. length of swim relay
cm 25. 26. length of a book
km 27. 28. distance between Brookings & Volga
cm 29. 30. length of hand
m 31. 32. 200-yard dash
m 33. 34. typical golf fairway

DIRECTIONS: State rules which help you change units between the
      English and metric systems.

35. inches to centimeters. Double and add \( \frac{1}{2} \)

36. miles to kilometers. Add \( \frac{1}{2} \) plus a little

37. yards to meters. Subtract 1/10

38. kilometers to miles. Divide by 2 and add a little

39. meters to yards. Add 1/10

DIRECTIONS: In the kitchen, consumers will soon discover recipes
      that give pan dimensions in metric units. The con-
      sumer can label his/her pans in the new units.
      Estimate metric dimensions for these pans; specify
      the unit of length as well as the appropriate number.

40. 20 cm 8-inch round
41. 22 or 23 cm 9-inch round
42. 25 cm 10-inch round
43. 44. 25 cm x 15 cm 10-inch x 6-inch
45. 46. 35 cm x 27 or 28 cm 14 x 11-inch
47. 48. 22 or 23 cm x 12 or 13 cm 9 x 5 inch
DIRECTIONS: In the future long distances will be given in kilometers instead of miles. Estimate these distances in kilometers and write the number and symbol in the blank to the left.

87 to 102.3 km
360 to 422.4 km
60 to 70.4 km
30 to 35.2 km
157.5 to 184.8 km
1447.5 to 1698.4 km
378 to 443 km
1264 to 1462.8 km

49. Brookings to Sioux Falls, 58 miles or ?
50. Brookings to Omaha, 240 miles or ?
51. Brookings to Madison, 40 miles or ?
52. Brookings to Arlington, 20 miles or ?
53. Pierre to Dupree, 105 miles or ?
54. Pierre to Dallas, Texas, 965 miles or ?
55. Des Moines to Peoria, 252 miles or ?
56. New York City to Chicago, 843 miles or ?

DIRECTIONS: Minnesota and Ohio already have road signs stating the speed limit in kilometers per hour. Estimate these speeds in miles per hour.

25 to 33 miles
45 to 59.4 miles
15 to 19.8 miles
10 to 13.2 miles
17 to 23.1 miles
5 to 6.6 miles
40 to 52.8 miles

57. 50 kilometers or ?
58. 90 kilometers or ?
59. 30 kilometers or ?
60. 20 kilometers or ?
61. 35 kilometers or ?
62. 10 kilometers or ?
63. 80 kilometers or ?

DIRECTIONS: Men's shirts will be sold in the new metric units. Estimate the new size of shirt which corresponds to these sizes.

37 or 38 cm
40 cm

64. Size 15 men's shirt
65. Size 16 men's shirt
DIRECTIONS: Body measurements will be given in new units of length; estimate the lady's measurements in the new system. Specify the unit as well as the appropriate number.

<table>
<thead>
<tr>
<th>INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 cm</td>
</tr>
<tr>
<td>65 cm</td>
</tr>
<tr>
<td>95 cm</td>
</tr>
<tr>
<td>37 or 38 cm</td>
</tr>
</tbody>
</table>

Now estimate this man's measurements in metric units.

<table>
<thead>
<tr>
<th>INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 cm</td>
</tr>
<tr>
<td>80 cm</td>
</tr>
<tr>
<td>97 or 98 cm</td>
</tr>
<tr>
<td>40 cm</td>
</tr>
<tr>
<td>82 or 83 cm</td>
</tr>
</tbody>
</table>

DIRECTIONS: Change these lengths in yards to the new metric units; specify the unit as well as the appropriate number.

<table>
<thead>
<tr>
<th>m</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>360 m</td>
<td>75. 400 yards</td>
</tr>
<tr>
<td>247.5 m</td>
<td>76. 275 yards</td>
</tr>
<tr>
<td>45 m</td>
<td>77. 50 yards</td>
</tr>
<tr>
<td>135 m</td>
<td>78. 150 yards</td>
</tr>
<tr>
<td>22.5 m</td>
<td>79. 25 yards</td>
</tr>
<tr>
<td>270 m</td>
<td>80. 300 yards</td>
</tr>
<tr>
<td>540 m</td>
<td>81. 600 yards</td>
</tr>
<tr>
<td>126 m</td>
<td>82. 140 yards</td>
</tr>
</tbody>
</table>
DIRECTIONS: Convert these lengths given in meters to the appropriate English unit; specify the unit of length as well as the appropriate number.

3.3 yd. 83. 3 meters
2200 yd. 84. 2000 meters
110 yd. 85. 100 meters
550 yd. 86. 500 meters
68.2 yd. 87. 62 meters
19.8 yd 88. 18 meters
242 yd. 89. 220 meters
88 yd. 90. 80 meters

DIRECTIONS: Estimate the length of these lines in metric units; specify the unit of length as well as the appropriate number.

5.1 to 6.9 cm 91.
9.3 to 12.7 cm 92.
8.5 to 11.5 mm 93.
11 cm to 15 cm 94.
8.5 to 11.5 cm 95.
DIRECTIONS: Estimate the length of these items in metric units, specify the unit as well as the number.

ESTIMATED LENGTH

4.8 to 6.6 cm  

.85 to 1.15 cm or 8.5 to 11.5 mm

5.9 to 8.1 cm

1.7 to 2.3 mm

12.7 to 17.3 cm
POST-TEST

DIRECTIONS: Blanks at the left correspond with numbered omissions in the test. Fill in each blank with one word which best completes the statement.

1. Units of length in the metric system are recorded in the base unit _______.
2. The base unit is a little more than three inches longer than the _______.
3. Units smaller than the basic unit use prefixes _______, _______, or _______.
4. _______.
5. _______.
6. The most commonly used unit larger than the base unit has the prefix _______.

DIRECTIONS: Write in the blank at the left the word and the symbol for the most appropriate unit of metric length for each item.

WORD   SYMBOL

meter   _____  7.  ___m  8. length of a room
millimeter  9.  ___mm  10. diameter of a wire
centimeter  11.  ___cm  12. length of a pencil
millimeter  13.  ___mm  14. thickness of button
meter   _____  15.  ___m  16. length of a swimming pool
kilometer  17.  ___km  18. distance between New York City and San Francisco
millimeter  19.  ___mm  20. diameter of a straw
meter   _____  21.  ___m  22. height of a door
centimeter  23.  ___cm  24. length of shoe
centimeter  25.  ___cm  26. body measurements
kilometer 27. km 28. distance between Sioux Falls and Sioux City

meter 29. m 30. length of a football field

centimeter 31. cm 32. length of a scissors

millimeter 33. mm 34. thickness of a pencil

State the rules of thumb as they were given in the program to help you change units between the English and metric systems.

35. miles to kilometers. Add $\frac{1}{2}$ plus a little

36. inches to centimeters. Double and add $\frac{1}{2}$

37. kilometers to miles. Divide by 2 and add a little

38. meters to yards. Add $\frac{1}{10}$

39. yards to meters. Subtract $\frac{1}{10}$

DIRECTIONS: Using the appropriate rule of thumb, write the dimensions or these objects; specify the unit of length as well as the appropriate number.

40. 41. 20 cm x 20 cm 8 x 8-inch pan

42. 43. 22 or 23 cm x 10 cm 9 x 4-inch pan

44. 45. 25 cm x 37 or 38 cm 10 x 15-inch pan

46. 47. 40 cm x 27 or 28 cm 16 x 11-inch pan

DIRECTIONS: Using the appropriate rule of thumb, estimate these distances; specify the unit of length as well as the appropriate number.

90 to 105.6 km 48. Brookings to Watertown, 60 miles or 

288 to 337.9 km 49. Brookings to Pierre, 192 miles or 

3000 to 3520 km 50. Carson City, Nev. to Milwaukee, Wis., 2000 miles or 

270 to 316.8 km 51. Sioux Falls to Omaha, 180 miles or 

544.5 to 638 km 52. Brookings to Rapid City, 363 miles or
1500 to 1760 km 53. Wichita, Kans. to Yellowstone National Park, 1000 miles or ___?

112.5 to 132 km 54. Sioux Falls to Sioux City, 75 miles or ___?

2763 to 3241 km 55. St. Louis, Mo. to Los Angeles, Calif., 1842 miles or ___?

DIRECTIONS: If you were driving in Minnesota, you would see signs with the speed limit in kilometers; use the appropriate rule of thumb and change these distances to miles.

30 to 39.6 miles 56. 60 kilometers, or ___

44 to 58.3 miles 57. 88 kilometers, or ___

12.5 to 16.5 miles 58. 25 kilometers, or ___

20 to 26.4 miles 59. 40 kilometers, or ___

35 to 46.2 miles 60. 70 kilometers, or ___

50 to 66 miles 61. 100 kilometers, or ___

27.5 to 36.3 miles 62. 55 kilometers, or ___

DIRECTIONS: Using the appropriate rule of thumb, write the new size which corresponds to these men's shirts. Specify the unit of length as well as the size.

40 cm 63. Size 16 men's shirt

35 cm 64. Size 14 men's shirt

42 to 43 cm 65. Size 17 men's shirt

DIRECTIONS: Using the appropriate rule of thumb, estimate this lady's body measurements; specify the unit of length as well as the number.

85 cm 66. Bust

60 cm 67. Waist

90 cm 68. Hips

40 cm 69. Back waist length

INCHES

34

24

36

16
DIRECTIONS: Using the appropriate rule of thumb, convert these distances; specify the unit of length as well as the number.

450 m 75. 500 yards
330 yd. 76. 300 meters
18 m 77. 20 yards
1100 yd. 78. 1000 meters
675 m 79. 750 yards
44 yd. 80. 40 meters
4.5 m 81. 5 yards
225 m 82. 250 yards
290 yd. 83. 900 meters
54 m 84. 60 yards
77 yd. 85. 70 meters
1800 m 86. 2000 yards
1650 yd. 87. 1500 meters
720 m 88. 800 yards
132 yd. 89. 120 meters
1.1 yd. 90. 1 meter
DIRECTIONS: Estimate the length of these lines in metric units; specify the unit of length as well as the number.

10.2 to 13.8 cm  91.

5.9 to 8.1 cm  92.

9.3 to 12.7 cm  93.

4.2 to 5.8 cm  94.

2.5 to 3.5 cm  95.

DIRECTIONS: Estimate the length of these items; specify the unit of length as well as the number.

4.2 to 5.8 cm  96. Bobby pin

1.8 to 2.4 cm  97. Safety pin

10.3 to 13.9 cm  98. Pencil

.8 to 1.2 cm  99. Screw

4.7 to 6.3 cm  100. Length of Box
YOUR OPINIONS PLEASE!!!!

You have had an opportunity to experience a self-instructional program on metric length. How did you feel about this program? Check the appropriate item(s) that describe(s) your feelings.

___ too much math
___ interesting
___ repetitious
___ too difficult
___ beneficial

___ frustrating
___ recommend it to a friend
___ too brief, need more help
___ too long
___ boring, too simple

After completing a program on metric length, how much do you want to use it in your daily life? Check one.

___ not at all
___ a little
___ quite a bit
___ a lot

How would you prefer to learn the metric system? Rank these methods as to 1-your first choice, 2-your second choice, and 3-your third choice, etc.

___ television
___ newspaper
___ correspondence course
___ movies

___ classroom with lecture and discussion
___ lecture
___ in self-instructional program like this one

Do you have any other feelings or comments about this program?

Please complete:

Male ___ Female ___

Check with X the educational institutions you attended:
___ grade school ___ junior college ___ four year college
___ high school ___ vocational school ___ graduate school

Mark above with O the institutions from which you graduated.

Check your age in the appropriate range:

___ 16 to 25 ___ 36 to 45 ___ 56 to 65
___ 26 to 35 ___ 46 to 55 ___ 66 or above

I hope you aren't fuzzy

about using metric length in

your daily life.

Instead, I hope you are as happy as Mr. Long and his family!

THANK YOU FOR YOUR COOPERATION!!!!!