THE EFFECTS OF A METRICALLY ORIENTED PHYSICAL ACTIVITY PROGRAM UPON THE ABILITY OF SIXTH GRADE STUDENTS TO LEARN LINEAR CONCEPTS OF METRIC MEASUREMENT

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ABSTRACT

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By

Karen L. Torsky

The purpose of this study was to determine the effects of a metrically oriented physical activity program upon the ability of sixth grade students to learn linear concepts of metric measurement. Thirty-six sixth grade students enrolled in the T. S. Nurnberger Middle School, St. Louis, Michigan, served as subjects. A physical activity program emphasizing metric concepts of linear measurement was presented to the experimental group (N=18) for one-half hour each day for an eight day period. A workbook program emphasizing metric concepts of linear measurement was presented to the control group (N=18) for one-half hour each day for the same eight day period. All metric instruction in this study was conducted by the investigator. The students received no additional metric instruction in their regularly scheduled classes.

The test instrument used in this study was an adaptation of the metric performance test constructed by the Michigan Department of Education. Since the present study

utilized a pre-test and a post-test, the investigator divided the original test into two comparable parts, consisting of twenty-nine questions each. Prior to this study, the questions on the pre-test and post-test forms had been tested for reliability by the investigator in a pilot study.

Statistical analysis in this study included an F-test to determine if the variances of the gain scores for the experimental and control groups were equal. Normality was demonstrated by a subjective evaluation of the graphs of the various frequency distributions. A t-test was then selected to determine the difference between gain scores for the experimental and control groups. The results of this study indicate that there is a significant advantage in learning linear concepts of metric measurement through exposure to a metrically oriented physical activity program as compared to learning the concepts through a metrically oriented workbook program. However, analysis of partial test score data indicated that millimeter concepts were learned more readily through workbook activities than through physical activities.

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CHAPTER I

INTRODUCTION

Research has substantiated the existence of a low positive relationship between perceptual-motor performance and academic performance (Howe, 1959; Skubic and Anderson, 1970; Ismail and Gruber, 1967; Thomas and Chissom, 1974). Certain cognitive abilities, primarily reading and language skills, have been found to be related specifically to motor functioning (Leithwood, 1971).

Participation in physical education activities provides an opportunity for individuals to improve academic performance. Positive changes in the academic performance of educable mentally retarded children (Chansky and Taylor, 1964) have been achieved through exposure to physical activity programs. Specific groups of normal elementary children (Chang and Chang, 1967; Corder, 1966; Rosen, 1966; Gill, Hedtner, and Lough, 1968) also have demonstrated positive changes in academic performance that have been attributed to participation in physical activity programs.

Extensive research has been completed on the effects of physical activity programs upon reading and language skills (O'Donnell and Eisenson, 1969; McCormick, Sohnobrich, Footlik, Poether, 1968). However, there is very little scientific literature dealing with the effects of physical activity upon the development of mathematical skills.

There seem to be some similarities between the development of reading and language skills and the development of mathematical skills. In reading and language, the learner must perceive and master figures (letters), symbols (punctuation), and concepts which are similar to the figures (numbers), symbols (signs), and quantities found in mathematics. Since these similarities appear to exist, and since student performance in reading and language skills has been improved through physical activity, it is conceivable that student performance in mathematics also can be improved through the use of physical activity. It is evident that there is a need for more study of the interrelatedness of physical activity and the development of mathematical skills.

Need for the Study

There has been very little research reported concerning the effects of physical activity programs upon the learning of mathematical skills. It is important to establish what effect, if any, physical activity programs have on the learning of mathematical skills. A core curriculum approach would be enhanced by the use of physical activity as an effective aid to learning in cognitive disciplines such as mathematics. Also, it may be possible to increase the amount of physical activity for students in school systems that have very limited physical education programs, by teaching cognitive concepts through physical activity.

Metric measurement is a new content area in mathematics that needs more research. Although the concept of measurement is not new to American mathematics education, the units of metric measurement are unfamiliar, especially to elementary school children. In the past, the metric system has been used minimally in the United States. Recent legislation, however, has initiated a change from the present English system of measurement to the metric system of measurement. Many United States industries will have converted their operations to the metric system of measurement by the year 1980. In view of this fact, the young people of this country must be educated in the use of the metric system of measurement. Effective techniques of teaching these measurement units must be established by educators.

The teaching of metrics does not have to be limited to mathematics classes. The author believes that other disciplines, such as physical education, can incorporate the teaching of metrics into their specific subject matter. As the concept of core curriculum becomes more widespread, it is possible for other disciplines to formulate and test techniques for providing instruction in metric measurement.

Purpose of the Study

The purpose of this study was to determine the effects of a metrically oriented physical activity program on the ability of sixth grade students to learn linear units of metric measurement. A metrically oriented activity program was designed to be used in the gymnasium by the experimental group. A metrically oriented workbook program was designed to be used in the classroom by the control group.

Research Plan

Many dictionaries, encyclopedias, and almanacs refer to the measurement of distance as linear measurement. The Michigan State Department of Education refers to the measurement of distance as linear measurement in their metric objectives and metric test questions which are utilized in this study. Consequently, throughout this study the measurement of distance will be referred to as linear measurement.

This study involved thirty-six sixth grade students enrolled in the third, fourth, fifth, and sixth hour study halls at the T. S. Nurnberger Middle School, St. Louis, Michigan. Due to the limited availability of the gymnasium, students in the third and fourth hour study halls were designated as Group A, the experimental group. Students in the fifth and sixth hour study halls were designated as Group B, the control group. Enrollment in a specific study hall period was the result of multiple scheduling factors and was not a function of student intelligence or behavior.

A physical activity program emphasizing metric concepts of linear measurement was presented, in the gymnasium, to the experimental group for one-half hour each day, for an eight-day period. A workbook program emphasizing metric concepts of linear measurement was presented, in the classroom, to the control group for one-half hour each day, for an eight-day period. The usual environment for instruction in measurement concepts has been in the classroom through a textbook and workbook approach. The students in the fifth and sixth hour study halls received instruction in this typical educational environment and, therefore, were labeled as the control group. All metric instruction in this study was conducted solely by the investigator, which insured that consistent treatment was provided within and between the two experimental classes and the two control classes. Data were pooled for statistical purposes to form one experimental group (N=18) and one control group (N=18).

The subjects involved in this study also received normal physical education and mathematics classes taught by regularly scheduled teachers. There was no emphasis on metric concepts in these regularly scheduled classes. In view of this fact, it was possible to assume a certain degree of control over the students' exposure to this specific area of mathematics instruction.

At the beginning of this study, an adaptation of the metric performance test constructed by the Michigan Department of Education was administered to both the experimental and control groups. Due to class scheduling procedures within the school, students could not be assigned randomly to treatment periods. However, it could be assumed that students were assigned randomly to study hall periods. In addition to the problem of randomization, the number of students involved in this study was small. Consequently, a pre-test and a post-test were utilized to protect the design of this study. The use of a pre-test form and a parallel post-test form was employed to avoid familiarity with the test by repeating the same questions. Since the study utilized a pre-test and a post-test, the investigator divided the original test into two comparable parts consisting of twenty-nine questions each by assigning the even-numbered questions from each of the thirteen objectives to the pre-test and the odd-numbered questions from each of the thirteen objectives to the post-test. At the end of the eight-day program, the post-test in metric measurement was administered to all thirty-six subjects.

In a pilot study, the split-halves technique (Finney, 1948) was used to determine the reliability of the individual test questions. The groups of questions for each objective also were tested for reliability in the same manner. The Pearson Product Moment Correlation and the Spearman-Brown Correction Equation were calculated for the entire test on linear measurement. The Pearson Product Moment Correlation and Spearman-Brown Correction Equation also were run against the test questions for a sample of six of the thirteen objectives (four of the eight lessons) in the pilot study.

The pre-test and post-test data were used to calculate mean gain scores for the experimental and control groups on the metric performance test. The data were first tested to establish whether or not they met the assumptions of a "t-test." An uncorrelated "t-test" then was used to determine whether or not significant differences existed between mean gain scores for the experimental and control groups as a result of the treatment.

Hypothesis

The research hypothesis to be tested in this investigation is that there will be no difference between the mean gain scores on a metric concepts test for the sixth grade students involved in a metrically oriented physical activity program and the sixth grade students involved in a metrically oriented workbook program.

Limitations

1. The subjects were those students enrolled in the St. Louis, Michigan, Middle School System, and therefore the conclusions of this study may be limited by certain characteristics of this community.

2. Due to the availability of the gymnasium, the third and fourth hour study hall students were designated as the experimental group and the fifth and sixth hour study hall students were designated as the control group. A lunch period separated the experimental group from the control group. Consequently, the subjects' response to

the treatment could have been affected by a relationship between the lunch time and the treatment time.

Definitions

1. Academic Achievement: "...the important knowledges, skills, and understandings commonly accepted as desirable outcomes of the major branches of the elementary curriculum" (Kelly et al., 1966).

2. Linear Metric Measurement: A specification of distance in various metric units of length.

3. Metric Performance Objectives: A specification of student actions indicating specific metric concepts that a student is expected to learn at a specified grade level.

4. Metrically Oriented Physical Activity Program: A physical activity program, taught in a gymnasium, that places an emphasis on linear concepts of measurement in the metric system.

5. Metrically Oriented Workbook Program: A program that places an emphasis on linear concepts of measurement in the metric system taught through workbook and classroom activities.

CHAPTER II

REVIEW OF LITERATURE

Many studies have examined the relationships between physical and intellectual development. This chapter will present an analysis of the literature regarding academic achievement and its relationship to physical activity programs. Theoretical implications will be presented for the learning of metrics through a physical activity program.

Relationships of Academic Achievement and Physical Activity Programs

Studies investigating the relationship between academic achievement and physical activity programs frequently have identified subjects by mental ability. Motor development and academic achievement have been studied for mentally retarded children and for children of normal and above normal intelligence.

Retarded Children

Motor task scores for normal boys and girls have been found to be superior to those for retarded boys and girls (Howe, 1959). When measuring the relationship between motor proficiency and mental ability for ten year old children, it was determined that children of average intelligence are significantly superior to mentally retarded children in terms of motor proficiency (Sloan, 1951). The investigators of these studies concluded that exposure to motor activity could affect, favorably, the intellectual development of the mentally retarded child.

Normal Children

Some relationships of perceptual-motor and motor performance to intelligence and academic achievement have been established for normal children. A study was conducted on normal fourth grade subjects by Skubic and Anderson (1970). The Stanford Achievement Test, the California Test of Mental Maturity, and a perceptual motor battery were administered to the children to separate them into a high achieving group and a low achieving group. The high and low achievers scored the same on five of the eleven perceptual-motor tests in the battery. However, the high achievers scored better than the low achievers on the California Test of Mental Maturity and on the six other tests in the perceptual-motor battery and specific components of the Stanford Achievement Test, namely, word meaning, paragraph meaning, and arithmetic concepts.

Researchers have investigated the relationships of intelligence and academic performance to motor performance. Pre-school children classified as intellectually advantaged children have been found to score high on a test of motor functioning (Leithwood, 1971). In his study Leithwood also concluded that more complex intellectual abilities are specifically related to motor abilities. According to a motor task test battery designed by Seils, third grade students identified as high performers showed more satisfactory scholastic adjustment than those identified as low performers (Rarick and McKee, 1949).

The association of chronological age and grade level with student motor and academic achievement has been established. It has been found that for the first few years of school, perceptual-motor achievement can be used as a concurrent predictor of academic achievement (Ismail and Gruber, 1967; Ismail, Kane and Kirkendall, 1969; and Thomas and Chissom, 1972 and 1973). However, in a study by Thomas and Chissom (1974) it was found that perceptual-motor achievement of kindergarten subjects could not be used as a prediction of their academic performance in the first grade.

The relationship of chronological age and grade level to student motor and academic achievement decreases as age and grade level increase. Singer and Brunk (1967) examined the perceptual-motor task, referred to as the Figure Reproduction Test, and its relationship to scores from the Stanford Achievement Test and the Pinter Test, both tests of academic achievement. A low positive relationship between intellectual and perceptual-motor abilities was evident in this group of third and fourth grade students. However, they concluded from the data that learning abilities, both intellectual and perceptual-motor, have developed specificity by the time an individual reaches this age and grade level. Similar results were found with third and sixth grade children when investigating perceptual-motor performance and academic achievement (Singer, 1968). This study demonstrated that relationships of grade levels and age groupings to perceptual-motor tasks were low and frequently not significant. It was discovered also that intelligence test scores did not correlate any higher with performance on perceptual-motor tasks than did simple motor tasks for either of the grade levels. These findings are supported by Chissom (1971) and Thomas and Chissom (1972), who concluded that academic and perceptual-motor measures showed a decreasing relationship as children reached the third grade.

Chang and Chang (1967) discovered that reading achievement and visual-motor skills of superior second grade subjects correlated significantly with the scores of the Bender-Gesalt and the WISC, both tests of visual-motor proficiency. The scores of the superior third grade subjects in this study did not show the significant correlation between the same tests that the scores of the second grade subjects had shown. This indicates that the second grade rather than the third grade is more likely to show a correlation between reading achievement and visual-motor skills.

Academic achievement and its relationship to motor and perceptual-motor achievement is limited primarily to the specific areas of reading and language skills. When examining first and second grade children for performance of selected motor skills and reading readiness, Trussell

(1969) discovered significant correlations between many motor skills and the perceptual aspects of reading. However, the correlations were not high enough to serve as reliable predictors of perceptual-motor skills and reading readiness. It was observed that for subjects with normal intelligence in the upper elementary grade levels, a lack of visual-motor development can be severe enough to cause reading problems. In a study by Sterritt and Rudnick (1966), it was concluded that fourth grade boys of high intelligence earned higher scores on the Iowa Tests of Basic Skills in Reading Comprehension than did fourth grade boys of low intelligence. Birch and Belmont (1965) reasoned that, for children in kindergarten through the second grade, auditory-visual integration was evident and that the correlation between reading ability and intelligence rose with age.

A relationship of selected motor skill and physical achievement measures to specific areas of academic achievement has been demonstrated. In a study involving first, third, and fifth grade students it was found that: (1) achievement in reading correlated significantly with the throw and catch test and the zig-zag run test but not with the jump and reach test or the kicking test, and (2) significant differences were found among selected reading levels with the zig-zag run test and the throw and catch test but not with the jump and reach test and the kicking test (Plack, 1967).

In general, it is evident that perceptual-motor and motor performance have a relationship to academic performance. Some conclusions can be drawn regarding the relationship between academic performance and perceptual-motor and motor performance. These conclusions are restricted to specific groupings of subjects and specific aspects of perceptual-motor performance. Many investigations have focused upon the relationships between reading and language skills and perceptual-motor performance. The number of studies specifically related to mathematics performance and physical activity programs, however, are limited. Those studies that have included mathematics skills have indicated a positive relationship between student performance in mathematics and perceptual-motor and motor performance.

Experimental and Clinical Studies of Perceptual-Motor and Motor Achievement and Academic Achievement

Experimental and clinical studies have been conducted to investigate the effects of perceptual-motor and motor programs on academic achievement. In a study by O'Donnell and Eisenson (1969), students were tested to determine the effects of the Delacato training program upon visual-motor integration and reading achievement. This study utilized disabled readers randomly assigned to two experimental groups (a Delacato training program and a partial Delacato training program) and one control group (participation in selected physical education activities). The investigators found that in all three treatment groups, older pupils did not improve as much as younger pupils. However, no statistical differences were found among the three groups. Improvements in perceptual-motor performance, intelligence, and academic achievement were found in educable mentally retarded children after they had been exposed to a perceptual-motor program (Chansky and Taylor, 1964). This was true for the children instructed individually as well as for those instructed in a group. The students who were encouraged to make inferences, to orient themselves from left to right, to organize, and to make discriminations and the students who received immediate reinforcement improved in intelligence and academic achievement. In a study involving young boys who were exposed to a therapeutic play program, it was discovered that improvements between pre-test and post-test scores were significant in all of the perceptual-motor and IQ measures (Fretz, Johnson and Johnson, 1969).

A number of studies have examined the effects of perceptual-motor programs on specific areas of academic achievement, primarily reading and language skills. Perceptual-motor training has been found to enhance the reading achievement of underachieving first grade students (McCormick, Schnobrich, Footlik, Poether, 1968). This study involved forty-two children matched for IQ, sex, age, and Lee-Clark reading level. The subjects were assigned randomly to either the control group, a physical education exercise group, or to the experimental group, a perceptual-motor group. After a seven week program, the experimental group demonstrated statistically significant (.01 level) gains in reading. In a study by Rosen (1966), it was found that first grade subjects classified as low perceiving boys (the experimental group in a perceptual training program) showed a higher reading achievement level than those in the control group. However, in a perceptual-motor study involving kindergarten children, Falik (1969) found no significant differences between experimental and control subjects in reading readiness at the end of the kindergarten year or at the second grade level.

Gill, Herdtner, and Lough (1968) conducted a study involving nursery children classified as normal children. The children in the experimental group were exposed daily to fifteen to twenty minutes of instruction in body orientation exercises during the school year. The control group did not receive any instruction in body orientation exercises. They discovered that the perceptual development of experimental subjects at the first grade level was more advanced than that of the control subjects at the first grade level. This study also demonstrated that there are strong relationships between exposure to many perceptual tasks and the level of development in reading and arithmetic for girls.

Physical activity has been utilized as a means of presenting cognitive concepts to students to increase academic achievement. A study by Humphrey (1965) compared the use of language workbook exercises and active games upon the language understandings of normal third grade children. In this one day study, those subjects who received active games as a learning medium for language skills development demonstrated a significantly greater (.05 level) increase in learning than the group who received additional time on language workbook exercises and no active game participation.

Most of the studies discussed above cite desirable effects of perceptual-motor and motor programs on either specific or general areas of academic achievement. This research, dealing primarily with children in the early elementary grades or pre-school level, suggests that young children appear to be more responsive to treatment programs than older children.

Duration of the Study

The appropriate amount of time that is necessary to expose subjects to a treatment program must be considered. Metrics is a new area in American mathematics education. Research studies involving the length of time necessary to teach metric concepts are not readily available. By examining other experimental studies in mathematics, inferences can be drawn regarding the amount of time needed to teach metric concepts to sixth grade students.

It has been a general trend for the "new math" to incorporate more advanced mathematical concepts into the upper elementary school curriculum than had been incorporated in the past. One of the most advanced concepts which has been taught is probability and statistics. After twenty days of instruction, subjects with average to above average ability in mathematics demonstrated significant positive changes in their understanding of probability and statistics (Shepler, 1970). Other advanced concepts which have been included in elementary school programs are decimal versus nondecimal numeration and mathematical proofs. Subjects receiving nine, thirty minute sessions of nondecimal instruction have demonstrated a better understanding of the place value system than those subjects involved in decimal numeration instruction for a similar time period (Diedrich and Glennon, 1970). After a seventeen day unit of instruction in mathematical proofs, it was concluded that sixth grade students were able to demonstrate and reproduce proofs and related theorems (King, 1973).

Not only have "new math" concepts been presented at an earlier age, but new methods of presenting traditional mathematics concepts in greater detail also have been researched. Experimental subjects involved in a six day study on signed number operations (Riley, 1970) and experimental subjects involved in an eight day study on multiplying fractions (Burton, Lemke, and Williams, 1975) demonstrated significant positive changes in learning abilities. However, in a sixteen day study, Jerman (1973) was unable to establish significant positive changes in problem solving ability.

The studies cited above involve fifth and/or sixth grade students, difficult concepts, and treatment periods extending from six to twenty days. All of the studies, with the exception of one, indicate desirable student performance in relation to treatment time and difficulty of concepts being presented.

CHAPTER III

RESEARCH PROCEDURES

The purpose of this study was to determine the effects of a metrically oriented physical activity program on the learning of linear concepts of metric measurement by sixth grade students. A metrically oriented activity program was designed to be used in the gymnasium by the experimental group. A metrically oriented workbook program was designed to be used in the classroom by the control group.

Sample

The sample for this study was comprised of thirty-six sixth grade students enrolled in the third, fourth, fifth, and sixth hour study halls at the T. S. Nurnberger Middle School, St. Louis, Michigan. The school has a population of approximately 380 sixth, seventh, and eighth grade students. The St. Louis School District is a class C district located in a small rural community in mid-Michigan. The sixth grade subjects involved in this study were not exposed to metric concepts through the school prior to this study. Due to the availability of the gymnasium, the third and fourth hour study hall students were designated as the experimental group. The fifth and sixth hour study hall students, therefore, were designated as the control group. Enrollment in a specific study hall period was the result of multiple scheduling factors and not a function of student intelligence or behavior. The times of the experimental group's study hall periods were separated from the control group's study hall periods by a lunch period. The relationship of treatment time to lunch time was recognized as a limitation of the study. However, it was judged as not so severe a limitation as to preclude the conduct of the study. Data were pooled for statistical purposes to form one experimental group (N=18) and one control group (N=18).

Program Schedule

Prior to the presentation of the activity program and the workbook program, a pre-test form of the metric performance test was administered to all subjects. A physical activity program emphasizing metric concepts of linear measurement was presented to the experimental group for one-half hour each day, for an eight-day period. A workbook program emphasizing metric units of linear measurement was presented to the control group for one-half hour each day during the same eight-day period. Instruction in metrics in this study was a supplement to the regularly scheduled mathematics and physical education classes in which there was no emphasis on metric concepts. At the end of the eight-day experimental period, a post-test form of the metric performance test was administered to all subjects.

The Program

Due to the nature of the treatments, all instruction for the study was carried on in the gymnasium for the experimental group and in the classroom for the control group. All metric instruction in this study was conducted by the investigator. This insured that consistent treatment was provided within and between the experimental classes and the control classes.

Experimental Program--The experimental program was based on metrically oriented physical activities. Linear measurement was the area of metric measurement that was utilized. The experimental treatment was designed to combine physical movements with cognitive concepts of metric measurement (see Appendix A).

Control Program--The control program was based on metrically oriented workbook and classroom activities. Linear measurement was the area of metric measurement that was included in this study (see Appendix A).

Length of the Study

At this time, the amount of research literature involving the teaching of metric concepts is limited. Teaching methods and the necessary amount of time for presenting metric concepts to upper elementary school students have not been determined empirically. By examining research studies in mathematics, however, it is possible to draw inferences regarding the amount of time necessary for this study. The investigations cited in Chapter II, Duration of the Study, involved fifth and/or sixth grade students, and each study lasted for a relatively short treatment period in relation to the difficulty of the concepts being presented. The degree of difficulty in metrics is not as great as probability and statistics, or some of the other concepts reviewed. Although the concept of measurement is not new to American education, the units of metric measurement are unfamiliar, especially to elementary grade children. The author believes that the metric system of measurement is easier for individuals to learn than the English system of measurement. The metric system is divided into six categories of measurement. One base unit is identified within each category of metric measurement. Increments or decrements of that base unit occur in powers of ten. It is quite conceivable that given only minimal instruction on how to manipulate these units, an individual may be able to utilize the metric system of measurement more efficiently than the English system of measurement, which involves memorization of various units and their more complicated conversion factors. Therefore, an experimental period of eight days was determined to be adequate for this study.

The Test Instrument and Objectives

The metric performance test used in this study was an adaptation of the preliminary test developed in 1976 by the Michigan Department of Education, Department of Assessment and Evaluation. The state-designed test consists of two major units, each having three sub-units:

I. Geometric Units

A. Linear
B. Square
C. Cubic

II. Non-Geometric Units

A. Degree
B. Mass
C. Capacity

Each of the test sub-units consists of questions designed to assess student performance on metric objectives that were developed in 1976 by the Michigan Department of Education. No less than two test questions and no more than eight test questions are provided for each objective in the standardized test. Most of the test questions are multiple choice questions with four answer choices. The other type of question used in the test involved actual measurement with rulers. The subjects are required to measure lines of various lengths and record the answers on the test form. Based on analysis of the data, the Michigan Department of Education will shorten the test to three or four test questions for each metric objective to decrease the amount of time necessary for the administration of the test.

For the purpose of this study, the questions were grouped into two comparable parts to construct a pre-test form and a post-test form. This method also permitted the use of the split-halves technique to determine the reliability of the composite test. The test questions were taken from the original test created by the Michigan Department of Education, form numbers 21, 22, 27 and 28.

The sub-unit of linear measurement consists of thirteen objectives that are assessed by a total of fifty-eight questions (see Appendix B). The investigator constructed four additional questions for one objective that did not have at least four questions provided in the standardized metric performance test. This objective involved the use of a measurement tool to measure specific distances in centimeters and meters. The additional questions were constructed to provide a sufficient number of test questions for use in the pre-test and post-test forms for this specific objective. There were three objectives that each had only two questions. These objectives involved metric units and their converted amount, such as 1,000 meters equal 1 kilometer. No additional test questions were constructed for these objectives, since there are only two possible ways to write the test questions.

If an objective had seven test questions in the standardized test, one of the questions was subjectively eliminated by the investigator to permit the use of the split-halves technique for determining reliability. The test questions for each objective were separated into two groups by assigning even-numbered questions to the pre-test and odd-numbered questions to the post-test to construct parallel pre-test and post-test forms. One-half of the questions from each objective used the appropriate metric word within the test question and the other half of the questions used the appropriate metric symbol within the questions. The number of each type of question appearing in each test form was regulated to prevent all of one type of question from appearing on the same test form. Each form had twenty-nine questions including those constructed by the investigator.

The Pilot Study

Although the state developed test had been administered to a sample group across the State of Michigan, the data had not been analyzed at the time of this study. Consequently, the investigator conducted a pilot study with sixth grade students from the Mackinaw City School District. Experimental and control lessons related to certain metric objectives were tested for feasiability in the pilot study. The first four lesson plans, comprised of six objectives in linear metric measurement, were tested in this study. The activities planned for both the experimental and the control group were designed to present each lesson's objectives and to keep students involved in the activities during each thirty-minute treatment period. However, it was found that instructions for students in the experimental group needed to be more clearly stated to enable all students to understand how to properly use the recording worksheets. The students in the experimental group measured the distance they ran, jumped, threw a ball, etc. It was observed that some students would measure, record and convert their findings on the worksheet in a unit of measurement they found to be easier. As a result students had limited experience in converting metric units. Consequently, the instructions that were read to the students were altered for the main study to accommodate this situation.

The split-halves technique was used to determine the reliability of each of the test questions within each objective in linear measurement in the metric system (Finney, 1948). The questions for each objective also were pooled and tested for reliability, utilizing the same 2 x 2 contingency test. The Pearson Product Moment Correlation was calculated first for only the six objectives covered in the pilot study ($r=.58$) with a Spearman-Brown Correction Equation producing a corrected correlation of .73. The correlation appears to demonstrate a rather low relationship. However, it must be noted that there was a depressed range of scores which may have affected the correlation. The Pearson Product Moment Correlation also was calculated for the entire test on linear measurement ($r=.78$) with a Spearman-Brown Correction Equation, producing a corrected value of .88.

Administration of the Test Instrument

Pencils with erasers were provided for the subjects to take the metric performance test. The subjects were seated far enough apart to reduce the chances of seeing responses to test questions made by classmates. After the pencils were distributed, the subjects were instructed not to talk to each other. A test form was placed face down on each desk. When all subjects had received a test form, the following directions were read to the group. "This is a test involving the linear units of metric measurement. You may turn your test face up and leave it lying on your desk. DO NOT TURN THE PAGE UNTIL YOU ARE INSTRUCTED TO DO SO.

"Write your name on the upper left hand corner of the front page in the space provided. Then write the class period in the space provided below your name. [pause] The questions in this test are multiple choice questions. After reading the question, you will select the choice you think best answers the question. When you select an answer, you must circle the letter of the answer you choose. If you change an answer, you must erase completely the old answer and circle the new answer. It must be clear what your final answers are. When you reach the page that says STOP, bring the test to the front of the room. If you have any questions, raise your hand now. [after questions are answered] If you have any difficulties during the test, raise your hand, and I will come and help you. There is to be no talking. You now may begin the test."

When a subject brings a test to the front of the room, a 1 1/2 meter ruler will be given to the subject. The following instructions will be read to the subject. "You must measure lines 3 and 4 on the floor [point to the lines] and record your answer on the last page of the test. When you complete this task, you are to hand in the test and your pencil."

Only one subject can complete the measuring portion of the test at a time. This is to avoid the chance of subjects seeing the answers of their classmates.

Analysis of Data

Alpha was set at .10 since the accuracy of testing procedures in the area of cognitive learning can be influenced by many factors. By allowing a lenient alpha, it may be possible to determine feasibility of continued research in this area. Also, the experimental treatment is not necessarily being recommended as the most ideal method of instructing metric concepts, but only as one of a number of methods. The data first were tested to establish that they met the assumptions of a "t-test." An uncorrelated "t-test" was used to determine the difference between mean gain scores of the experimental and control groups in the final study.

CHAPTER IV

RESULTS AND DISCUSSION

The results of the statistical analyses of the data are presented and discussed in this chapter. An F-ratio test was used to evaluate the homogeneity of variances for the gain scores obtained on the control and experimental groups. Normality of the various distributions was determined subjectively by inspecting plots of the data. Subsequently, a t-test was used to determine the mean difference between the gain scores for the two groups.

Statistical Analysis

The mean scores, based on the total number of correct responses on the pre-test and post-test, and the standard deviations for each group are reported in Table 1.

The pre-test mean for the control group was greater than that of the experimental group. The higher mean value may be an indication that the control subjects had greater knowledge of linear metric concepts at the start of the treatment period. However, the means for the experimental and control groups were nearly identical for the post-test. The maximum number of correct scores on each of the test forms was twenty-nine. Scores for both experimental and control subjects combined indicate that

TABLE 1

MEANS AND STANDARD DEVIATIONS OF PRE-TEST AND POST-TEST SCORES FOR EXPERIMENTAL AND CONTROL GROUPS

Groups	Number of subjects	Pre-test mean	Pre-test standard deviation	Post-test mean	Post-test standard deviation
Experimental	18	12.88	34.81	22.11	24.92
Control	18	13.72	32.91	22.33	30.94

forty-six percent of the pre-test questions were answered correctly. On the post-test form, the students properly answered seventy-seven percent of the questions.

An F-test was calculated to determine if the variances of the gain scores for the two groups were equal. From the data presented in Table 2, it can be seen that homogeneity of population variances can be assumed. The probability (alpha) of making a type I error was limited to the .10 level for this analysis.

Since the F-test indicated equality of gain-score variances and normality was demonstrated by a subjective evaluation of the graphs of the various frequency distributions, a t-test was selected to determine the difference between gain scores for the experimental and control groups. Alpha, again, was set at the .10 level. The total number of correct responses on each test form by the control

TABLE 2

F-RATIO TEST OF THE HOMOGENEITY OF VARIANCES OF GAIN SCORES ON THE METRIC PERFORMANCE TEST

	df	Total number of correct responses: pre-test	post-test	total difference	Gain score standard deviation	F
Experimental	17	232	398	166	6.4493	1.2879
Control	17	247	402	155	5.0075	

For alpha at the .10 level, F = 1.9117

group was greater than the total number of correct responses by the experimental group. However, the increase in number of correct responses between pre-test and post-test was higher for the experimental group.

Table 3 shows that there was a significant difference between the gain scores of the two groups in favor of the experimental treatment. The mean gain scores for the experimental and control groups were 9.22 and 8.61, respectively.

The environment in which the students received instruction appears to have affected student learning. The experimental group obtained higher gain scores on the metric performance test as a result of the different method through which cognitive concepts were presented to them. The fact that students in the experimental group experienced the

TABLE 3

DIFFERENCE BETWEEN MEAN GAIN SCORES FOR EXPERIMENTAL AND CONTROL GROUPS

	df	Standard deviation	Total difference	t
Experimental	17	6.4493	166	13.7965
Control	17	5.0075	155	

For alpha at the .10 level, t = ±1.3070

length of the units of measurement through physical activity and were exposed to a variety (in contrast to the usual classroom techniques) of instructional techniques could account for the difference in gain scores. This theory is supported by the findings of Humphrey (1965), who utilized active games rather than language workbook exercises to enhance third grade student learning of certain language concepts. The experimental treatment in the present study provided an additional means by which the students could relate to the concepts of linear metric measurement. The data from this study and Humphrey's study indicate that certain cognitive concepts can be learned through motor and perceptual-motor experiences.

In this study the students received eight days of instruction in linear concepts of metric measurement. The investigator noticed that up to the fifth day of treatment, both groups appeared to improve in their comprehension of the concepts being presented. However, after the fifth day of treatment the students did not appear to make a noticeable positive change in learning linear concepts of metric measurement. This observation was based on student responses during treatment periods and written worksheet responses for both experimental and control subjects. This observation is further enhanced by data gathered during the pilot study. In the pilot study the students received four days of instruction in linear concepts of metric measurement. The means for the pre-test and post-test forms (which were administered to the students at the end of the treatment period) were both 23.00. The mean for the post-test in this study was 22.22.

None of the students in this study were eliminated as a result of absences. One student in the experimental group was absent for three of the eight days of treatment. However, with only five days of instruction, his performance on the metric performance tests was not atypical of the other students involved in this study. Consequently, the data gathered on this student were not dropped from this study. This student's performance also suggests that five days of treatment may be an adequate amount of time for treatment.

Data also were examined for the parts of the total test which related to meter/centimeter and millimeter concepts. An F-test was calculated on the data for objectives related to meter/centimeter and millimeter concepts to determine if the variances of the gain scores for the two groups were equal. From the data presented in Tables 4 and 5, it can be seen that homogeneity of population variances can be assumed for the data on both meter/centimeter and millimeter concepts. The probability (alpha) of making a type I error was limited to the .10 level for this analysis.

Since the F-test indicated equality of gain-score variances and normality was demonstrated by a subjective evaluation of the graphs of the various frequency distributions, a t-test was selected to determine the difference between gain scores for the experimental and control groups on objectives related to meter/centimeter and millimeter concepts. Alpha was set at the .10 level. Table 6 demonstrates that, for objectives related to centimeter/meter concepts, there was a significant difference between the gain scores for the two groups in favor of the experimental treatment. The mean gain scores for the experimental and control groups were 3.39 and 3.11, respectively.

Table 7 demonstrates that, for objectives related to millimeter concepts, there was a significant difference between the gain scores for the two groups in favor of the control treatment. The mean gain scores for the experimental and control groups were 2.22 and 2.61, respectively.

It was determined that students in the experimental group scored higher than students in the control group on objectives that involved meter and centimeter concepts. However, the control group scored higher than the

TABLE 4

F-RATIO TEST OF THE HOMOGENEITY OF VARIANCES FOR GAIN SCORES ON OBJECTIVES RELATING TO METER/CENTIMETER CONCEPTS

Groups	df	Total number of correct responses: pre-test	post-test	Total dif-ference	Gain score standard deviation	F
Experi-mental	17	56	117	61	2.9132	1.0975
Control	17	57	113	56	2.6543	

For alpha at the .10 level, F = 1.9117

TABLE 5

F-RATIO TEST OF THE HOMOGENEITY OF VARIANCES FOR GAIN SCORES ON OBJECTIVES RELATING TO MILLIMETER CONCEPTS

Groups	df	Total number of correct responses: pre-test	post-test	Total dif-ference	Gain score standard deviation	F
Experi-mental	17	74	114	40	2.2894	1.0162
Control	17	85	132	47	2.2527	

For alpha at the .10 level, F = 1.9117

TABLE 6

DIFFERENCE BETWEEN MEAN GAIN SCORES FOR EXPERIMENTAL AND CONTROL GROUPS ON OBJECTIVES RELATING TO METER/CENTIMETER CONCEPTS

	df	Standard deviation	Total difference	t
Experimental	17	2.9132	61	8.9976
Control	17	2.6543	56	

For alpha at the .10 level, t = ±1.3070

TABLE 7

DIFFERENCE BETWEEN MEAN GAIN SCORES FOR EXPERIMENTAL AND CONTROL GROUPS ON OBJECTIVES RELATING TO MILLIMETER CONCEPTS

	df	Standard deviation	Total difference	t
Experimental	17	2.2894	40	13.9470
Control	17	2.2527	47	

For alpha at the .10 level, t = ±1.3070

experimental group on objectives that involved millimeter concepts. It is conceivable that the small size of the millimeter is not conducive to learning through physical activity.

The investigator observed that the experimental group and the control group demonstrated similar cooperation and enthusiasm throughout this study. However, within each group the third hour experimental group and the fifth hour control group were noticeably more responsive and cooperative than their counterparts. Although the majority of students involved in this study welcomed the opportunity to leave their study hall period, there were a few students who expressed dissatisfaction with the alteration of their normal schedules. However, even these students usually were cooperative during the treatment periods.

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine the effects of a metrically oriented physical activity program on the ability of sixth grade students to learn linear units of metric measurement. A metrically oriented activity program was designed to be used in the gymnasium by the experimental group. A metrically oriented workbook program was designed to be used in the classroom by the control group.

Thirty-six sixth grade students enrolled in the third, fourth, fifth and sixth hour study hall periods at the T. S. Nurnberger Middle School, St. Louis, Michigan, served as the subjects. The third and fourth hour study hall students were designated as the experimental group. The fifth and sixth hour study hall students were designated as the control group. At the beginning of the program a pre-test in linear metric measurement was administered to all students. After thirty minutes of instruction each day for an eight-day period, a post-test in linear metric measurement was administered to all students.

An F-test was run to determine if the gain score variances between the two groups were equal. The result of the F-test demonstrated that homogeneity of population variances could be assumed.

After checking the assumption of normality and establishing that the variances of the gain scores were equal, a t-test was computed to establish if there was a significant difference between gain scores of the experimental group and the control group. It was determined that there was a significant difference between gain scores for the two groups at the .10 level in favor of the experimental group.

Conclusion

Within the limitations of this study, and in relation to the analysis of the composite test scores, it can be concluded that there is a significant advantage in learning linear concepts of metric measurement through exposure to a metrically oriented physical activity program as compared to learning the concepts through a metrically oriented workbook program. From subsequent analysis of partial test score data, however, it can be concluded that certain millimeter concepts of metric measurement can be learned more effectively through workbook activities than through physical activities. This analysis of partial test score data reinforced the conclusion that meter/centimeter concepts of metric measurement can be learned more effectively through physical activities than through workbook activities.

Recommendations

The investigator feels that additional research is needed in the area of physical activity and learning, specifically linear concepts of metric measurement. The following recommendations are made in conjunction with this study:

1. A test should be developed and used in which students would estimate various distances in metric units. It is possible that the ability to estimate distances in metric units might be enhanced more by an activity program than by a workbook program. Measurement should not be limited to paper and pencil situations as was the testing procedure in this study.

2. A shorter amount of treatment time with a review of all concepts at the end of instruction should be tested to see if it is as effective a treatment as the originally recommended amount of time.

APPENDICES

APPENDIX A

Unit 1: Linear Measurement

Lesson 1

Concept: Meter

Objective 1: Given the term meter/m the student will select the word/symbol for the term from a list. 3 minutes

Experimental Group: Display card 1 for students to see. Read card 1 to students. Explain that meter is a suffix to all units of linear measurement.

Control Group: Display card 1 for students to see. Read card 1 to students. Explain that meter is a suffix to all units of linear measurement.

Objective 2: "Given a measuring stick scaled in... meters and an object, the learner will measure the length of the object to the nearest...meter." 10 minutes

Experimental Group: Students will measure a 1 meter distance on the floor and then take one step for that distance. Students will then measure other distances (3, 5 and 10 m) and jump, hop, and run (respectively) that distance.

Control Group: Teacher will assign an item in the room to each student. Students will measure and record on paper how many meter(s) long their object is. When students are finished they will guess the length of each item. The student who was responsible for measuring the item will report the actual measured length of the object.

Concept: Kilometer

Objective 13: "The learner will..." select from a list "...the number of meters in one kilometer and give the correct symbol for kilometer." 17 minutes

Experimental Group: Display card 2 for the students to see. Read card 2 to the students. Explain that 1,000 meters equal 1 kilometer.

Students will pace and jog 1 kilometer in a marked off area. The kilometer distance will be marked in units of 100 meters. The first 100 meters will be paced and the next 100 meters will be jogged. Every 100 meters will be alternated between pacing and jogging.

Control Group: Display card 2 for the students to see. Read card 2 to the students. Explain that 1,000 meters equal 1 kilometer.

Distribute worksheet: *Milliken*, Book 3, p. 8. Students will complete and then correct the worksheet in class.

METER M

CARD 1

WHITE POSTERBOARD CARD 1m x 2dm; LETTERS BLACK 4cm x 3cm

KILOMETER KM

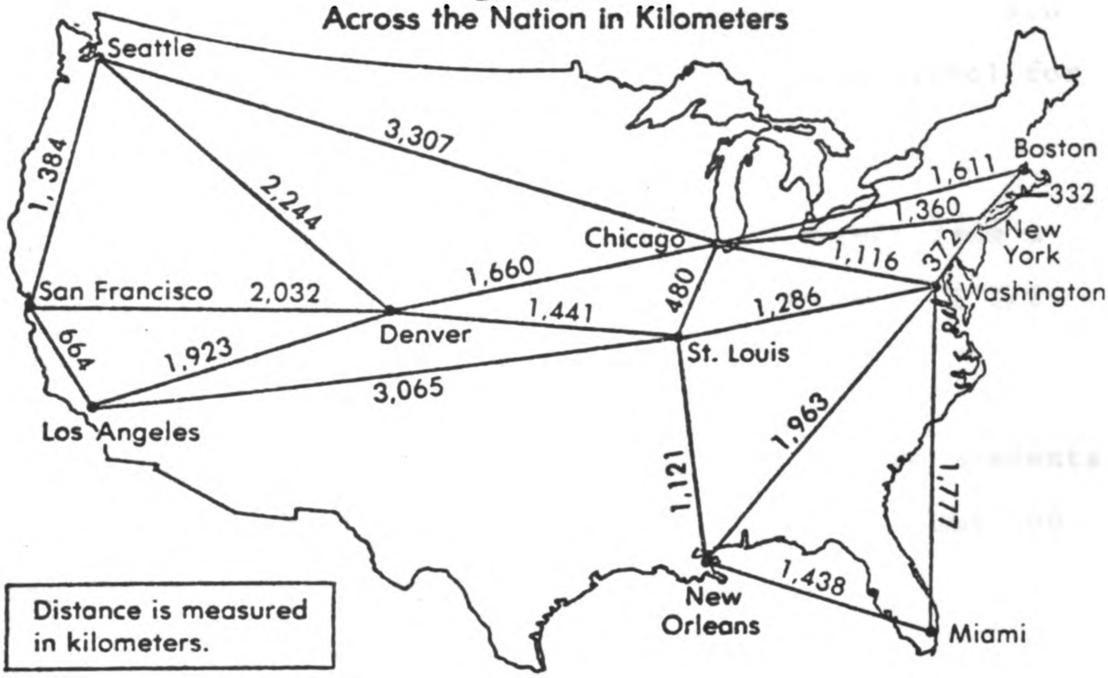
1000M = 1KM

CARD 2

WHITE POSTERBOARD CARD 1m x 2dm; LETTERS BLACK 4cm x 3cm

Lesson 1

Across the Nation in Kilometers



1. What is the distance from:
   a) San Francisco to Denver to St. Louis? ____________________
   b) Chicago to Washington to Miami? ____________________
   c) New Orleans to St. Louis to Chicago to Seattle? ____________________
   d) Los Angeles to Denver to Chicago to Boston? ____________________
2. What is the shortest route from:
   a) Miami to Chicago? ____________________
   b) Washington to San Francisco? ____________________
   c) New Orleans to Los Angeles? ____________________
   d) Denver to Seattle? ____________________
   e) St. Louis to Boston? ____________________

Write the following on the back of this paper.

3. Plan a trip traveling less than 1,000 kilometers.

   ____

4. Plan a trip traveling between 1,500 and 2,000 kilometers.

   ____

5. Plan a trip traveling between 3,000 and 3,500 kilometers.

   ____

Lesson 2

Concept: Centimeter

Objective 1: Given the term centimeter/cm the student will select from a list the correct word/symbol for the term. 1 1/2 minutes

Objective 3: "The student will..." select from a list "...the number of centimeters in a meter." 1 1/2 minutes.

Experimental Group: Display card 3 for the students to see. Read card 3 to the students. Explain that 100 centimeters equal 1 meter.

Objective 2: "Given a measuring stick scaled in... centimeters and an object, the learner will measure the length of the object to the nearest...centimeter." 27 minutes

Experimental Group: Distribute Experimental Worksheet No. 2. Students will walk heel-to-toe on a narrow line (crack in boards) on the floor leaving a 1 cm (up to 10 cm) distance between the heel and toe. A student will have a partner measure and record the distance and symbol on Experimental Worksheet No. 2. With each of the next steps, the distance between the heel and the toe will be 2 cm, 3 cm, 4 cm, etc., up to 10 cm. The students then will jump 1 m. Partner A will measure and record the distance jumped by Partner B (the distance from the starting line to the heel). The distance, symbol, and an indication of how close to 1 m (-1 m, 1 m, or +1 m) the jump was, will be recorded in the meter column on the sheet. Students then will change responsibilities.

Control Group: Distribute worksheets: *Milliken,* Book 1, pp. 7, 10, 18; *Milliken,* Book 3, p. 3. Students will complete all worksheets in class and correct them during the last 10 minutes of class.

CENTIMETER CM

100CM=1M

CARD 3

WHITE POSTERBOARD CARD 1m x 2dm; LETTERS BLACK 4cm x 3cm

Lesson 2
HEEL-TO-TOE

NAME ________

MARK DISTANCE IN CENTIMETERS AND USE SYMBOLS

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

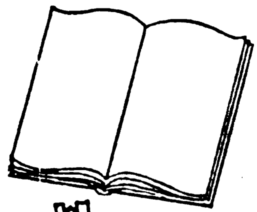
JUMP

1st try		2nd try		3rd try	
centimeter	meter	centimeter	meter	centimeter	meter

Lesson 2

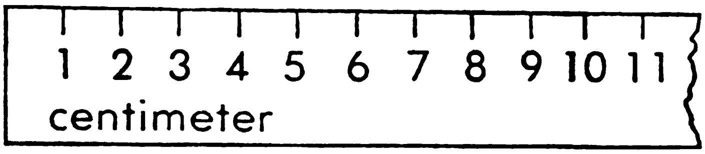
Meet the Centimeter.

Meet your friend, the centimeter.
He will help you see
The length of books and pencils,
A silver nail, and a golden key.



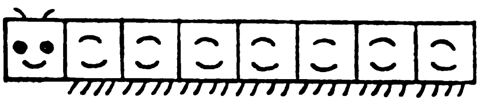
a centimeter

A **centimeter** is a unit of measure.

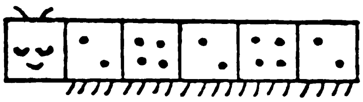


This is a **centimeter ruler.**

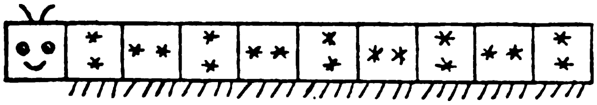
Measure each little centipede with your centimeter ruler.



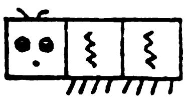
☐ centimeters



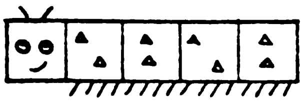
☐ centimeters



☐ centimeters



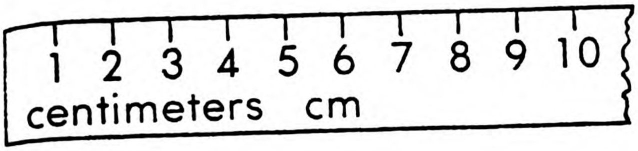
☐ centimeters



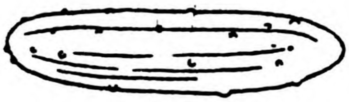
☐ centimeters

Lesson 2

How Does Your Garden Grow?

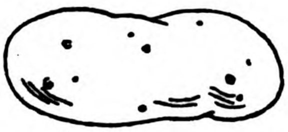


John and Ann have had a garden all summer. Use your centimeter ruler to measure each of the vegetables that they grew. Measure to the nearest centimeter.

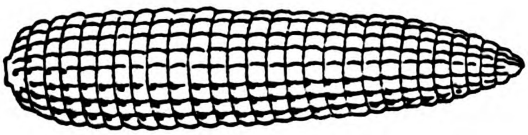


☐ centimeters (cm) long

☐ centimeters (cm) long



☐ centimeters (cm) long



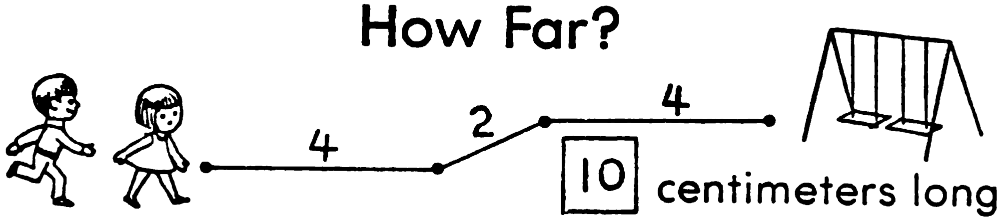
☐ centimeters (cm) long

☐ centimeters long
or
☐ cm long

☐ centimeters long
or
☐ cm long

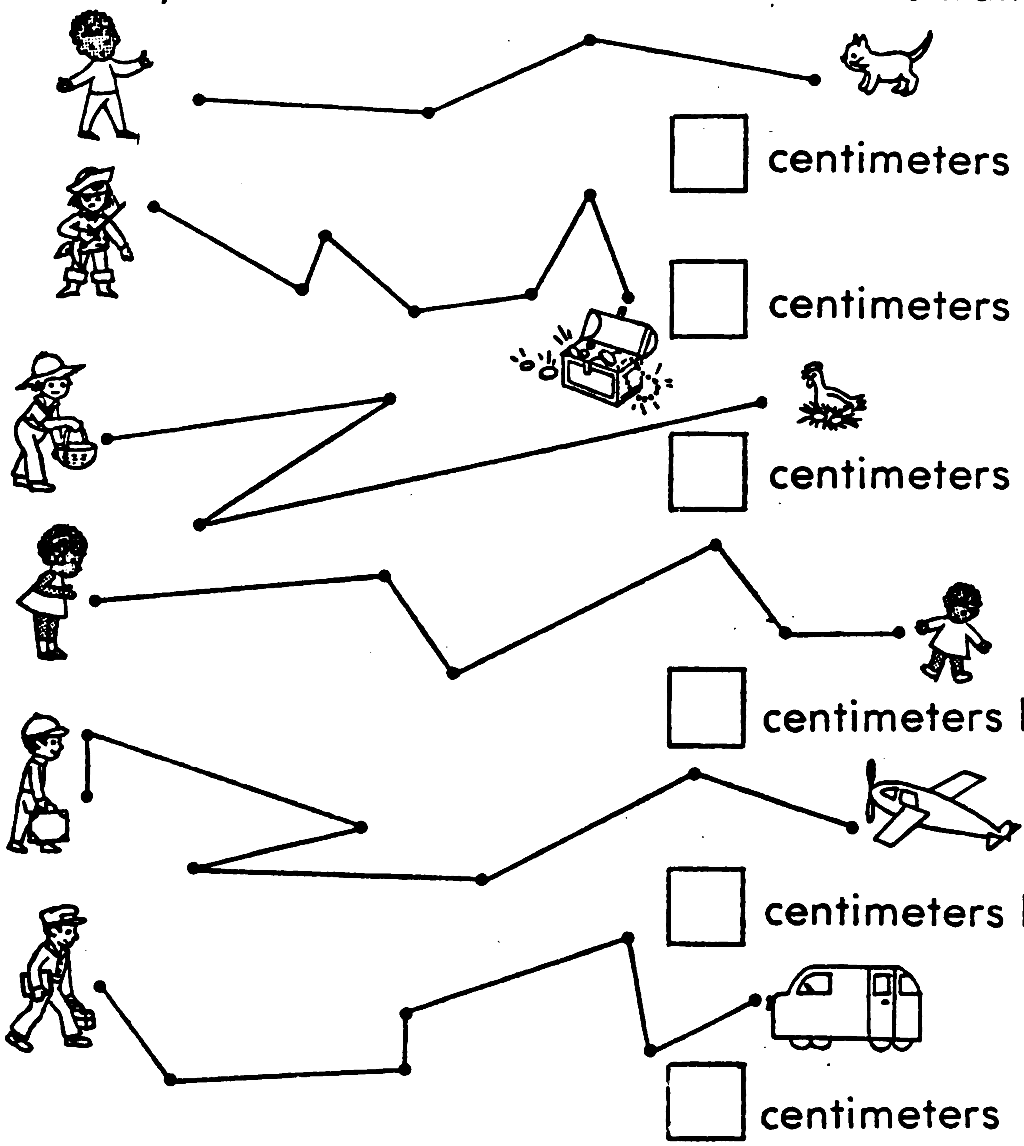
Lesson 2

How Far?



centimeters long

Use your centimeter ruler to measure the trails.



centimeters long

centimeters long

centimeters long

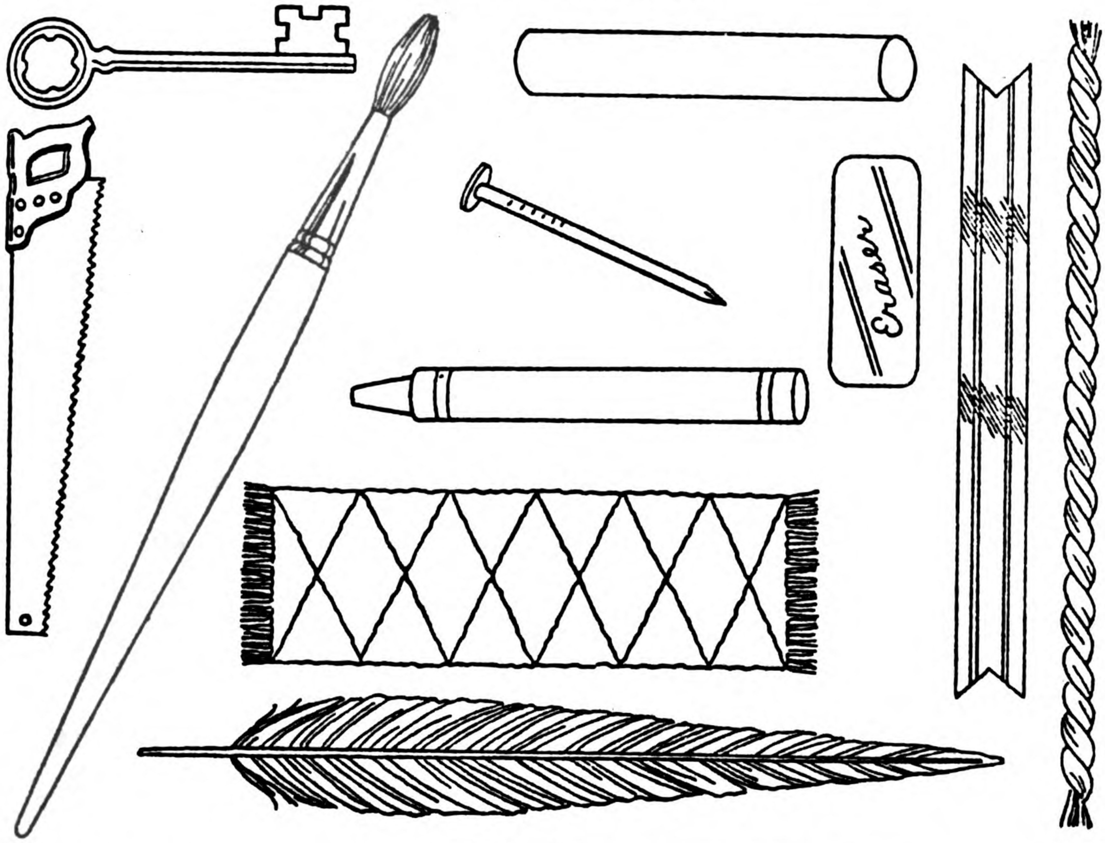
centimeters long

centimeters long

centimeters long

Lesson 2

A Centimeter Puzzle



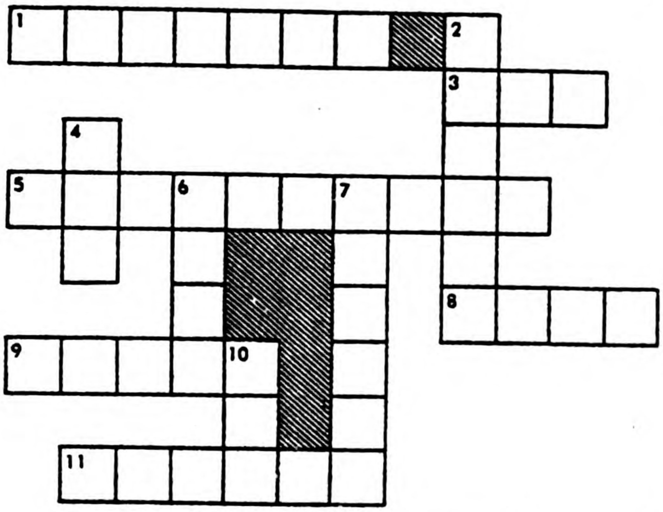
Find the item that fits each measurement and place its name in the appropriate box of the crossword puzzle.

Across

1. 15 cm
3. 10 cm
5. 16 cm
8. 14 cm
9. 7 cm
11. 8 cm

Down

2. 4 cm
4. 9 cm
6. 5 cm
7. 11 cm
10. 6 cm



Lesson 3

Concept: Meter = Centimeter
Centimeter = Meter

Objective 4: "Given any whole number of meters (1-9), the learner will..." select from a list "...an equivalent number of centimeters." 15 minutes

Objective 12: "Given a whole number of centimeters (1-1,000), the learner will..." select from a list "...an equivalent number of meters." 15 minutes

Experimental Group: Distribute Experimental Worksheet No. 3. The students will be divided into groups of two. All students will do the long jump. Partner A will run 5 meters and jump (long jump) from a marked point. Partner B will mark where Partner A's foot landed. Prior to the jump all students will first guess and record the length of the run in meters and centimeters. The estimate is to be written down. Run length will then be measured by the students in centimeters and meters and compared to the estimated amount. After the student jumps, he will estimate the distance jumped in both centimeters and meters. The estimates will be written down. The distance jumped will be measured in centimeters and meters.

Control Group: Distribute Experimental Worksheet No. 3. Students will complete the worksheet and correct it in class. Use flash cards for the remaining time.

EXP 3

NAME ________

RUN LENGTH

MARK DISTANCE IN CENTIMETERS AND METERS. USE SYMBOLS.

guessed		measured	
centimeter	meter	centimeter	meter

LONG JUMP

MARK DISTANCE IN CENTIMETERS AND METERS. USE SYMBOLS.

guessed		measured	
centimeter	meter	centimeter	meter

Lesson 3

Worksheet 3

Convert the following meters into centimeters. Write your answers in the spaces provided.

4m	____________	1m	____________	7m	____________
2m	____________	9m	____________	3m	____________
8m	____________	6m	____________	5m	____________

Convert the following centimeters into meters. Write your answers in the spaces provided.

1,000cm	____________	300cm	____________	500cm	____________
800cm	____________	700cm	____________	600cm	____________
900cm	____________	400cm	____________	200cm	____________
100cm	____________				

Lesson 4

Concept: Centimeter = Meter

Objective 5: "Given any multiple of 100 centimeters (100-900), the learner will..." select from a list "...an equivalent number of meters." 30 minutes

Experimental Group: Distribute Experimental Worksheet No. 4. The students will be divided into groups of two. Partner A will record meter and centimeter distances that he thinks he will throw the ball (under-handed) while Partner B marks the point at which the ball lands. Partners will work together with a meter/centimeter measurement tool to measure the distance that the ball was thrown. The actual distance of the throw will be recorded in meters and centimeters. Partner B then will throw the ball while Partner A marks the landing spot. The distance will be measured with a meter/centimeter measurement tool.

Control Group: Distribute worksheet: *Milliken*, Book 3, p. 5. Students will complete and correct the worksheet with the teacher in class.

EXP 4

NAME ____________________

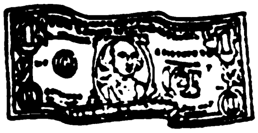
BALL THROW

MARK DISTANCE IN CENTIMETERS AND METERS. USE SYMBOLS.

estimated distance		measured distance	
centimeter	meter	centimeter	meter

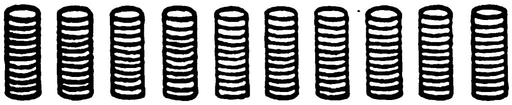
Lesson 4

Money and Measures



1 Dollor

10 Dimes



100 Pennies

Name the value in cents.		Name the value in centimeters	
1) 4 dollars 6 dimes 2 pennies	________	7) 2 m 6 cm	________
2) 9 dollars 1 dime 6 pennies	________	8) 3 m 1 cm	________
3) 7 dollars 0 dimes 5 pennies	________	9) 8 m 0 cm	________
4) 3 dollars 3 dimes 0 pennies	________	10) 4 m 7 cm	________
5) 6 dollars 4 dimes 1 penny	________	11) 9 m 0 cm	________
6) 8 dollars 0 dimes 0 pennies	________	12) 6 m 5 cm	________

Money and meters are written in a similar manner.

145¢ = $1.45   145 cm = 1.45 m

360¢ = $3.60   360 cm = 3.6 m (the zero is dropped)

Write the value in meters.		Write the value in centimeters.	
13) 103 cm ________	18) 660 cm ________	23) 6.14 m ________	28) 4.03 m ________
14) 516 cm ________	19) 1568 cm ________	24) 4.09 m ________	29) 12.17 m ________
15) 920 cm ________	20) 1210 cm ________	25) 9.81 m ________	30) 24.09 m ________
16) 445 cm ________	21) 2102 cm ________	26) 6.5 m ________	31) 42.6 m ________
17) 892 cm ________	22) 4520 cm ________	27) 7.3 m ________	32) 87.9 m ________

Circle the largest measure.				Circle the smallest measure.			
33)	3 m	301 cm	3 cm	39)	2 m	2 cm	25 cm
34)	8.2 m	802 cm	80 cm	40)	8.5 m	8.05 m	800 cm
35)	17.12 m	17.02 m	17.2 m	41)	1.21 m	1.02 m	1.01 m
36)	59.8 m	598 cm	1598 cm	42)	61 cm	6.1 m	601 cm
37)	4.3 m	435 cm	43 m	43)	14.7 m	1407 cm	140 m
38)	12.1 m	1218 cm	12.08m	44)	28.08 m	2.80 m	208 cm

Lesson 5

Concept: Millimeter; Millimeter = Meter

Objective 1: Given the term millimeter/mm the student will select the correct word/symbol from a list. 1 1/2 minutes

Objective 7: "The learner will..." select from a list "...the number of millimeters in one meter." 1 1/2 minutes

Experimental Group: Display card 4 for the students to see. Read card 4 to the students. Explain that 1,000 millimeters equal 1 meter.

Control Group: [same directions as Experimental Group]

Objective 6: "The learner will..." select from a list "...the number of millimeters in one centimeter." 2 minutes

Experimental Group: Display card 4 for the students to see. Read card 4 to the students. Explain that 10 millimeters equal 1 centimeter.

Control Group: Display card 4 for the students to see. Read card 4 to the students. Explain that 10 millimeters equal 1 centimeter.

Objective 11: "Given any number of millimeters (1-100), the learner will..." select from a list "...an equivalent number of centimeters." 25 minutes

Experimental Group: Distribute Experimental Worksheet No. 5. Students will divide into groups of two. Partner A will stand at the edge of the tumbling mat and do a forward sommersault. Partner B will mark the point with chalk (to be called "point A") where the toes of the most forward foot land. Distance will be measured in centimeters from the edge of the mat to the point where the toes of the most forward foot land.

The centimeter distance will be recorded and converted to millimeters on the worksheet. Partner A will then do a forward sommersault in the tuck position. Partner B will mark point (to be called "point B") with chalk where toes of most forward foot land. Distance will be measured in millimeters from the edge of the mat to the point where the toes of the most forward foot land. The millimeter distance will be recorded and converted to centimeters on the worksheet. The distance between point A and B then will be measured in centimeters and recorded and converted to millimeters on the worksheet. Partners will then change responsibilities.

Control Group: Distribute Experimental Worksheet No. 5: *Hayes*, p. 8. Allow 15 minutes for students to complete and correct the worksheet (with teacher) in class.

In the remaining time the students will have an opportunity to select objects that appear to be 10 centimeters or less in length and guess the actual length in centimeters and equivalent millimeters. The teacher will measure the object and report the true length to the class.

MILLIMETER MM

10MM = 1CM

1000MM = 1M

CARD 4

WHITE POSTERBOARD CARD 1m x 2dm; LETTERS BLACK 4cm x 3cm

EXP 5

Name ______________________

FORWARD SOMMERSAULT

RECORD DISTANCE IN MILLIMETERS AND CENTIMETERS. USE SYMBOLS.

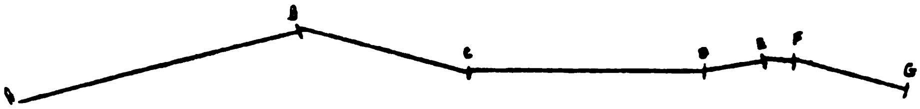
sommersault (Point A)		tuck sommersault (Point B)	
millimeter	centimeter	millimeter	centimeter

MEASURED DISTANCE FROM POINT A TO POINT B

millimeter	centimeter

LESSON 5

Measure each line segment. Record length of each segment in centimeters and millimeters.



line A B= _____mm _____cm

line B C= _____mm _____cm

line C D= _____mm _____cm

line D E= _____mm _____cm

line E F= _____mm _____cm

line F G= _____mm _____cm

Convert the following lengths to centimeters.

9 mm = _______

42 mm = _______

85 mm = _______

100 mm = _______

7 mm = _______

36 mm = _______

1 mm = _______

Lesson 5

MILLIMETERS 8

You probably noticed that your ruler has smaller divisions on it than the centimeter. This unit is called the millimeter.

Take a finger and put it on your thumb. Pull them apart so that you can just see light between them. That distance is about one millimeter. The symboi for millimeter is mm, without a period, as "10 mm are in one centimeter."

A. Study your ruler to answer these questions.

1. There are ________ millimeters in a centimeter.
2. There are ________ centimeters in a meter.
3. There are ________ millimeters in a meter.

In the metric system we always use the one unit of measure that seems to be the best for the job.

B. What unit of measurement should we use to measure:

1. Your pencil's length ____________
2. Your height ____________
3. This sheet of paper ____________
4. The thickness of a nickel ____________
5. The length of the room ____________

C. Measure the following in the unit shown.

1. ——— = ________ cm
2. ——— = ________ mm
3. —————— = ________ cm
4. – = ________ mm
5. —— = ________ mm
6. ———————— = ________ cm
7. ———— = ________ mm
8. ———— = ________ cm

Make up at least five exercises of your own and answer them.

Lesson 6

Concept: Centimeter = Millimeter

Objective 9: "Given a number of centimeters, the learner will..." select from a list "...an equivalent number of millimeters." 30 minutes

Experimental Group: Distribute Experimental Worksheet No. 6. Students will be divided into groups of two. Partner A will jump (long jump) while Partner B marks the point where Partner A landed. The distance jumped will be estimated by the student in both centimeters and millimeters and then recorded. Partners then will measure and record on the worksheet the distance in centimeters and millimeters and compare the estimates and findings.

Control Group: Distribute Experimental Worksheet No. 6. Students will complete and correct the worksheet with the teacher in class.

EXP 6

Estimate and record the distance jumped in centimeters and millimeters. Use symbols.

ESTIMATE		MEASURED	
centimeters	millimeters	centimeters	millimeters

Worksheet

Lesson 6

Centimeter = Millimeter

Measure each line. Write length of each line in centimeters and millimeters.

A. ⊢———————⊣ cm = mm =

B. ⊢——⊣ cm = mm =

C. ⊢——————⊣ cm = mm =

D. ⊢————⊣ cm = mm =

E. ⊢⊣ cm = mm =

F. ⊢————————————————⊣ cm = mm =

G. ⊢—————————————⊣ cm = mm =

H. Measure the length of your desk. cm = mm =

I. Measure the height of your desk from the floor to the highest point of the desk. cm = mm =

J. Measure the length of a textbook. cm = mm =

K. Measure the width of a textbook. cm = mm =

L. Measure the length of the chalkboard. cm = mm =

Lesson 7

Concept: Centimeter = Millimeter: Whole Numbers and Decimals

Objective 10: "Given a number of centimeters expressed as a whole number and tenths the learner will..." select from a list "...an equivalent number of millimeters." 30 minutes

Experimental Group: Each student will secretly be assigned a number by the teacher. The teacher will work from a sequence of numbers that has been constructed so as not to deter any student from having the same number of opportunities to move forward. One of the numbers will be an unassigned number. Students will stand along the base line at one end of the gym. The teacher will call out three numbers prior to each flash card problem. The teacher will read the centimeter problem from the flash card and hold the flash card up for the students to see. The teacher will give millimeter answer. If the answer is correct the students will advance forward one step. Students whose number was called will not advance forward even if the flash card answer is correct. This is to keep some students from "copying" movements of the other students. If the answer is not correct, the students should not move. If a student advances for an incorrect answer he must step back two steps. If a student does not advance for a correct answer he will step back one step. Those students who reach the finish line first are the winners. Other movement skills, such as jumping and hopping, will be used in addition to stepping.

Control Group: Distribute Experimental Worksheet No. 7: *Weber Costello,* p. 2. Allow 20 minutes for students to complete and correct in class. Use flash cards for the remaining class time.

Lesson 7

Convert the following centimeter lengths to millimeters.

	A		B	
1)	4.5 cm	______	34.5 cm	______
2)	8.7 cm	______	27.9 cm	______
3)	32.8 cm	______	43.2 cm	______
4)	95.7 cm	______	9.5 cm	______
5)	83.2 cm	______	5.7 cm	______
6)	4.0 cm	______	8.5 cm	______
7)	92.8 cm	______	3.1 cm	______
8)	87.9 cm	______	50.0 cm	______
9)	65.2 cm	______	99.9 cm	______
10)	79.3 cm	______	87.5 cm	______
11)	2.4 cm	______	63.3 cm	______
12)	3.9 cm	______	30.5 cm	______

Lesson 7

NAME____________________

METRIC LENGTH
ADD THE MISSING PREFIXES

PREFIXES

kilo milli

centi

a.____________metre = 1000 metres

c.____________metre = 10 millimetres

e.____________metre = 100 centimetres

g.____________metre = 0.001 metre

h.____________metre = 0.01 metre

THINK METRIC! Measuring Length and Area 2
884-179, WEBER COSTELLO CO., 1974

Lesson 8

Concept: Centimeter = Millimeter in Multiples

Objective 8: "Given any multiple of 10 millimeters (10-1,000), the learner will..." select from a list "...an equivalent number of centimeters." 30 minutes

Experimental Group: Distribute Experimental Worksheet No. 8. Distribute one chalk board eraser to each group. Students will stand on a line in groups of two. A distance will be called out in millimeters by the teacher. Students will toss the eraser that given distance and then measure (cm and mm) the distance with a partner and record on a sheet to see how accurate the toss was.

Control Group: Distribute worksheets: *Weber Costello*, p. 1; *Weber Costello*, p. 3. Allow 20 minutes for students to complete and correct the worksheets in class. Select 10 objects in the classroom that measure from 10 to 1,000 millimeters. Ask the students for equivalent centimeter lengths.

EXP 8

Measure the distance thrown in millimeters and centimeters. Use symbols.

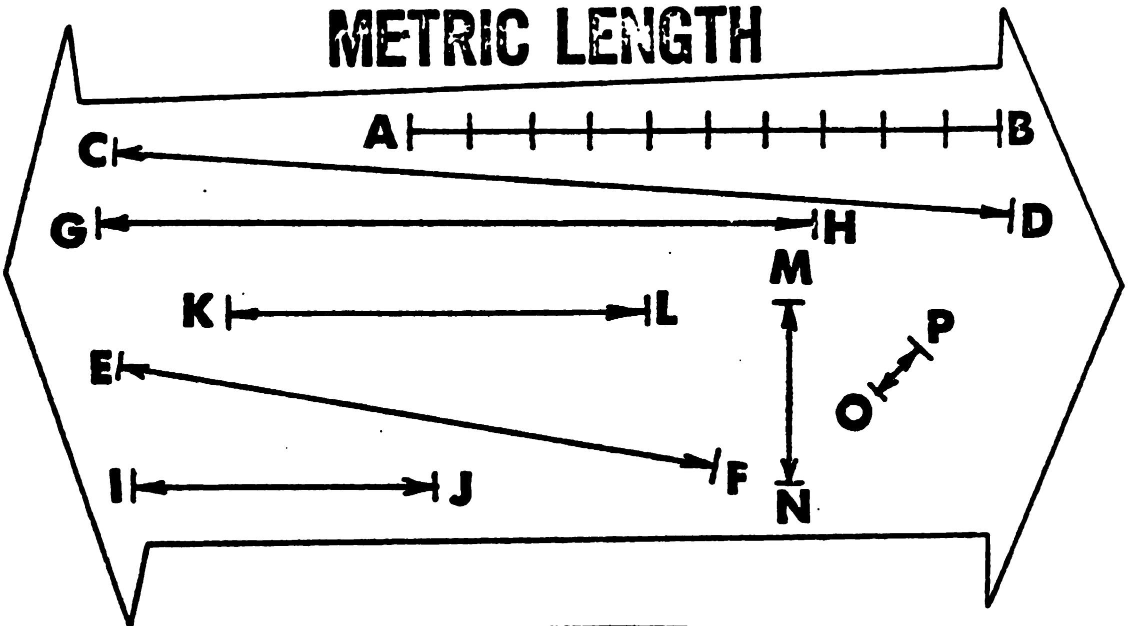
DISTANCE

millimeters	centimeters

Lesson 8

NAME_______________

ESTIMATING METRIC LENGTH



If line segment AB is 10 centimetres (cm) or 100 millimetres (mm),

1. Line segment CD is_______________cm or_______________mm.
2. Line segment EF is_______________cm or_______________mm.
3. Line segment GH is_______________cm or_______________mm.
4. Line segment IJ is_______________cm or_______________mm.
5. Line segment KL is_______________cm or_______________mm.
6. Line segment MN is_______________cm or_______________mm.
7. Line segment OP is_______________cm or_______________mm.

Total length of all line segments is_______________cm or_______________mm.

Lesson 8 NAME______________

UNSCRAMBLE the metric units of measure:

METRIC LENGTH

A. e i m n e t e

__c__ __t__ ______ __r__ = 10 millimetres

B. k r m e e l t

__i__ __o__ ________ = 1000 metres

C. e e m r t

__________ = 100 centimetres

D. t r e e m i i l

__m__ __l__ __________ = 0.001 metre

G. t m n c e t r e i

__e__ ______________ = 0.01 metre

APPENDIX B

The objectives appear in this appendix in the same order as they appear on the Michigan State Department of Education Minimal Performance Objective Appendix. However, the objectives are renumbered to provide more clarity when referring to individual objectives in each lesson plan. For reference purposes, in parentheses next to each objective is the objective number as it appears on the Michigan State Department of Education Minimal Performance Objective Appendix.

Objective	Total Number of Test Questions
1 (8) "Given the term meter, centimeter, millimeter/m, cm, mm the student will select the word/symbol for the term from a list."	6
2 (9) "Given a measuring stick scaled in meters and centimeters and an object, the learner will measure the length of the object to the nearest meter or centimeter."	8
3 (10) "The student will..." select from a list "...the number of centimeters in a meter."	2
4 (11) "Given any whole number of meters (1-9), the learner will..." select from a list "...an equivalent number of centimeters."	4

Objective	Total Number of Test Questions
5 (12) "Given any multiple of 100 centimeters (100-900), the learner will..." select from a list "...an equivalent number of meters."	6
6 (15) "The learner will..." select from a list "...the number of millimeters in one centimeter."	2
7 (16) "The learner will..." select from a list "...the number of millimeters in one meter."	2
8 (17) "Given any multiple of 10 millimeters (10-1,000), the learner will..." select from a list "...an equivalent number of centimeters."	4
9 (18) "Given any number of centimeters, the learner will..." select from a list "...an equivalent number of millimeters."	4
10 (19) "Given a number of centimeters expressed as a whole number and tenths the learner will..." select from a list "...an equivalent number of millimeters."	4
11 (20) "Given any number of millimeters (1-100), the learner will..." select from a list "...an equivalent number of centimeters."	6
12 (23) "Given a whole number of centimeters (1-1,000), the learner will..." select from a list "...an equivalent number of meters."	6
13 (24) "The learner will..." select from a list "...the number of meters in one kilometer and give the correct symbol for kilometer."	4

LINEAR METRIC
PERFORMANCE ASSESSMENT

GRADE SIX
FORM PRE

STUDENT NAME   L PRE

GRADE__________

27-22-1
What does the metric symbol <u>m</u> stand for?

A millimeter

B centimeter

C decimeter

D meter

27-23-3
What does the metric symbol <u>cm</u> stand for?

A millimeter

B centimeter

C decimeter

D meter

4
21- 4-1
3 meters is equal to how many centimeters?

A 3

B 30

C 300

D 3,000

5
21-11-1
900 centimeters is equal to how many meters?

A 9

B 90

C 900

D 9,000

27-27-2
What is the metric symbol for <u>millimeter</u>?

A m

B dm

C cm

D mm

3
27-28-1
100 centimeters is equal to how many meters?

A 0.1

B 1

C 10

D 100

21- 6-2
4 m= ☐ cm

A 40

B 400

C 4,000

D 40,000

21-13-2
700 cm= ☐ m

A 0.07

B 0.7

C 7

D 700

STUDENT NAME

L PRE

21-14-3
Which one of the following is equal to 600 centimeters?

A 6 m

B 60 m

C 600 m

D 6,000 m

7
21-10-1
1 meter is equal to how many millimeters?

A 1

B 10

C 100

D 1,000

21-22-2
700 millimeters is equal to how many centimeters?

A 0.07

B 0.7

C 7

D 70

21-29-2
70 centimeters is equal to how many millimeters?

A 0.7

B 7

C 70

D 700

6
21-18-1
1 centimeter is equal to how many millimeters?

A 10

B 100

C 1,000

D 10,000

8
21-20-1
30 millimeters is equal to how many centimeters?

A 0.3

B 3

C 30

D 300

9
21-27-1
2 centimeters is equal to how many millimeters?

A 0.02

B 0.2

C 2

D 20

10
21-34-1
2.5 centimeters is equal to how many millimeters?

A 0.25

B 2.5

C 25

D 250

STUDENT NAME L PRE

21-36-2
24.8 centimeters is equal to how many millimeters?

A 0.248

B 2.48

C 24.8

D 248

22- 4-2
9 mm= ( ) cm

A 0.09

B 0.9

C 9

D 90

12
22- 9-1
20 centimeters is equal to how many meters?

A 0.02

B 0.2

C 2

D 20

22-13-3
14 cm= ( ) m

A 0.014

B 0.14

C 1.4

D 14

11
22- 1-1
7 millimeters is equal to how many centimeters?

A 0.7

B 7

C 70

D 700

22- 6-3
31 mm= ( ) cm

A 3.1

B 31

C 310

D 3,100

22-11-2
400 cm= ( ) m

A 0.004

B 0.04

C 0.4

D 4

13
27-12-1
What does the metric symbol km stand for?

A Kelvin

B kilometer

C kilogram

D dekameter

STUDENT NAME L PRE

27- *-2
1 kilometer is equal to how many meters?

A 10

B 100

C 1,000

D 10,000

stop

DO NOT BREAK SEAL

IF YOU HAVE ANSWERED ALL QUESTIONS AND HAVE COMPLETED THE TEST, TAKE THE TEST TO THE FRONT OF THE ROOM

STUDENT NAME L PRE

Directions: Measure the tape line on the floor to the nearest meter.
Write your answers in the squares.

2
28- 1 -1

1. Line 1 is [ ] m long.

28- 2 -2

2. Line 2 is [ ] m long.

Directions: Measure the lines below to the nearest centimeter.
Write your answers in the squares.

2
28- 3- 3

Line 3 is [ ] cm long.

3. ____

28- 4- 4

Line 4 is [ ] cm long.

4. __________________

L I N E A R M E T R I C
P E R F O R M A N C E A S S E S S M E N T

GRADE SIX
FORM POST

STUDENT NAME L POST

1
27-24-1
What is the metric symbol for meter?

A mm

B cm

C dm

D m

27-26-3
What is the metric symbol for <u>centimeter</u>?

A m

B dm

C cm

D mm

4
21- 5-1
5 m= ☐ cm

A 5

B 50

C 500

D 5,000

5
21-12-1
800 cm= ☐ m

A 8

B 80

C 800

D 8,000

27-21-2
What does the metric symbol <u>mm</u> stand for?

A meter

B decimeter

C centimeter

D millimeter

3
21- 3-1
1 meter is equal to how many centimeters?

A 10

B 100

C 1,000

D 10,000

21- 7-2
2 meters is equal to how many centimeters?

A 2

B 20

C 200

D 2,000

21-15-2
200cm= ☐ m

A 0.0002

B 0.002

C 2

D 20

STUDENT NAME L POST

21-17-3
300 cm= ▭ m

A 3

B 30

C 300

D 3,000

7
27-30-1
1,000 millimeters is equal to how many meters?

A 0.0001

B 0.001

C 0.1

D 1

21-23-2
40 mm= ▭ cm

A 0.4

B 4

C 40

D 400

21-30-2
65 centimeters is equal to how many millimeters?

A 650

B 6,500

C 65,000

D 650,000

6
27-20-1
10 millimeters is equal to how many centimeters?

A 1

B 10

C 100

D 1,000

8
21-21-1
50 millimeters is equal to how many centimeters?

A 0.5

B 5

C 50

D 500

9
21-28-1
8 centimeters is equal to how many millimeters?

A 0.8

B 8

C 80

D 800

10
21-35-1
4.7 centimeters is equal to how many millimeters?

A 0.47

B 4.7

C 47

D 470

STUDENT NAME L POST

21-38-2
5.2 cm= ( ) mm

A 0.052

B 0.52

C 5.2

D 52

22- 5-2
5 mm= ( ) cm

A 0.05

B 0.5

C 5

D 50

12
22-10-1
2 centimeters is equal to how many meters?

A 0.02

B 0.2

C 2

D 20

22-14-3
114 cm= ( ) m

A 0.0114

B 0.114

C 1.14

D 11.4

11
22- 2-1
42 millimeters is equal to how many centimeters?

A 0.042

B 0.42

C 4.2

D 42

22- 7-3
12 mm= ( ) cm

A 0.012

B 0.12

C 1.2

D 12

22-12-2
4 cm= ( ) m

A 0.04

B 0.4

C 4

D 40

13
27-11-1
1,000 meters is equal to how many kilometers?

A 1

B 10

C 100

D 1,000

STUDENT NAME **L POST**

22-16-2
What is the correct symbol for <u>kilometer</u>.

A k

B kg

C kl

D km

stop

DO NOT BREAK SEAL

IF YOU HAVE ANSWERED ALL QUESTIONS
AND HAVE COMPLETED THE TEST, TAKE
THE TEST TO THE FRONT OF THE ROOM

STUDENTS NAME L POST

Directions: Measure the tape lines on the floor to the nearest meter. Write your answers in the squares.

2
28- *-1

1. Line 1a is [ ] m long.

28- *- 2

2. Line 2a is [ ] m long.

Directions: Measure the lines below to the nearest centimeter. Write your answers in the squares.

2
28- *- 3

Line 3 is [ ] cm long.

3. ————————————

28- *- 4

Line 4 is [ ] cm long.

4. ————————————————

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