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Signature Donna Whitehead Silverman

Date May 30, 1975

AN INTRODUCTION TO METRIC MEASUREMENT IN THE FOURTH GRADES OF THE BUTTE ELEMENTARY SCHOOLS

by

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ABSTRACT

The problem of this study of Butte fourth grade classes was to determine the current status of measurement instruction and to establish the appropriate performance objectives for teaching metric measurement.

The information was needed as a foundation for a curricula in the teaching of metric measurement to fourth graders. The population of the study was eighteen teachers from eleven of the fourteen elementary schools in Butte.

The major objectives of this study were: 1) to determine what media of instruction teachers feel is most effective in teaching measurement, 2) to determine the time limitations on a curricula for measurement, 3) to establish the performance objectives in metric measurement that teachers felt were important, 4) to develop a metric measurement program for children in the fourth grade in the Butte Elementary Schools.

Ninety-four percent of the volunteer teachers responded. The responses indicated an interest by teachers in metrication. A summary of the findings were:

1. Teachers rate a combined instructional media of printed and activity material as the most effective methods of teaching measurement.

2. Teachers feel a need for in-service training in the metric system and methodology of teaching metrication.

3. Teachers have little, if any, metric measurement materials available in their classroom.

4. Teachers rate instruction in linear measurement, area, perimeter, weight, and temperature as the most appropriate areas for fourth grade measurement lessons.

Chapter 1

DESCRIPTION OF THE PROJECT

Introduction

The United States has achieved an enviable position in industrial technology. The theories of mass production with standardization of assembly procedure, planned obsolescence, interchangeability of parts and efficiency of management have established a remarkable industrial entity. Measurement units and procedures are essential to our assembly-line techniques that so characterize our technological, industrial society (Osborn, 1974).

The tradition of British measure in the United States has created an extensive economic problem in the industrial and commercial world. Industrial parts constructed using the English system of measurement cannot be maintained with metric tools. The United States being the only major industrial country still using the English system of measurement is manufacturing products requiring unique tools for maintenance. The United States is gradually moving toward the metric system of measurement. Business and industry realize that world trade is dependent upon standardization of measurement units. Companies such as Caterpillar Tractor,

International Harvester and General Motors are converting their production assemblages to metric specification.

The Federal Government has recognized that the burden of teaching metrication to the general population resides with the schools. The schools will be responsible for the development of adequate courses of study and practical instruction which can be carried by the child from school to home. Federal Funds of $100,000,000 have been appropriated for educational needs generated by this transition. This money will alleviate some of the costs generated in the development of new programs.

The development of a satisfactory curriculum is dependent upon many factors within the school. Of primary concern is the educational and performance objectives determined by educators relative to the particular students. The curriculum should be based upon consideration of the childs academic growth and progress with measurement concepts at his particular grade level. Also to be effective the curriculum should provide foundation material for the teacher to facilitate ease of instruction.

Statement of the Problem

The problem of this study of Butte fourth grade classes was to determine the current status of measurement

instruction and establish the appropriate performance objectives for teaching metric measurement.

Purpose for the Study

This study had three objectives. The first objective was a survey of the present status of measurement instruction in the Butte fourth grade elementary schools. The second objective was to establish a set of student performance objectives relative to learning measurement in the metric system. The third objective was to construct a curricula of instruction in metric measurement for fourth graders. This curricula was based on Piaget's theories of intellectual development as it relates to measurement tasks. The content was based on the accepted (SI) metric standards in measurement of length, weight, and temperature. Performance objectives designated by the teachers as being most important were used as guidelines in developing the curriculum. The teachers preference of instructional media and time commonly allotted to measurement instruction were also considered in developing the program.

General Questions to be Answered

An attempt will be made to answer the following questions:

1. How much time is currently being allotted in the fourth grade to teach and develop measurement concepts?

2. What materials are currently available to teach metrics?

3. How confident do teachers feel about teaching the metric system?

4. What measurement objectives do teachers deem most important when teaching fourth graders?

5. What methods do teachers favor for teaching measurement?

General Procedure

To provide a foundation for the development of a scope and sequence for metrication the researcher administered a survey instrument to fourth grade teachers. The curriculum coordinator for the Butte School District notified each elementary school principal in the district of this survey. The researcher then personally contacted each principal to determine if they were interested in having their school participate in the study. Eleven of the fourteen elementary schools agreed to participate. The three schools which did not participate had only one fourth grade teacher each and these teachers are soon to retire. Eighteen volunteer teachers from the eleven schools received the

survey during the week of March 24, 1975. The compiled data and evaluations of these teachers are recorded in Chapter 4 of this study.

Delimitations of the Study

1) Scope of this study was limited to the design of a course of study specifically relevant to fourth grades in the Butte Public School District.

2) The teachers evaluating the appropriateness of the objectives had limited background in the metric system.

3) Several of the teachers expressed uneasiness in rating objectives for the metric system because of their inadequate backgrounds in the terminology.

4) All teachers indicated a need to have more training in teaching the metric system.

5) The researcher relied on volunteers and those interested in metrication to reply to the survey. Therefore the results do not represent all teachers in the school district.

Definition of Terms

Metrication--The process of changing from the British system of measurement to the Metric system as defined by the Internation System of Units (Hallerberg, 1973).

Spiral Curriculum Design--a school curriculum developed around a hierarchy of concepts through the inclusion of the same subjects or topics at various grade levels and at correspondingly varying levels of depth, abstraction and sophistication (Good, 1973).

Unit Curriculum Design--in curriculum, the organization of the instructional program into units of work such as subject-matter units (Good, 1973).

Summary

The United States is the leading industrialized nation of the world. To maintain this position it is imperative that this nation adopt the world metric measurement system. The conversion to this metric system will be aided by efficient instruction in the elementary school. The problem of this study of Butte Fourth grade classes was to determine the current status of measurement instruction and to establish appropriate performance objectives for teaching metric measurement. The purpose of this study was first to determine the present status of measurement instruction, second, to establish a set of student performance objectives relative to learning metric measurement, and third, to design a course of study reflecting the intellectual development of

the children and promoting the measurement skills rated as important by the teachers.

Chapter 2

REVIEW OF LITERATURE

Measure is basically a process of assigning number to the physical characteristics of length, weight, time and temperature. A measurement system is the family of units and standards, which, together provide the basis for measuring. The development of these systems varied throughout the world as each geographical region independently devised its own schemes. The Modernized International (SI) Metric System is nothing more than a simple language of measurement and provides, with just seven base units, a coherent system of interrelated units. The following is a genealogy of this system as it evolved from man's effort to devise decimal units of measurement.

Historical Development of the Metric System

In 1670 Gabriel Mouton, the Vicar of St. Paul's Church in Lyons, proposed a decimal system of weights and measure. His proposal designated that the basic unit of length be a fraction of the length of a great circle of the earth and then the multiples and sub-divisions were defined in successive powers of ten (Hopkins, 1974). Christopher Wren, founder of the Royal Society of London, proposed as the standard unit of length, the length of the pendulum

whose swing takes one second. This relationship of length to time is known as the Principle of the Pendulum. The pendulum length was called one meter and provided a standard of measurement readily available to any country (William, 1973).

A metric system of measurement was developed by the French Academy in 1790. The unit of length in this system was defined as the circumference of earth along a meridian divided by forty million. This unit was named the metre--a derivative of the Greek word metron meaning "a measure" (Ver Voodt, 1973).

The need for a uniform measure was also being discussed in the United States Congress. The Constitution had provided that the Congress should have the power "to coin money, . . .and fix the standard of weights and measurements." Prior to this Thomas Jefferson had convinced the Congress of the Confederation to adopt the dollar based on the decimal system, and by 1792 the coinage system was implemented. Jefferson then borrowed the Principle of the Pendulum to establish a standard of length. He suggested the rod be divided into five sections each called a "foot." Each foot was then to be divided into ten equal parts, thereby, initiating a decimal system. Similarly, measures

based on divisions of ten were suggested for weight and volume (Hallerberg, 1973). Unfortunately, Congress was not receptive to this proposal and designated the British System as the system of measurement to be used in the United States.

As the English speaking world legislated laws to regulate and improve the measurement system, France simply discarded the old system and adopted a new one in its place. Politics and religion were the leading forces which discouraged American-British adoption of the French metric system. This system was conceived during the French Revolution and became associated with the "godless," or "atheists." It was commonly referred to as "a system conceived in sin and born in iniquity" (Hallerburg, 1973). Rather than limiting the revision to weights and measures the French also converted the seven day week into ten days and abolished the Sabbath. This alone was reason enough for the American colonists to reject any good the system might have had.

A document representing a complete investigation of the metric and English systems of measurement was submitted to Congress in 1821 by John Quincy Adams (Hopkins, 1974). Adams recommended retention of the English system by the United States, but he proposed a program for achieving greater uniformity among the States. He also recommended

that the President negotiate with France, England, and Spain with the intent of achieving uniformity of measurement among all four nations. Adams concluded, however, that "the time was not right" at home for adopting a metric system (Suydam, 1974).

Legislation in 1866 made it "lawful throughout the United States to employ the weights and measures of the metric system." As a result of this legislation the natural sciences are currently using the metric system almost exclusively (Suydam, 1974).

As of 1893, the United States prototype meter and kilogram have been considered the nation's "fundamental standard of length and mass." Under these new procedures the units of the English customary system were defined, not by their own standard, but by careful specification of the fraction of a meter that determined a yard and the fraction of a kilogram that constituted a pound (Hopkins, 1973). The national yard is $\frac{3600}{3937}$ of a meter.

Exactly one hundred years ago the Treaty of the Meter was signed in Paris by seventeen nations, including the United States. The treaty provided for the fabrication of new and improved standards for metric weights and measures, the establishment and maintenance of a permanent

International Bureau of Weights and Measures, and the creation of a general conference as a permanent deliberative body to pass upon international weight and measure matters. Final United States approval of the Treaty was granted in 1878 (Hopkins, 1974).

Thirty-five nations had officially accepted the metric system by the beginning of the twentieth century. This phenomenal growth is accounted for by historian Edward F. Cox:

> The Metric system was the scientifically recommended one in an age when science and its products were being welcomed into society. The many national adoptions produced a "band-wagon" effect and induced further adoption. The great acceleration of world trade led men of commerce, with ever greater familiarity, to proclaim the virtues of the system and to urge more adoption. It was often associated with "Progress" in an age of "Progress" (Hopkins, 1974).

The issue of metrication in the United States remained quite dormant until the 1960's. The launching of Sputnik not only upset the United States relative to her security in mathematics and science but also led to an investigation of her system of measurement. This period of time also gave rise to the redefinition of the meter in terms of a wave length of light. It was defined as 1,650,763.73 wavelengths of the orange-red line produced by krypton 86 (Hopkins, 1974). The modernized metric system known as the

International System of Units (SI) was established and the metric system became stronger and more universal.

In 1968, Congress directed the Secretary of Commerce to undertake the three-year United States Metric Study to evaluate the impact of the metric trend and to consider alternatives for national policy (Suydam, 1974). The resulting thirteen volume survey of manufacturers and non-manufacturers, indicated an overwhelming majority supported the move as being in the national interest (Hopkins, 1974). It was recommended that the States change to predominant use of the metric system through a coordinated national program. Ten years was the recommended time schedule and firm governmental commitment to this goal was asked (Helgren, 1973). Also, early priority was to be given to educating every American school child and the public at large to think in metric terms (Helgren, 1973).

In 1972 The Metric Conversion Act was passed by the Senate, but no action was taken by the House. Currently, fourteen countries are preparing to go metric to join the 114 that already have. The following is a map showing the countries of noncommitment to metrication (What About Metric, (1973).

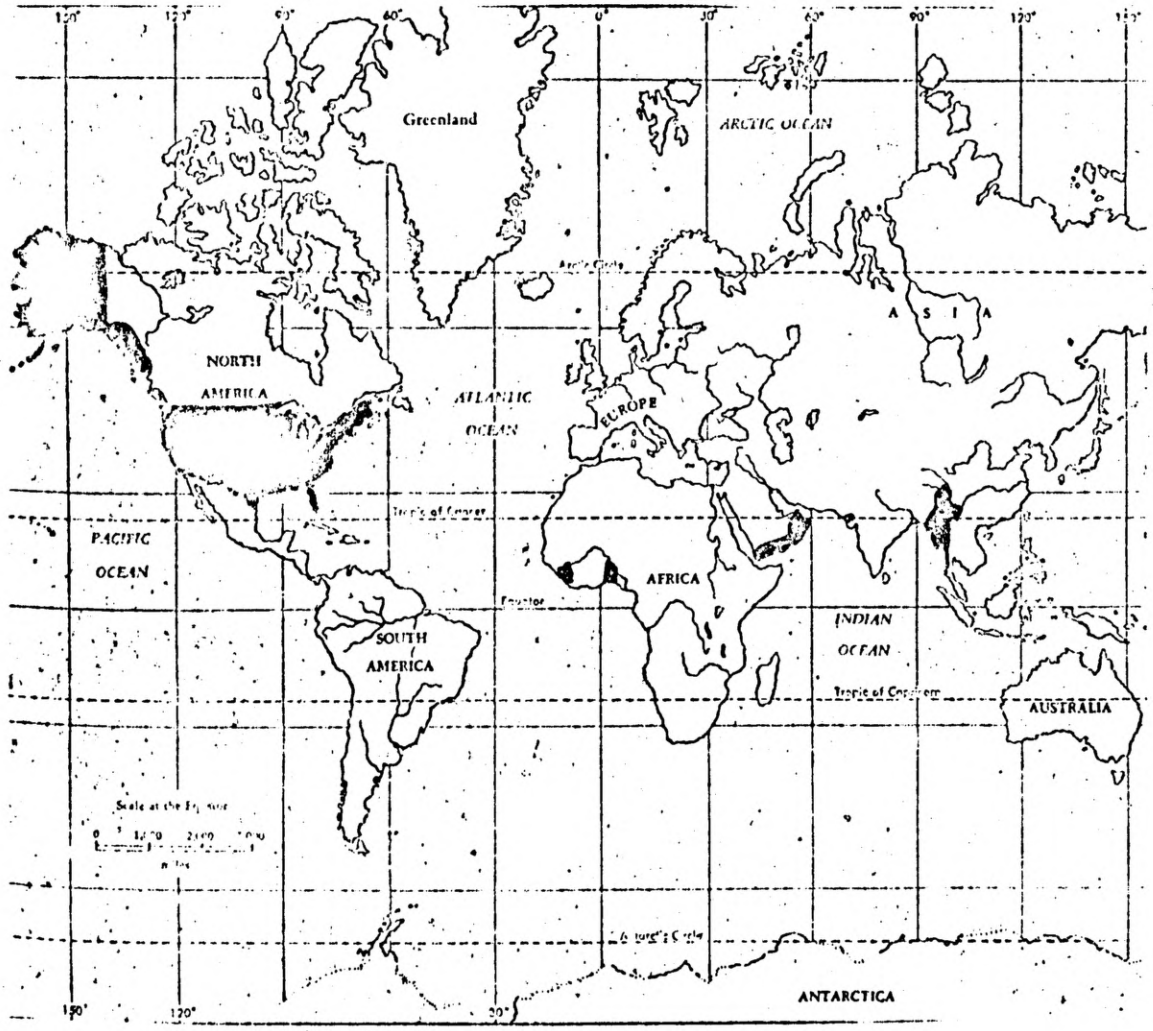


Figure 1. Countries of Noncommitment to Metrication

Present Position of the United States Relating to Metrication

Introduction. Dr. Edward Teller, father of the hydrogen bomb, described America's situation as follows:

> Our nation has embarked on one of the most tremendous and inspiring, but dangerous, enterprises in history; we have set out to build an industrialized and lawful world free from war and free from economic misery. We are now so involved in this undertaking that unless we succeed we may cease to exist. The danger of being overtaken by Russia in our accelerating contest for world leadership is very real. In this important contest it seems inconceivable that we should allow ourselves to be hamstrung by a situation which has hurt us in the past, is hurting us today, and will continue to hurt us in the future. But the fact is that the United States is out of step with the rest of the world in an immensely significant way: we measure things differently (Donovan, 1970).

Political position. The United States and Russia are vying for the support, goodwill, and resources of many countries that are industrializing. These nations are using the same measurement system as Russia. When technical assistance is sent into these areas which are already metric, the United States must first teach the technicians the British System of measurement to establish their dependence upon our products (Donovan, 1970).

The concept of standardization is synonymous with the Industrial Revolution in America. The United States long led the world in standardization and interchangeability of parts. In some instances, the American Standards are the best in the world, or in many cases, the only standards in the world. The ABC screw thread standard represents the

complete and sophisticated system there exists for fasteners and is recognized by the International Organization for Standardization. In aviation, American standards are practically universal around the world because of our leadership in this field (Donovan, 1970).

In recent years, there has been a coalition of effort outside the United States to develop metric standards that, in some areas, could be better than the American Standard. In many ways, the new metric standard made for economy by providing for less variety. Although, the United States is a member of the International Organization for Standardization, its participation has been slight (Donovan, 1970). This may well be a short sighted mistake on our behalf for just a small fraction of the metric standards has been written and approved. Around 10,000 remain yet to be written. There is still time for the USA to join the world and help write standards that could favor American Industry (Hopkins, 1974).

Costs of Conversion. Seventy percent of the United States multi-national concerns in 1974 have all-metric overseas plants. They have produced almost $200 billion in sales in a recent year as opposed to all other non-metric plants shipping only $48 billion in goods to metric nations

(Hopkins, 1974). One economist claims that the United States is losing $10 billion a year in exports because of non-metric usage. A comprehensive study has not been conducted to verify the effects of non-metric usage on foreign trade but the following figures raise some questions that those who are opposing metrication may find hard to answer.

U.S. percentage of total imports as compared to the major world countries

1960 - 20.5%

1966 - 19.10%

U.S. share of machinery imports as compared to the major world countries

1960 - 35.5%

1966 - 31.1%

U.S. share of total imports as compared to the non-metric countries

1960 - 27.4%

1966 - 30.4%

U.S. share of machinery imports as compared to non-metric countries

1960 - 54.2%

1966 - 58.2%

U.S. share of total imports as compared to the metric countries

1960 - 17.5%

1966 - 14.3 %

U.S. share of machinery imports as compared to the metric countries

1960 - 27.6%

1966 - 20.6%

In summary, the United States share of total imports to metric countries declined by about eighteen percent from 1960 to 1966. The share of total imports to nonmetric countries increased eleven percent. Currently the United States has very few countries in which to export its goods in nonmetric units (see map, page 14), and the number is likely to decrease even faster in the near future (Donovan, 1970).

Cost of conversion is a major source of dispute relative to going metric. It is impossible to pre-determine accurately the actual dollars that will be involved due to the many extenuating circumstances. Experience from other countries has shown that a crash program to convert quickly is the most expensive route. In going metric, India and Japan found that cost estimates were many times higher than

the actual expenses that they incurred during the transition to the metric system. Some industrial firms who adopted the metric system in England in advance of the national program are reporting savings up to fifteen percent in design time as a result of the use of SI.

The pharmaceutical industry of the United States has converted almost completely to the metric system and has kept exact records on cost. This was one industry in which conversion is very desirable and costs are low. However, a typical experience in this industry shows that for a conversion cost of $13,000 an annual savings in excess of this amount has been realized due to a decrease in the cost factors of inventory control and computation of formulations (Donovan, 1970).

Conversion will more likely take place over an extended period of time during which much machinery can be replaced as it wears out or becomes obsolete. In many cases, replacement of minor parts and adjustments can accomplish the task rather than replacements of the entire machine. A cynical observer might wonder at some of the excessive estimates for conversion as perhaps an economic play by some industry for government dollars to help ease the cost transition. Estimates were supplied by 126 manufacturing

firms to the Three Year Study Committee. The economic health of these companies are very important to our nation, therefore, the high costs of metrication are a very real concern. However, these industries produce only eleven percent of the gross national product. Eighty-nine percent of things produced in the United States are from industries in which the impact of conversion is fairly small due to the limited amount of hardware which would have to be replaced (Donovan, 1970).

None of the cost estimates take into consideration compensating savings. In the area of statistical computations, inventory control, data processing and computer programming a tremendous dollar savings in man-hours will be realized through simplified computations and easier communications. For the aerospace industry alone, the total is several hundred thousand man-hours per year. The 15,000 scientists, engineers, and technicians at the National Aeronautics and Space Administration work almost exclusively in the metric system. The Committee on Science and Astronautics must convert the metric specifications to the inch-pound units in order to purchase space hardware. The United States Weather Bureau alone estimates that at least

1,000 man-hours a month are wasted in the process of converting between the two systems (Donovan, 1970).

Another factor that relates to conversion costs is added profit and additional employment that would result in some supply industries. Many new jobs would be created in education and industry in order to produce new goods and measurement tools in metric units and familiarize individuals with the new system.

The Ford Motor Company, which now has a metric car on the American scene, has heartened metric advocates. The following is a statement by the Vice-President of Engineering several years ago:

> The benefits of a single measuring system in a world-wide, interdependent economy are so great that we believe that the conversion to the Metric System is inevitable. Although there may be short term costs and confusion during such a far reaching change, the long term gains appear to be overwhelming for any country that expects to be an active participant in world commerce and trade. The basically simple structure of the Metric System also carries with it many substantial benefits, even for an isolated user. The magnitude of the conversion task in the automobile industry is such that any attempt of conversion on a crash basis would be chaotic, both physically and financially. On the other hand, a well-planned conversion can minimize both the cost and confusion, and permit the benefits of the system to be realized at the earliest possible date (Donovan, 1970).

Ford, as well as the major corporations of General Motors, IBM, Xerox, and Honeywell are now in the process of conversion. The effects of these companies, as they buy parts

and equipment and then sell their products, will be strong and pervasive upon the suppliers and the consumers.

Effects of metrication upon the American citizen. No investigation of an issue in America is complete without considering the feelings of and the implications for the common-man. A Gallop Poll conducted in August 1971 and published in October of that year, found that only forty-four percent of the adults in the United States knew what the metric system was; and of these, only forty-two percent were in favor of adopting it. The survey also showed that of the adults who had attended college, eight out of ten were aware of the metric system; and of these, adoption of the metric system was favored five to four. This trend confirmed investigations conducted by the Department of Commerce that the more people know about metrication the more they favor its adoption (Viet, 1973). The evidence, then seems to indicate that education of the public is a must. This education will largely be done in the elementary schools through the school children who will carry the language, measurement experience, computation, exercise, and problem solving with the metric system into the homes of the United States. The classroom experiences relative to measurement should be very

practical to make the metric system a viable tool to the American Public.

The public is being educated now in metrication through television and purchase of commercial goods. The international athletic competition lengths are determined in meters. Skiing is metric. Boots, skis, and distance runs are in metric measure. Foreign made motors are metric. Forty-five to fifty percent of packaged food products now have metric quantities on the label. Imported shoes for women and men are sold by metric foot size. Thirty-five millimeter films are commonplace. The public has been counting calories for years without knowing that a calorie is the amount of heat needed to raise the temperature of one gram of water, one degree Celsius.

We have been thoroughly indoctrinated in 100 mm cigarettes and the inconvenience caused by being one mm longer. Air pollution is measured in micrograms. Weather reports are being given in both American and metric measurement. More and more of the American life is being affected by the metric system.

Advantages of metrication. The following principles of measurement have been recognized for over 200 years and

yet the British System of measurement fits none of these criteria:

> 1. Standard unit of length should be based on some unchanging, absolute standard found in the physical universe.
> 2. Basic units of length, volume, weight should be directly related to each other.
> 3. The specifically named multiples and sub-divisions of the standard units should be decimally related (Hallerberg, 1973).

Contrast these basic rules with the formation of the British System. In early pre-England the various independent regions of population measured each in its own peculiar way. When Caesar's legions invaded Britain the Romans contributed some units; others were derived from trade with the continent. As a result, by the Middle Ages, the system of weights and measure in the British Isles had more varied units than could be found in a like area anywhere else in the world. Terms such as bing, bind, fatt, flyke, shid, and swod were market day terms. None related to the other. An early English linear measure that has affected our world so completely is the yard, which, legend has it, was determined by the length of the girdle of a Saxon king. The condition of weights and measures in Great Britain became so troublesome that every British ruler from the 10th century to the 20th century has tried, without much success, to legislate rules of measurement. In the 18th century,

France also faced a similar problem, but rather than attempt to control the uncontrollable mess, the metric system was devised, adopted, and used.

One example of the lack of uniformity in the British system is the ton. "Anyone" would tell you that a ton is 2000 pounds, just as in England "everyone" knows that a ton is 2240 pounds. Originally, the ton was a large tub. Later, it was a unit of 250 wine gallons. Besides this common ton, there is the register ton of 100 cubic feet and the measurement ton of 40 cubic feet. The English water ton of 224 British Imperial gallons is used for petroleum measure. There exists a timber ton of 20 bushels and the metric ton of 1000 kilograms or 2204.6 pounds. The word ton is eight different units of measurement.

"Which is heavier--a pound of gold or a pound of feathers?" Surely this is a ridiculous question until one recalls that feathers are measured in avoirdupois weight and one pound is 7000 grains. A pound of gold is determined by troy weight and measures 5,760 grains. Therefore, a pound of feathers weighs more than a pound of gold. In the same line of reasoning one should be confident in stating that an ounce of feathers weighs more than an ounce of gold. However, one ounce of gold is 480 grains because in troy

weight a pound is 12 ounces. But there are 16 ounces in an avoirdupois pound, therefore, an ounce of feathers is 437.5 grains (Donovan, 1970).

As time passed, the world with the exception of the English speaking peoples adopted the decimal metric system. Great Britain, Canada, and Australia are now in the throes of conversion, leaving the United States out of step with almost 95% of the world (What About Metric, 1973).

Educational Implications of Metrication

In the "Education Amendments of 1974" is the provision authorizing the Commissioner of Education, during the period beginning July 1, 1975 and ending June 30, 1978:

> . . .to encourage educational agencies and institutions to prepare students to use the metric system of measurement with ease and facility as a part of the regular education program.
> . . . . . .
>
> The Commissioner shall carry out a program of grants and contracts in order to encourage educational agencies and institutions to prepare students to use the metric system of measurement.
> . . . . . .
>
> For the purpose of carrying out this section, the Commissioner is authorized to expend $100,000,000 for each of the fiscal years ending prior to July 1, 1978.

It is recognized by our government that the burden of educating the American population will lie with the

schools. Two recommendations of the United States Metric Study, as quoted by King are:

> . . .switch to metric system be accompanied by a major revision of elementary school curriculum. Should emphasize decimal fractions and present the metric system in a context that provides active participation in measurement activities.
> . . . . . .
>
> . . .then inservice training for going metric be condensed into a short period of time (8-15 hours) just before the teachers begin to teach the metric system. Because teachers generally teach as they are taught, the training should be similar to that which they will use with their students (King, 1973).

Most of the nations that converted to metrics in the twentieth century are agrarian or were in the early stages of industrialization when the change occurred. These situations account for the lack of transitional information relative to costs and educational practices. India decided to convert in 1956 and the Director of the Indian Standards Institute reported:

> The use of the Metric System in schools presents little problem once the Metric System becomes a reality. . . . Our children are now learning the Metric System without the least difficulty in spite of the fact that proper text books are hard to get and also the teaching of the system is a comparatively new task for the teachers. . . . The common man ultimately proved to be remarkably adaptable and learned the Metric System in no time (Donovan, 1970).

Research over the past thirty years suggests that measurement is a much more involved process than we commonly

thought (Helgren, 1973). Development of intuitive thought processes concerning measurement concepts in the use of units, distance, and conservation of length is necessary prior to formal measurement instruction to insure understanding (Copeland, 1970).

Mistakes in curriculum designs such as the following should be noted and corrected:

> 1. Metric measurement was not studied as a system by itself.
> 2. Children were not taught to THINK METRIC.
> 3. Textbooks often contained only a single unit in the system, and problems were merely conversions from one system to the other.
> 4. The unit on the metric system was frequently at the end of the textbook. As a result it was seldom taught (Helgren, 1973).

It is imperative that we use metrication as a means of injecting new life into the teaching of measurement. Measurement too often has been some worksheet exercise together with conversions between units. It has been regarded by students as a dull process when in actuality it should be challenging, viable, and practical.

Specific guides for teaching the metric system as recommended by the National Council of Teachers of Mathematics are the following:

> 1. Choose an appropriate unit of measure and use it to measure a variety of objects.

> The most important component of thinking in any measurement system is a thorough understanding of the unit used. The unit chosen should be appropriate to the size of the object measured.

2. Use multiples of the basic unit, as the need arises for a larger unit, and subdivisions of the basic unit, where smaller units are needed.

> Limitation of the number of larger and smaller units taught makes the learning goals more realistic and more manageable. The goals of thorough learning of a few larger and smaller units is much preferred to mere acquaintance with many different units.

3. Limit expectations of mastery of conversions within a measuring system to commonly used units adjacent in size.

> In metric, centimeters are usually related to meters; milimeters to centimeters; but very little is done in relating millimeters to meters.

4. Use the approximate nature of the measuring process in the physical world as a theme.

> Helping children to give measurements using language such as "more than 2 meters but less than 3 meters" provides experience with approximation. It also points to the needs for smaller units and fractional numbers.

5. Use measurement as motivation for fractions, for decimals, and for arithmetic.

6. Use the actual units as often as possible; avoid the scaled-down versions often found in textbooks or worksheets.

> It is folly to try to teach the meter by drawing a scale version of it. Students have great trouble in responding to measurement questions and estimates using such "distorted" representations.

7. Teach only the commonly used multiples and subdivisions, and their corresponding prefixes.

> To teach measurement within the British system fifteen words needed to be learned: inch, foot, yard, mile, acre, ounce, pound, ton, pint, quart, gallon, peck, bushel,

> dozen, and gross. To use the equivalent units in the metric system a child need learn only eight words, seven of them of one syllable. Meter, liter, and gram combined with the prefixes milli-, centi-, and kilo- cover all the common units except the hectare and the metric ton (Hawkins, 1973).

Fred W. Hough, chairman of the American Geophysical Union Study of the Metric System, made the statement that

> Teachers of mathematics will agree that fully twenty-five percent of the child's time, and the teacher's time as well, could be saved in arithmetic courses if the simple, interrelated metric decimal units were substituted for the English system of measure. Such monstrosities as proper and improper fractions, numberators, least common denominators, greatest common divisors, and mixed numbers could be laid to rest with the celluloid collar and the oxcart (Donovan, 1970).

A study that may have some validity in the field of education was made by UNESCO a few years ago. This survey was made among 13-year-olds in 12 European countries and disclosed that the educational achievement of English school children was significantly below that of children in other countries studied. This disparity was attributed to the excessive use of fractions and outmoded units in the British schools.

In Hawaii the United States has a reasonably successful experimental model for teaching metrication. The implementation plan in the schools provides for a twelve hour

workshop for the teachers prior to teaching metrics within their classes. An activity oriented curricula was developed based on Piaget's theories of child development and formal instruction is not emphasized until grade three. This progressive attitude of Hawaii toward metrication is promoted by the states close geographical position to metric Asia.

Metrication as it Relates to the Child

Difficulties not attributable to the conversion to and use of the metric system have existed relative to the teaching of measurement. The fact that the beginning of most secondary and collegiate physics classes are devoted to the teaching of measurement is testimony to the need of improved elementary and secondary instruction. The child needs measure to quantify his world, to make mathematical as well as verbal descriptions of his environment.

To the adult mind the task of measuring seems obvious and can usually be accomplished with little difficulty but this is not true of a child. The following is a resume of the characteristics of distance and the implications to the thought processes of the child.

1. Distance is a function which maps a line segment $\overline{AB}$ into the set of nonnegative real numbers. That is, distance communicates to others the "length" of the

segment $\overline{AB}$ (Osborne, 1974). For the child to utilize this function of distance he must first mentally be able to deal with the characteristic of "numberness" of a set. Second, he must be able to conceptualize a 1-1 correspondence between the object and the unit of measurement. Third, conservation of length must be preserved as the unit, the object, or both are moved in space. These three concepts are conceptualized at the end of the pre-operational stage which generally ends on the average when the child is between the ages of 6 to 8. However, most children still measure in the early operational stage on a trial and error basis. Therefore, until the end of the third grade, to measure a distance is a very difficult procedure (Copeland, 1970).

2. Distance from a point A to a point B is the same as the distance from B to A (Osborne, 1974). For this relationship to be reasonable to the child reversal of his thought processes is required. This reversal is interrelated to the concept of conservation of length as an object is moved (Copeland, 1970).

3. If point B is between A and C and lies on the common line joining A and C, then the distance of A to B added to the distance of B to C equals the distance from A to C(Osborne, 1974). This concept depends upon the child's

ability to understand enclosure. Enclosure usually is conceptualized in the pre-operational stage. The idea of a "Straight-line" is not abstracted until the child reaches approximately seven years of age. Children do not seem to visualize a path in terms of an ordered system of points and intervals. Therefore, to refer to a "point" B as being between A and C is a very abstract idea. A child seems to concentrate mainly on the starting point of a line and returns visually to the line at the endpoint (Copeland, 1970).

4. If B is a point between A and C, then a whole number p can be found such that $p(AB) \geq AC$ (Osborne, 1974). This concept is used each time a student moves his unit of measurement a certain number of successive times to determine the total length of an object. Conservation of length is an essential condition for this operation. Visualization of a straight line as a series of intervals also is required (Copeland, 1970).

The above analysis of distance was provided by Alan Osburne, a contributor to the National Council of Teachers of Mathematics A Metric Handbook. The learning implications were formulated from the works of Richard Copeland in, How Children Learn Mathematics. The purpose for the analysis of the simple concept of length is to furnish the reader with some insight as to the complexity of the measurement process for the young child. In

particular, if measurement is taught too soon at too abstract a level the entire process will be beyond his level of cognitive development.

Summary

In 1866 the metric system became the lawful system of weights and measure for the United States. The yard has been defined as a fractional part of the meter since 1893. After a half century of little concern about the metric system, the 1960's ushered into the American consciousness a realization that the metric (SI) system, as established by the International Organization for Standardization, is an important factor in the sciences and the economy. The three year United States Metric Study of 1968 indicated that a majority of manufacturers and non-manufacturers alike support a move to adoption of the metric system as being in the national interest. Politically we cannot afford to pursue an isolationist policy in our measuring standards as we are economically dependent upon the rest of the world (Donovan, 1970).

The United States has been a world leader in standardization of measure. In many cases American Standards are the only standard, but as these standards are rewritten

in the metric system it is imperative to our industries that we reassume an active role in this writing.

The costs of conversion for United States industry are very real obstacles. However, the possibility of losing foreign markets due to non-metric usage is not economically advisable for the United States.

Experience from other countries has shown that education of the public through the schools is an important force in easing the transition from one system to another. Care however must be exercised in metrication to prevent confusion. Metric consultants often are new in the field and are poor educators. Prior to 1968 there were variations in educational materials used for teaching metrication, some of which were erroneous or obsolete. Therefore, it is imperative the (SI) standard be used when the metric system is introduced.

The process of converting our schools from the British system to the metric system of measurement will provide educators the opportunity to evaluate our current practices in teaching measurement. Curriculums concerned with the childs learning processes may provide more efficient instruction than has been evidenced in the existing courses of study.

The conversion to metric can be an orderly challenging shift or a confusing troublesome process. Ease of transition is dependent upon education of the citizenry, the planning of the corporations, and support from the federal government.

Chapter 3

PROCEDURE

Introduction

The purpose of this study was to investigate the status of measurement instruction in the fourth grades of the Butte elementary schools. Information concerning preferred methodology, time allotment to measurement instruction and relevant performance objectives was necessary to provide a realistic foundation for the proposed metric program. The research of Piaget, which investigates the ways children learn to measure, makes it apparent that an organized approach to metrication integrating the appropriate concrete experiences with relevant materials and supplies, would produce meaningful learning experiences for the youngster. The results of this survey were used to establish a fourth grade teacher's handbook containing suggested materials and activities for teaching the metric system.

The chapter explains the development of the survey instrument, defines the population, and describes the sampling procedures. The method of data collection is discussed with reference to validity.

Population Description and Sampling Procedures

The principal of each elementary school in Butte was given written notification by the Curriculum Director of School District No. 1 that this study was being conducted. The researcher personally approached each principal to determine if he desired that his school participate. The fourth grade teachers were then asked if they would volunteer their personal ratings on the listed objectives for measurement. Three elementary schools, each with one fourth grade teacher, elected not to participate in this study. The teachers in these schools will retire soon and did not wish to participate. The population of this study was the fourth grade teachers from eleven elementary schools in the Butte school system. Seventeen of the twenty-eight teachers in these eleven schools volunteered to rate the proposed objectives for measurement activity in the fourth grade.

The following instructions were given to each participant:

1. If any obvious objectives were missing, would the teacher please add them at the end of the survey.

2. If any objective was definitely not appropriate to measurement, the teacher was to cross it out.

3. If any objective was difficult to rate due to the teachers unfamiliarity with the metric vocabulary, the question was to be omitted.

4. A rating of one was to be given to any objective that definitely was not appropriate for fourth grade instruction.

5. A rating of two was to be applied to any objective that had reasonable value to fourth grade instruction.

6. A rating of three was to be given to any objective that was "right on."

Method of Collecting Data

The data was collected in the following manner. A survey instrument was designed to ascertain the opinions of the fourth grade teachers relative to appropriate student performance objectives in metric measurement at the fourth grade level. This list is a compendium of thirty-five commonly stated objectives found in other curriculum surveys, together with the objectives stated by the Butte teachers on a recent (January through March, 1975) evaluation. A questionnaire on current classroom procedures, material sources, and teacher preparation was integrated into the survey. Six questions were posed to provide information

concerning teaching methods preferred, teacher attitudes toward classroom activities, material now available, and time allotted to measurement instruction. The teachers were asked to indicate how confident they felt toward teaching the metric system, and whether or not they would be interested in a workshop or in-service training in metrication.

The cover letter preceding the study was sent by Dr. Casagrande, the Butte Curriculum Director, to each principal explaining the purpose of the survey and requesting the cooperation of each administrator. Considering the small population size the instrument was presented by the researcher personally to each of the volunteer teachers. The completed surveys then were returned to the curriculum director's office or were collected by the researcher.

Method of Organizing Data

The response from the teachers on the general questions were tabulated and recorded in Chapter 4 in Tables 1-6 (pp. 45-48). The ratings as given by the teachers to the performance objectives are recorded in Table 7 (p. 49). The researcher assigned a value to each rating response on the following basis. No points were given for each response that rated the objective as being inappropriate for the

fourth grade. One point was given for each response that rated the objective as "worth consideration." Two points were given for each response that rated the objective as "very appropriate." The total point value was then computed by summing the point values of all respondents for each objective.

Validity of the Instrument

To check the validity of the instrument, four persons were asked to consider the instrument for completeness, ease of answering, wording, content, and conciseness of the directions. The persons involved were; Dr. Eric Strohmeyer, department of educational services and research; Dr. Gary Smith, professor of elementary mathematics; Dr. Leroy Casagrande, director of curriculum in the Butte Public Schools; and Ms. Margie Younkin, fourth grade teacher at the Longfellow School in Butte.

Restatement of Questions

1. How much time is currently being allotted in the fourth grade to teach and develop measurement concepts?

2. What materials are currently available to teach metrics?

3. How confident do teachers feel about teaching the metric system?

4. What measurement objectives do teachers deem most important when teaching fourth graders?

5. What methods do teachers favor for teaching measurement?

Summary

To answer the questions of the study a survey instrument was developed. The face validity of the instrument was established before being administered to the study population. The Curriculum Director of School District #1 notified the elementary school principals that the study was being conducted. The principals were then contacted personally to determine if they desired to have their school participate in the study. Eleven of the fourteen elementary schools were surveyed, involving seventeen volunteer teachers. A survey instrument was designed to ascertain the opinions of the fourth grade teachers relative to appropriate student performance objectives in metric measurement at the fourth grade level. A questionnaire on current classroom procedures, material sources, and teacher preparation was integrated into the survey. The teachers were

asked to indicate how confident they felt toward teaching the metric system, and whether or not they would be interested in a workshop or in-service training in metrication.

The results of this survey were tabulated and used as a guide in developing a teachers handbook for a measurement curricula in fourth grade.

Chapter 4

ANALYSIS OF THE FINDINGS OF THIS STUDY

The number of surveys returned and the responses of the teachers to the study indicated positive interest in metrication. Seventeen fourth grade teachers from eleven elementary schools in Butte completed the questionnaire. The teachers candidly offered information on classroom methods, personal confidence in teaching the metric system, and their evaluations of thirty-five performance objectives for metrication. The chapter presents a summary of the questionnaire results. Tables are included with details provided in the text.

Results and Summary of the Survey Instrument

The survey requested teachers to indicate what type of measurement material is preferred by them for instruction. As presented in Table 1, fifteen respondents reported feeling most comfortable with a combination of printed and activity type materials. Two respondents indicated a preference for activity oriented methods.

Table 1

Opinions of a Selected Group of Butte Fourth Grade Teachers Relative to the Types of Materials They Would Find Most Useful in Teaching Measurement

written	mostly activity	combined printed and activity
0	2	15

Both groups reported their preferred methods as being the most effective method in the teaching of measurement. The teacher responses relative to question 2 were identical to their responses in question 1.

Table 2

Most Effective Method of Teaching Measurement as Reported by the Select Group of Fourth Grade Teachers

written	mostly activity	combined printed and activity
0	2	15

Fifteen respondents reported a need for specific kinds of metric supplies as, meter sticks, liquid measures, and weights. The other two respondents were very indefinite.

Table 3

Metric Aids Needed by Teachers to Provide Concrete Learning Experiences for the Fourth Graders

Anything	Not Sure	No Reply	Linear, volume, and weight Aids
3	4	5	5

Fifteen of the selected teachers reported having no materials now available for metric instruction. One respondent reported from the pilot school for testing metric materials and therefore responded that sufficient supplies were available and one respondent reported teaching with a minimum supply.

Table 4

Instructional Material Now Available in the Classrooms of the Select Group of Fourth Grade Teachers

None	Meter stick, metric scales, kit with tapes	Metric pilot school well supplied
15	1	1

The present measurement curricula have been designed using two basic types of teaching structures, the unit and the spiral. Seven teachers reported using unit instruction,

whereas, ten teachers reported using the spiral approach.

The time allotted by the teachers in formal teaching of measurement varied greatly as shown by Table 5. The minimum time reported was two class periods. The maximum reported time was sixteen class periods or 12 hours assuming a class period of 45 minutes.

Table 5

Time Presently Allotted by the Group of Select Fourth Grade Teachers in Butte for Instruction in Measurement

10 - 12 hours	10 - 30 minutes per week	2 class periods	6 class periods	varies
5	3	1	1	5

In response to the questions concerning teacher preparation for metrication, fourteen teachers reported inadequate preparation for teaching the metric system. Three teachers felt their background would be sufficient. All seventeen teachers indicated a need for some kind of training for teaching metrics. The requested number of hours of in-service instruction varied as reported in Table 6.

Table 6

The Requested Time Blocks for In-Service Training as Reported by the Select Group of Fourth Grade Teachers

one hour	two hours	four hours	eight hours	no response
3	1	7	4	2

Results and Summary of Performance Objectives

The performance objectives were rated by the teachers as 1) not applying to their fourth grade class, 2) worth consideration for their fourth grade, or 3) very appropriate for their class. In Table 7 the objectives are listed according to a point value system. One point was given to the objective for each number two rating of "worth consideration." Two points were given for each number three rating of "very appropriate." No points were given for a number one rating of "not applying."

Table 7

Ratings Given to the Performance Objectives for Metric Measurement Instruction by the Select Group of Fourth Grade Teachers in Butte

Objectives	Ratings			Total Point Accumulations
	1	2	3	
Student can recall and give one reason for standard units.		4	13	30
Student will be able to find perimeter by measuring printed figures with a standard unit.		6	11	28
Student will be able to linearly order 5 objects, smallest to largest.	3	1	13	27
Student will be able to measure an object linearly with some arbitrary unit.	1	5	11	27
Student will be able to recall abbreviations for centimeter, meter, millimeter, decimeter, kilometers.		7	10	27
Student will recall abbreviations for grams and kilograms.		7	10	27
Student will be able to select the proper metric units of measurement for length, area, weight, temperature.	1	8	8	26
Student will be able to select proper device (ruler, yard stick, meter stick) to measure lengths in feet, yard, centimeters, meters.	2	4	11	26
Student will recall that weight units are grams and kilograms.	1	6	10	26
Student will recall what he weighs in kilograms.		8	9	26
Student will be able to find area of drawn figures with measurements given.	1	8	8	24

Table 7 (continued)

Objectives	Ratings 1	2	3	Total Point Accumulations
Student will be able to keep a daily journal of outdoor temperature in Celsius degrees.		10	7	24
Student will be able to read a thermometer and/or pictorial representation to the nearest degree in Celsius.		10	7	24
Student will be able to give approximate lengths to the nearest centimeter and/or meter by visual examination.	1	9	7	23
Student will be able to weigh objects to nearest kilogram.	2	7	8	23
Student will recall normal body temperature in Celsius degrees.	2	7	8	23
Student will recall the freezing and boiling temperatures in Celsius.	1	9	7	23
Student will be able to identify 3 objects that approximately weigh one gram.	1	10	6	22
Student will be able to weigh small objects to nearest gram.	3	6	8	22
Student will be able to recall decimal values of prefixes of centi, deci, milli, kilo.	3	7	7	21
Given written or oral problems the student will identify the meter as equal to 100 cm and use in solving problem.	2	9	6	21
Student will recall that temperature is measured in Celsius degrees.	2	7	7	(16)* 21
Student will be able to give approximate lengths of an object in centimeters and meters by visual examination.	2	8	6	(16)* 20

Table 7 (continued)

Objectives	Ratings 1	2	3	Total Point Accumulations
Given written or oral problems the student will be able to use his knowledge that a centimeter is a little less than a half inch to solve problems.	1	8	6	(15)* 20
Student will be able to visually exam and give approximate weight of 5 common objects in kilograms.	3	9	5	19
Student will be able to look at common containers of liquid substances and reasonably estimate liter capacity to nearest halves and/or wholes.	3	9	5	19
Student will be able to multiply decimal numerals with numbers in tenths and hundredths places.	5	8	4	16
Students will be able to recall the fractional ratio of millimeters to centimeters to decimeters to meters.	7	5	5	15
Student will be able to add and subtract decimal problems involving numbers with one to three decimal places.	6	7	4	15
Student will be able to give approximate lengths of an object to the nearest millimeter by visual examination.	8	5	4	13
Student will give decimal relationships between kilograms, grams, milligrams.	7	7	3	13
Student will be able to divide decimal problems with numbers in the tenths and hundredths places.	8	7	2	13
Student will be able to find volume of printed shapes with given dimensions.	8	6	3	12

Table 7 (continued)

Objectives	Ratings 1	2	3	Total Point Accumulations
Student will recall the decimal values of mega, and hecto.	7	9	1	11
Student will recall the use to solve problems the relationship between metric weight and volume.	10	4	2	8

*These questions were not answered by all 17 respondents, the number of respondents answering the questionnaire is denoted in parentheses.

Twenty-four of the objectives rated by the respondents as "worth consideration" or "very appropriate" were concerned primarily with instruction in linear measurement, area, perimeter, weight, and temperature. The teachers indicated that within linear measurement it is important to provide instruction in standardization of units, linear ordering, use of arbitrary units, selection of proper standard units for measuring specific lengths, estimation, and use of appropriate abbreviations.

Area instruction should include use of proper units and the finding of areas of printed shapes.

Perimeter instruction should be concerned with teaching the meaning of perimeter and how to find it for printed figures.

As rated by the teachers, weight instruction should promote understanding in the use of proper units of weight by relating physical objects to specific weight units through comparisons of objects to weights. The child should learn the logical unit for weighing a particular mass and should recognize the abbreviations for the terms.

The instruction in temperature should stress use of the proper metric units, proper use and reading of a thermometer. The child should also be able to recall body temperature, freezing, and boiling in degrees Celsius.

The researcher arbitrarily chose the first twenty-five objectives as the foundation for the fourth grade course guide in metric measurement. Objective twenty-six was not included because the inclusion of liter measurements in the course study would necessitate the introduction of volume, a concept not included in any of the other objectives. The time allotments reported in Table 5 (page 47) indicated that the maximum time provided in class for measurement varied from two to sixteen class periods assuming a class period of forty-five minutes. The course of study covering linear measurement, area, perimeter, weights, and temperature is programmed to cover approximately ten class periods. The time information available through the survey

does not support the feasibility of a longer curricula in measurement.

Summary

Two types of lesson structure, the unit or the spiral, were reported by the teachers questioned as being used in the teaching of measurement. Printed material together with activities was found to be the preferred media in the development of a measurement lesson. These teachers reported that they felt this combination of materials was also the most effective method of instruction. The time allotted to the instruction of measurement varied from two to sixteen class periods assuming a class period of forty-five minutes.

Teachers reported feeling insecure in the teaching of the metric system and indicated that in-service training would be desirable before metrication becomes mandatory in the school system. Instructional metric materials were reported available by only two of the seventeen respondents.

The teachers consistently rated instruction in linear measurement, area, perimeter, weight, and temperature as being the most appropriate topics for fourth grade measurement instruction.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A summary of Chapters 1, 2, 3, and 4 conclusions and recommendations are presented in this chapter.

Summary

The United States is the leading industrialized nation of the world. To maintain this position it is imperative that this nation adopt the world metric measurement system. The conversion to this metric system will be aided by efficient instruction in the elementary school. The problem of this study of Butte fourth grade classes was to determine the current status of measurement instruction and to establish appropriate performance objectives for teaching metric measurement. The purpose of this study was first to determine the present status of measurement instruction; second, to establish a set of student performance objectives relative to learning metric measurement; and third, to design a course of study reflecting the intellectual development of the children and promoting the measurement skills rated as important by the teachers.

In 1866 the metric system became the lawful system of weights and measure for the United States. The yard has been defined as a fractional part of the meter since 1893.

After a half century of little concern about the metric system, the 1960's ushered into the American consciousness a realization the metric (SI) system as established by the International Organization for Standardization is an important factor in the sciences and the economy. The three year United States Metric Study of 1968 indicated that a majority of manufacturers and non-manufacturers alike support a move to adoption of the metric system as being in the national interest. Politically we cannot afford to pursue an isolationist policy in our measuring standards as we are economically dependent upon the rest of the world (Donovan, 1970).

The United States has been a world leader in standardization of measure. In many cases American Standards are the only standard, but as these standards are rewritten in the metric system it is imperative to our industries that we reassume an active role in this writing.

The costs of conversion for United States industry are very real obstacles. However, the possibility of losing foreign markets due to non-metric usage is not economically advisable for the United States.

Experience from other countries has shown that education of the public through the schools is an important

force in easing the transition from one system to another. Care however must be exercised in metrication to prevent confusion. Metric consultants often are new in the field and are poor educators. Prior to 1968 there were variations in educational materials used for teaching metrication, some of which were erroneous or obsolete. Therefore, it is imperative the (SI) standard be used when the metric system is introduced.

The process of converting our schools from the British system to the metric system of measurement will provide educators the opportunity to evaluate our current practices in teaching measurement. Curriculums concerned with the childs learning processes may provide more efficient instruction than has been evidenced in the existing courses of study.

The conversion to metric can be an orderly, challenging shift or a confusing troublesome process. It all depends on the education of the population, the planning of the corporations, and the consistent support from the federal government.

To answer the questions of the study a survey instrument was developed. The face validity of the instrument was established before being administered to the study population.

The Curriculum Director of School District No. 1 notified the elementary school principals that the study was being conducted. The principals were then contacted personally to determine if they desired to have their school participate in the study. Eleven of the fourteen elementary schools were surveyed, involving seventeen volunteer teachers. A survey instrument was designed to ascertain the opinions of the fourth grade teachers relative to appropriate student performance objectives in metric measurement at the fourth grade level. A questionnaire on current classroom procedures, material sources, and teacher preparation was integrated into the survey. The teachers were asked to indicate how confident they felt toward teaching the metric system, and whether or not they would be interested in a workshop or in-service training in metrication.

Two types of lesson structure, the unit or the spiral, were reported by the teachers questioned as being used in the teaching of measurement. Printed material together with activities was found to be the preferred media in the development of a measurement lesson. These teachers reported that they felt this combination of materials was also the most effective method of instruction. The time allotted to the instruction of measurement varied from

two to sixteen class periods assuming a class period of forty-five minutes.

Teachers reported feeling insecure in the teaching of the metric system and indicated that in-service training would be desirable before metrication becomes mandatory in the school system. Instructional metric materials were reported available by only two of the seventeen respondents.

The teachers consistently rated instruction in linear measurement, area, perimeter, weight, and temperature as being the most appropriate topics for fourth grade measurement instructions.

The results of this survey were used as a guide in developing a teachers handbook for a measurement curricula in the fourth grade.

Conclusions

From the examination of the results of this study the following conclusions were made.

1. Teachers feel that a combined approach of printed material, together with activites is the most effective method of teaching measurement.

2. Teachers feel a need for in-service training in the metric system and the methodology of teaching metrication.

3. Teachers have little, if any, metric measurement materials available in their classrooms.

4. Teachers indicate that instruction in linear measurement, area, perimeter, weight and temperature is the most appropriate for fourth grade measurement lessons.

Recommendations

1. A district wide coordinated program in the teaching of measurement should be initiated in the Butte School District No. 1.

2. Materials for the teaching of metrics should be purchased for the teachers by some person familiar with the supplies and knowledgeable about instruction in the grade school.

3. Teachers should be provided with workshops or in-service training in the use of the metric system.

4. A scope and sequence for fourth grade metric study based on teacher written objectives should be developed.

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APPENDICES

APPENDIX A
THE SURVEY INSTRUMENT

GENERAL INFORMATION:

1. If written-printed materials and activity materials were provided you to teach measurement would you be most comfortable with:

   a) written alone b) mostly activity

   c) combined printed and activity

2. What method of teaching measurement do you feel is most effective?

   a) printed material b) activity

   c) combined printed and activity

3. List instructional material you would like to have to teach metrics (not currently available).

4. List instructional material you now have for teaching metrics.

5. Are you currently (1974-1975) teaching measurement as a unified unit_____or is it a spiral approach_____?

6. How much time (estimated in class periods) do you usually spend teaching measurement?_____

7. Do you feel adequately prepared to teach the metric system: yes___
   no____

8. Would you participate in a teacher workshop in preparation for this teaching responsibility? no____
   yes___

   If yes, how many hours would you give?
   ____1 hour ____2 hours ____4 hours ____8 hours
   Would your participation in a workshop be dependent upon receiving college credit? no___
   yes__

9. If a student has mastered a particular skill in your class, how much of the time would you expect him to answer correctly?
   ____50% ____75% ____90% ____100%

APPENDIX B

LIST OF PERFORMANCE OBJECTIVES

Please rate the following objectives relative to your fourth grade arithmetic class. Each objective will have two ratings. One to indicate the appropriateness of the objective for your class and two, a sub-rating.

RATINGS:

1. Doesn't apply to my class.
   a) too easy b) too difficult
2. Worth consideration
   Should be: a) introduced b) developed
   c) introduced and developed d) mastered
3. Very appropriate
   Should be: a) introduced b) developed
   c) introduced and developed d) mastered

____Student can recall and give one reason for standard units.
____Student will be able to linearly order 5 objects, smallest to largest.
____Student will be able to measure an object linearly with some arbitrary unit.
____Student will be able to find perimeter by measuring printed figures with a standard unit.
____Student will be able to find area of drawn figures with measurements given.
____Student will be able to find volume of printed shapes with given dimensions.
____Student will be able to select proper device (ruler, yard stick, meter stick) to measure lengths in feet, yards, centimeters, meters.
____Student will be able to select the proper metric units of measurement for length, area, weight, temperature.
____Student will be able to give approximate lengths to the nearest centimeter and/or meter by visual examination.
____Student will be able to give appropriate lengths of an object in centimeters and meters by visual examination.

_____Student will be able to give approximate lengths of an object to the nearest millimeter by visual examination.
_____Student will be able to recall the fractional ratio of millimeters to centimeters to decimeters to meters.
_____Student will be able to add and subract decimal problems involving numbers with one to three decimal places.
_____Student will be able to recall decimal values of prefixes of centi, deci, milli, kilo.
_____Student will be able to recall abbreviations for centimeter, meter, millimeter, decimeter, kilometers.
_____Given written or oral problems the student will be able to use his knowledge that a centimeter is a little less than a 1/2 inch to solve problems.
_____Given written or oral problems the student will identify the meter as equal to 100 cm and use in solving problem.
_____Student will recall that weight units are grams and kilograms.
_____Student will recall abbreviations for grams and kilograms.
_____Student will recall what he weighs in kilograms.
_____Student will be able to visually exam and give approximate weight of 5 common objects in kilograms (i.e. a car, carton of milk, a cat, a truck).
_____Student will be able to identify 3 objects that approximately weigh one gram.
_____Student will give decimal relationships between kilogram, grams, milligrams.
_____Student will be able to weigh small object to nearest gram.
_____Student will be able to weigh objects to nearest kilogram.
_____Student will recall and use to solve problems the relationship between metric weight and volume.
_____Student will be able to look at common containers of liquid substances and reasonably estimate liter capacity to nearest halves, and/or wholes.
_____Student will be able to multiply decimal numerals with numbers in tenths and hundredths places.
_____Student will be able to divide decimal problems with numbers in the tenths and hundredths places.
_____Student will recall the decimal values of mega, and hecto.
_____Student will recall that temperature is measured in Celsius degrees.

_____Student will recall the freezing and boiling temperatures in Celsius.
_____Student will be able to read a thermometer and/or pictorial representation to the nearest degree in Celsius.
_____Student will be able to keep a daily journal of outdoor temperature in Celsius degrees.
_____Student will recall normal body temperature in Celsius degrees.

COVER LETTER

METRIC MOUSE MEASUREMENT
UNIT

This course is intended as a unit to build understanding in the use of metric measurement of linear measure, perimeter, area, weight and temperature. The author understands that more exercises would be needed. If the text exercises are not of an appropriate nature it is hoped that some of the commercial materials will be purchased to provide reinforcement throughout the year.

At the end of this unit sample exercises from each of the recommended materials are shown. Addresses and approximate costs are provided.

APPENDIX C

FOURTH GRADE TEACHERS GUIDE ON METRICATION

Metric Mouse 1 - Teachers guide

Objectives for the lesson: to develop the performance skills designated as important in metric measurement.

This lesson is to develop the following linear measurement competencies. Time 1 - 2 periods

1. Investigation of need for standard units.
2. To develop a "feeling" for the length of a cm, m, and dm.
3. To relate metric lengths to the body for quick reference.
4. To develop an understanding of the relationship between a cm, dm, and m.
5. To introduce the abbreviations for cm and m.
6. To develop the ability to use a measuring unit to determine the length of an object.

MATERIALS TEACHER WILL NEED:

30 pieces of string about 1 1/2 meters long
15 pieces of string about 7 cm long
30-15 cm rulers (may be purchased at a drug store for 5-7 cents)
30 flexible meter rulers (GO-MO Company) (if tapes are not available, have the students glue the meter pieces provided here to flexible cardboard to form meter rules)
3 packages of 50 plastic straws. Cut each straw into two lengths of 10 cm. Each child will need 10 of these straws.

SUGGESTIONS

Part 1

1. The science program Minnemast has a booklet called Measurement with Reference Units No. 12 which has an excellent unit on standard units of measurement.

If this is available try it. If Minnemast is not available discuss with students at end of part 1 their results and why the values varied. Need for standard units is an important concept.

2. Students will have difficulty understanding the use of arrows on the beginning drawings. Before the lesson it would help to explain that the arrow indicates what part of the object is to be measured.

3. The students will need partners frequently throughout this unit; partners should be assigned before starting the unit.

4. In Part one, the partners work with 1 straw (10cm) and one string (7cm) in measuring. The partner which is using the string should have the largest answers.

Part 2

1. As the students "string" a meter, if the first straw and last straw are tied the others will then stay.

2. The primary type used in these exercises is all capitols. The children should be informed that all abbreviations are lower case letters. For example, meter is m, centimeter is cm, and decimeter is dm.

Part 3

1. Students will need the standardized units of the cm rulers and the meter ruler.

COMMERCIAL MATERIALS AVAILABLE TO COMPLEMENT THE LESSONS IN THIS UNIT ARE:

"Fun with Metric Material"
"Metric Fun Activity Cards"

METRIC MOUSE 2 Teachers Guide

MEASUREMENT OBJECTIVES FOR THE LESSON: Time 10 - 15 min.

1. To provide practice and develop skill in use of ruler and reading values to the nearest 1/2 cm.

2. To provide practice in using the centimeter abbreviation.

MATERIALS NEEDED:

Centimeter rulers

SUGGESTIONS:

1. Encourage student to think in terms of "about 1 cm" "about 1/2 cm" "a little more than 1/2 cm" or "a little less than 2 cm."

COMMERCIAL MATERIALS

"Metric Measurement Manual"
"Metric Measure Book A"

ANSWER KEY:

A. 2 cm
B. 4 cm
C. 3 cm
D. 2 1/2 cm
E. 2 1/2 cm
F. 1 cm
G. 1/2 cm
H. 1 cm
I. 1 1/2 cm
J. 4 cm
K. 3 cm
L. 2 1/2 cm
M. 1/2 cm
N. 2 cm
O. 1 cm
P. 1 cm

METRIC MOUSE 3 Teachers Guide

Time 10 - 15 min.

MEASUREMENT OBJECTIVES FOR THE LESSON:

1. To relate length of a decimeter to a pre-established length of the straw.
2. Introduce decimeter abbreviation.
3. To approximate metric lengths to real objects.

MATERIALS NEEDED:
CENTIMETER rulers

COMMERCIAL MATERIAL

"Metric Fun Activity Cares"
"Metric Measurement Manual"

Answer Key:

Only one metric mouse drawn - last line

Longer than a meter	Longer than a cm	Longer than 1 dm
teacher	dime	football
room	cup	car
car	bee?	grass?
bike	car	doorway
man	house	lion
	rat	man
	brick	bird?
	vitamin pill?	

METRIC MOUSE 4 Teachers Guide
Time 20 min.

MEASUREMENT OBJECTIVES FOR THE LESSON

1. Improve measurement skills with centimeters
2. To introduce the concept of measuring "around."
3. Improve skills of drawing straight lines with a ruler.

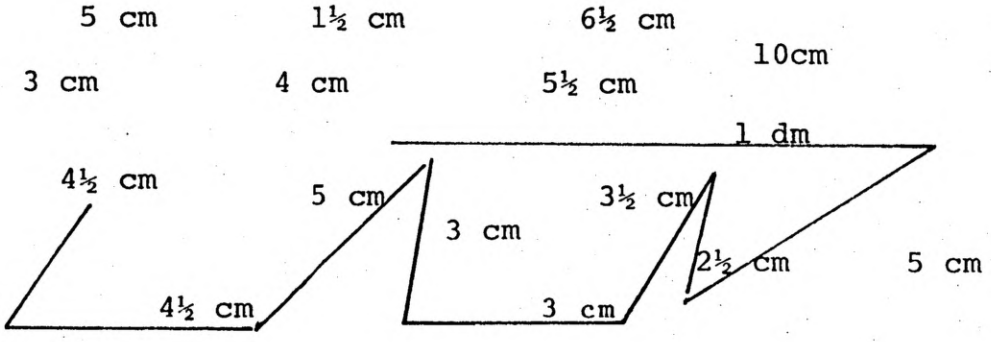
MATERIAL NEEDED:

centimeter rulers

COMMERCIAL MATERIALS

Geoboards	sheet of shapes included to be run on a transparency. Have student make shape on board and then measure around each shape with the cm ruler.
Dot paper	sheets included. Have students make at least 5 more polygons and measure "around."

ANSWER KEY



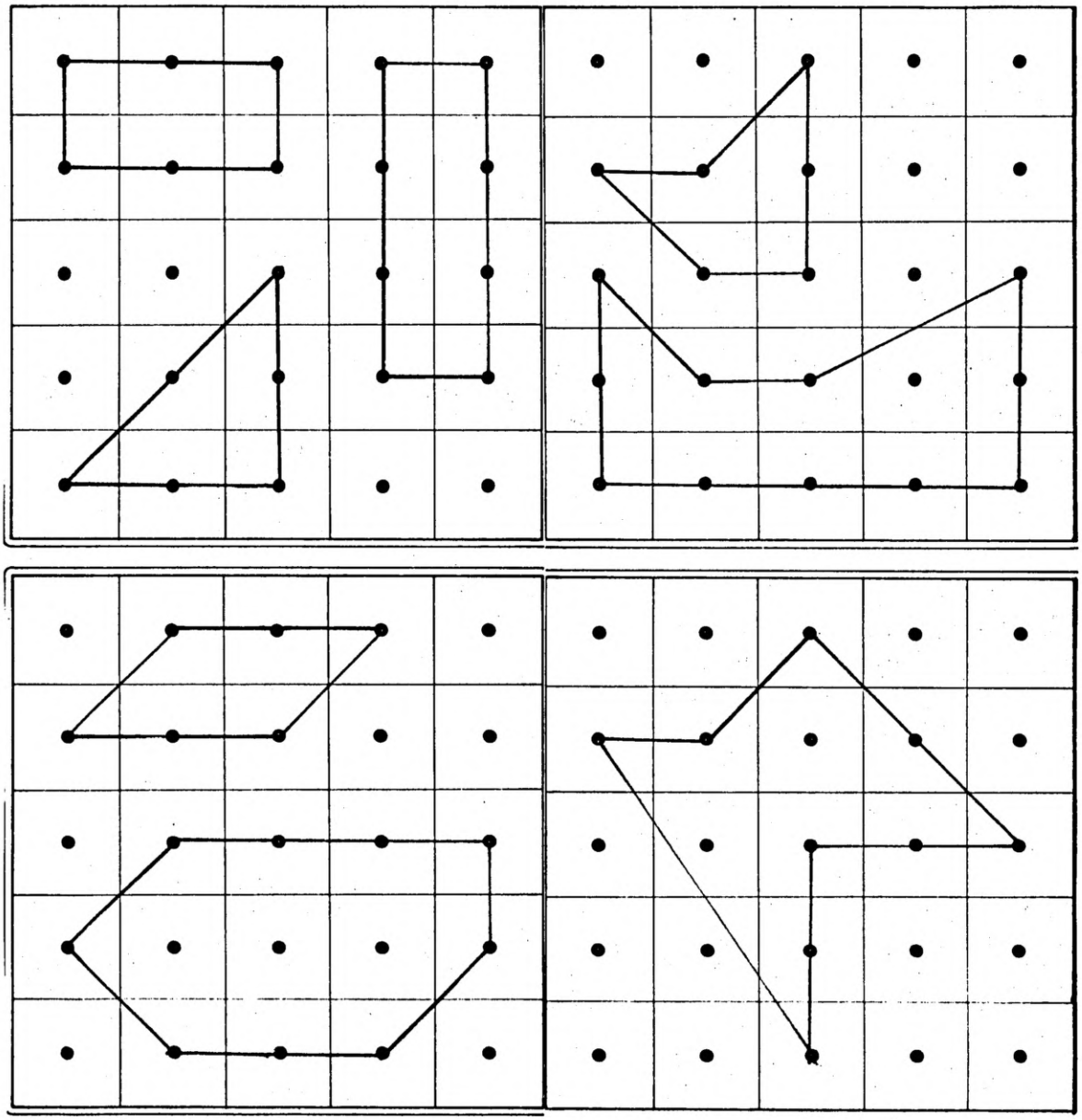


Figure 2. Geo Board Sheet

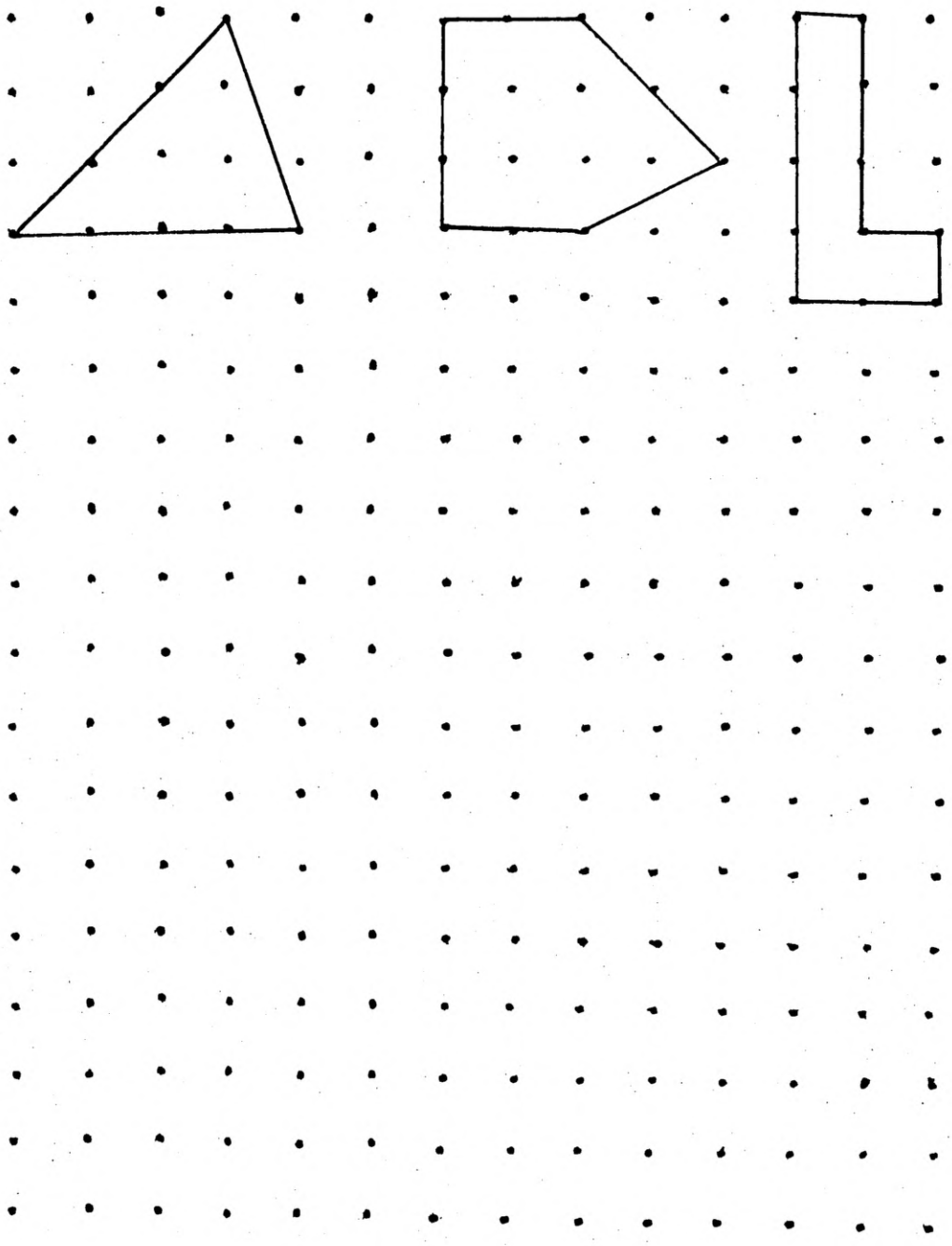


Figure 3. Dot Paper

EVALUATION Teachers Guide

1. Name one part of your body the length of a dm_____
2. Name one part of your body the length of a cm_____
3. Designate the length of a meter on your body_____
4. Abbreviation for centimeter_____meter_____
5. Name two objects shorter than a dm 1)_____ 2)_____
6. Is your teacher taller than 2 meters?_____
7. Find the perimeter of

8. Find the perimeter of

METRIC MOUSE 5

Teachers Guide
15 minutes

MEASUREMENT OBJECTIVE FOR LESSON:

1. To give students practice in measuring shapes and calculating the perimeter.

MATERIALS

cm rulers

COMMERCIAL MATERIALS

"Measure Metric Book B-C"

ANSWER KEY:

A. 4,6,2½	D. 4,2½,3,4	G. 3,4½,6,5½
B. 5,1½,5,1½	E. 2½,3½,4½,4,2,	H. 1,2½,5½,2,
C. 4,2½,4,2½	F. 3,4,6,5½	3,6½

METRIC MOUSE LINES

MEASUREMENT OBJECTIVE FOR LESSON:

1. To provide practice for the child in drawing straight lines and estimating distances.

MATERIALS:

Cubes referred to in game are 1 cm wooden cubes (or dice) on which the teacher can mark the following numbers.

1, 2, 3, 4, 5, 6	2, 3, 5, 6, 7, 8
2, 4, 6, 8, 0, 10	0, 2, 3, 6, 7, 10
1, 3, 5, 7, 9, 11	0, 1, 3, 5, 7, 9

Teacher must ditto game sheets as each student has one sheet per game.

Centimeter rulers.

METRIC MOUSE 6 Teachers Guide

Time 30-40 minutes

MEASUREMENT OBJECTIVES FOR THE LESSON:

1. To introduce student to area concept.
2. To develop an understanding of area by having student mark and measure squares on the candy bars.
3. To relate the meaning of area to actual computation of physical objects (hand, foot).
4. To introduce the idea of a centimeter cube.

MATERIALS NEEDED:

Scissors
Centimeter ruler
Glue

ANSWER KEY:

9, 10, 6, 8
24
Meter Bar

SUGGESTIONS:

The computation for area of the foot and hand implies a magic formula. Before area is computed on the foot, the students should have explained to them that some squares have a large part of themselves covered by the foot whereas, some squares have only a small part covered. Therefore, we are simply combining a square with a large portion covered to one that has a small portion covered and assuming that these two together make one completely covered square.

COMMERCIAL MATERIALS

"The Metric System With Activities"
"Measure Metric" Book B and C

METRIC MOUSE 7 Teachers Guide

Time: two class periods

MEASUREMENT OBJECTIVES FOR THE LESSON:

1. To establish in childs experience the small unit of measurement that the gram is.

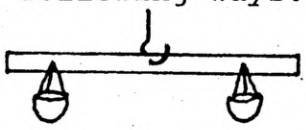
2. To introduce the abbreviation for gram.

3. To provide concrete experience in gram measurement.

MATERIALS NEEDED:

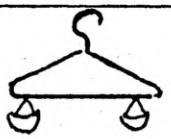
1. Balances - hopefully you have access to a set in a science lab kit.

2. Balances may be constructed in the following ways.



1. Coat hanger hook
2. piece of wood
3. 2 plastic food containers
4. string

5. If it is difficult to balance add a weight with a paper clip wherever necessary.

OR  Not quite as good.

3. Water

4. Grab Box of many small goodies (breakfast foods, pins, cotton, macaroni, marshmallows, hair, feathers, buttons, chalk)

FOR PAGE TWO YOU WILL NEED

5. A roll of nickels

6. A box of objects: paperclips, buttons, macaroni, rubber bands

7. Clay
8. Balances

SUGGESTIONS:

To teach measurement with kilograms a classroom science kit with these masses would be desirable. A classroom metric scale for weighing the student is very handy and can be used by the entire school. Cost of these scales is less than $15 and can be purchased through several school supply catalogs.

COMMERCIAL MATERIALS

"The Metric System"
"Merry Metric Cookbook" (neat recipes that can be done in the classroom with any source of heat, and a fry pan)

Commercial materials with appealing kilogram measure:

"Making Metric Maneuvers"
"The Metric System"

Information: 1 kilogram (kg) is 1000 grams (g)

1 kg is 2.2 pounds (about 2 pounds of butter)

METRIC MOUSE 8 Time: two class periods

MEASUREMENT OBJECT FOR LESSON:

1. To provide experience in developing a thermometer.
2. To develop a concept boiling and freezing in Celsius temperature.
3. To provide practice in reading real and printed thermometers.
4. To provide memory aids to facilitate "thinking metric."

MATERIALS NEEDED:

1. Thermometers not calibrated and heat resistant (May be purchased from the GO-MO Company)
2. 30 tongue depressors (May be obtained from Harringtons Surgical Supply for minimal cost)
3. 60 elastic bands.
4. Container of melting ice (not just ice water)
5. Container of boiling water
6. Centimeter rulers for the students to use for drawing lines
7. Glue
8. A file to scratch the thermometers

COMMERCIAL MATERIAL

"The Metric System"

ANSWER KEY:

1. $10^{\circ}C$
2. $-40^{\circ}C$
3. $30^{\circ}C$
4. $40^{\circ}C$
5. $0^{\circ}C$
6. $100^{\circ}C$
7. $0^{\circ}C$, $20^{\circ}C$
8. $33^{\circ}C$
9. $10^{\circ}C$
10. about $20^{\circ}C$
11. about $37^{\circ}C$

METRIC MOUSE 9 Teacher Guide

Time 30 min.

MEASUREMENT OBJECTIVES FOR THE LESSON:

1. Reinforcement of use of tapes and measuring to the nearest cm.
2. Review of size of body parts and body temperature.
3. Developing body metric measurement to use for reference in "Thinking Metric."

MATERIALS NEEDED

30 flexible meter tapes

SUGGESTIONS:

This exercise is neat if each child has his partner draw his outline on a piece of butcher paper. Then his measurement can be put on his own outline to be taken home and hung on the wall.

METRIC MOUSE 10

MEASUREMENT OBJECTIVES FOR THE LESSON:

1. To provide student with some arithmetical manipulation on relations of centi-, and deci.

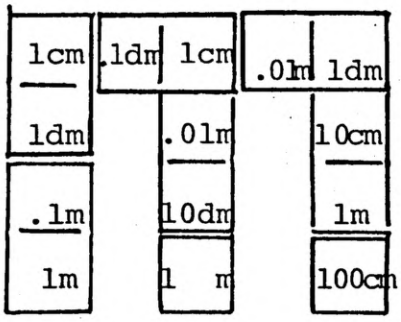
MATERIAL

Scissors, crayon

COMMERCIAL MATERIAL

"The Metric System"
(This book is a little more advanced than the others recommended. The material is very well constructed and interesting.)

ANSWER KEY



EVALUATION Teachers Guide

1. Freezing in Celsius_____.
2. Weight used to measure feather_____.
3. Part of your body that is 1 dm_____.
4. How many cm in a m_____.
5. About how much does a can of tuna weigh in grams_____.
6. What's your body temperature in C^{o}_____.
7. In what unit do you measure your height_____.
8. What are the abbreviations for Celsius _____
   gram_____
   meter_____
   centimeter_____
9. How high do you think the door is_____.
10. Boiling in Celsius_____.
11. How many dm in a meter_____.
12. Name a part of your body that is 1 cm_____.
13. How many centimeters wide is your paper_____.
14. What is room temperature in Celsius_____.
15. Name a coin that has a mass of 5 grams_____.

RESOURCES Teachers Guide

Resource	Approximate Cost
Minnemast Center 720 Washington Ave. SE Minneapolis, Minnesota 55455	$5
Metric Fun Activity Cards Published by: Teachers PO Box 398 Manhattan Beach, California 90266	Fun with Metric Measurements (83 sheets) $5
Metric Measurement Manual Pauper Press Box 303 Two River, Wisconsin 54241	34 exercises 34 pictures for measuring <$3
Metric Measure Book ABCD by Sala May Published by Harcourt Brace Jovanovich, Inc.	32 pages each <$3
The Metric System with Activities Midwest Publications Co., Inc. PO Box 129 Troy, Michigan 48084	24 pages w/50 individual investigations <$5
The Metric System Addison Wesley Publishing Co. Menlo Park, California	85 pages of neat activities <$3
Merry Metric Cookbook Activity Resources Co. Inc. PO Box 4875 Hayward, California 94545	<$3
Making Metric Maneuvers Activity Resources Co. PO Box 4875 Hayward, California 94545	100 pages of activities <$6

The Metric System of Measurement
Activity Resources Company Inc.
PO Box 4875
Hayward, California 94545

89 pages of puzzles and activities
<$5

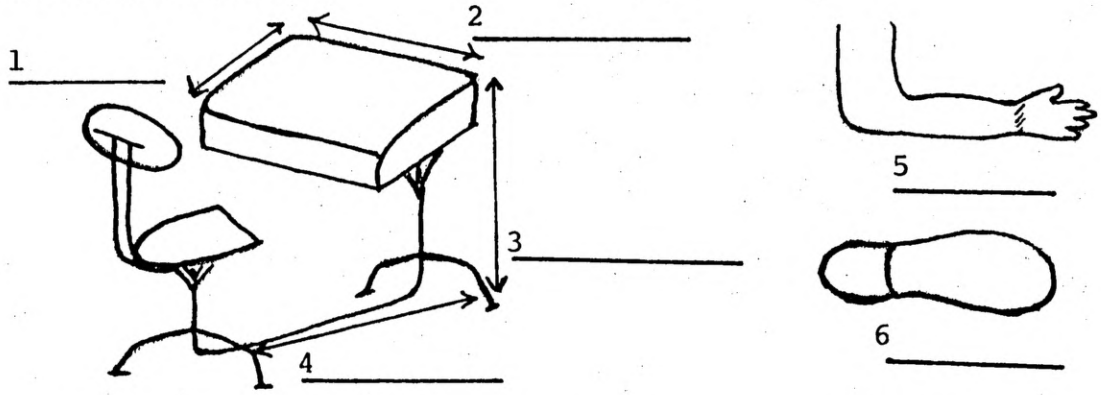
GO-MO-CO
1906 Main Street
Cedar Falls, Iowa 50613

100 cm tapes (10) pack
<$3

Ten pack thermometers
0^{o}-100^{o}C <$4

APPENDIX D
FOURTH GRADE STUDENT WORKBOOK ON METRICATION
METRIC MOUSE ONE

Measure the following objects with the unit the teacher gives you. As you measure, write the answer on the numbered blank.



Check your answers with your partner. Are the answers the same?_____What was your unit? (string, straw) What was your partners unit? (string, straw) Whose answers were largest? Why were the straw answers smaller than the string answers?_____What would help you and your partner to have the same answers?_____

_____

PART TWO

Take the straw and mark off 10 parts. Each part is called a centimeter. How many centimeters in a straw?_____ How many centimeters in 2 straws?_____How many centimeters in 5 straws?_____How many straws would make 100 centimeters?_____Look at the spelling of centimeter. What word do the first four letters spell?_____ How many cents in a dollar?_____That is the number of centimeters in a meter. Now string a meter on the long piece of string the teacher gives you. How many straws must you string on the string to make a meter?_____ This is because there are _____centimeters in each straw.

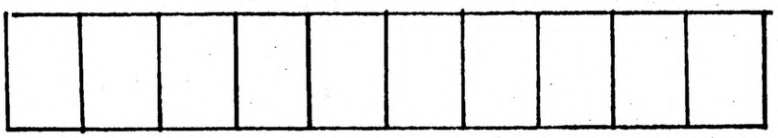
When you talk about money, cent is abbreviated as ¢. Dollar is abbreviated as $. Metric Mouse has a sore paw from writing centimeter so many times so would you use the abbreviation cm from now on. Also would you use meter's abbreviation of beautiful m. Metric mouse sometimes likes to be called MM because he thinks that this is real neat.

Using your straw meter stick measure your partner's height. My partner's name is_____, and his height is_____m. My height is _____m.

Now measure your partner in cm_____. My height in cm is_____. Guess how high you think the door is._____

PART THREE

This is 10 cm in a row.



See if your straws are the length of this ruler. How many of your straws are longer than this ruler?_____How many of your straws are shorter than this ruler?_____Sometimes Metric Mouse is a sloppy straw cutter so from now on we will use printed tapes and rulers to standardize our units. Return your straw meters to the teacher.

Using the ruler above, answer the following:

1) How wide is your little finger?_____
2) How long is your little finger?_____
3) How wide is the palm of your hand?_____

Using the metric rules, answer the following:

4) How long is your nose?_____
5) How wide is your smile?_____
6) List how far a meter is on your body_____
7) List three parts of your body that are a cm long_____

_____ _____

8) List a part of your body that is 10 cm long (1 straw)

_____

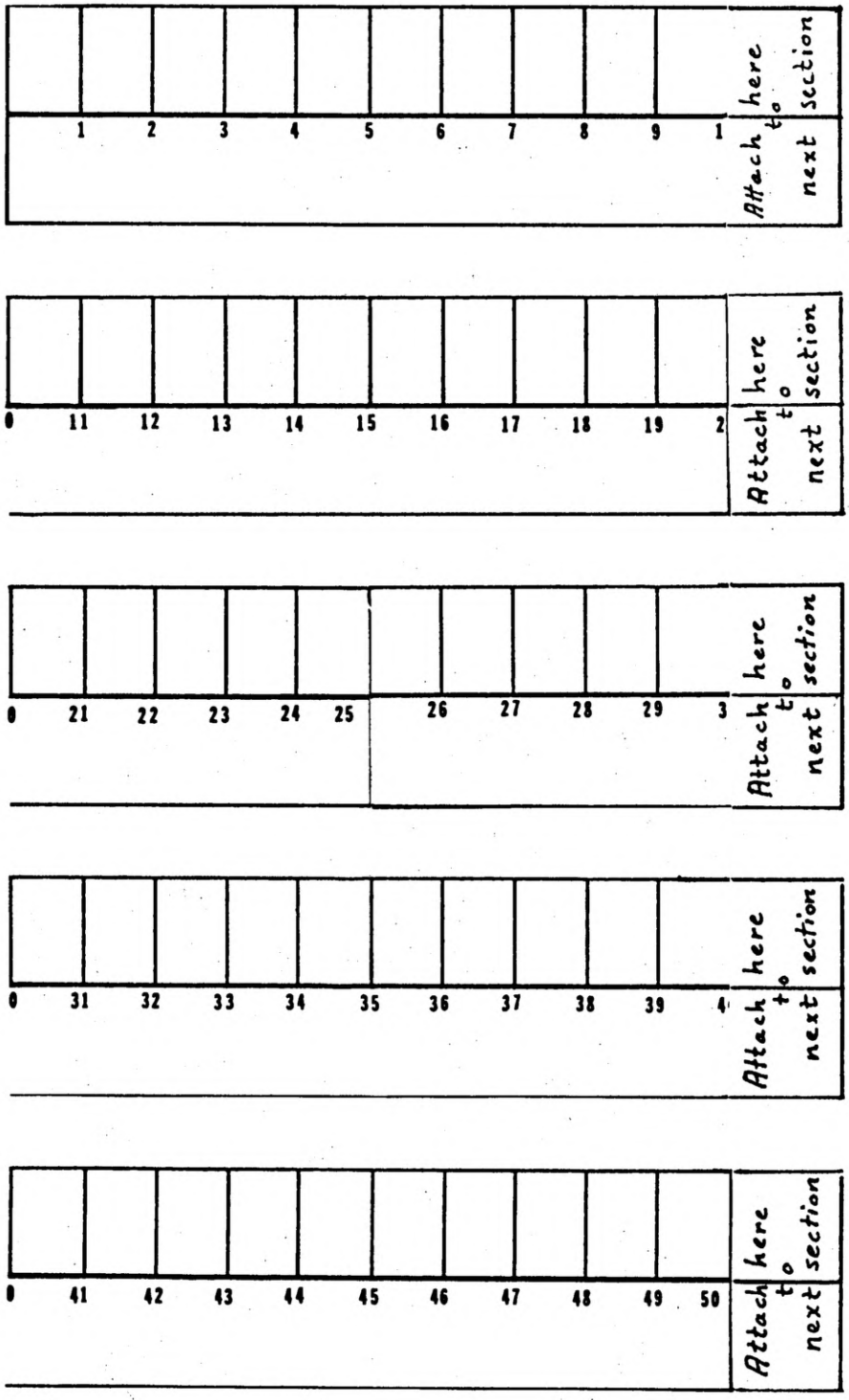


Figure 4. Meter Stick

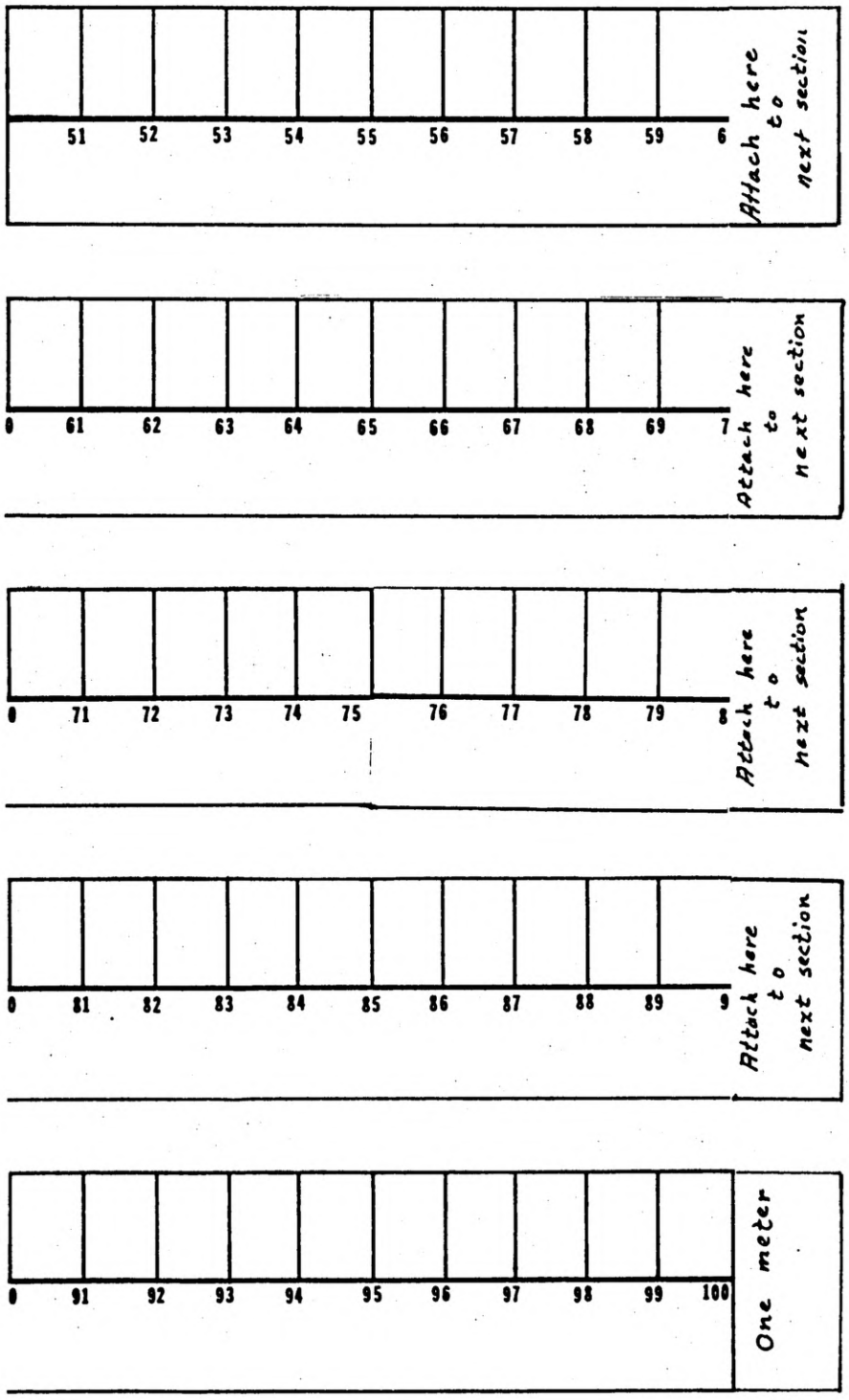


Figure 4. Meter Stick (continued)

METRIC MOUSE TWO

To provide a model for you, Metric Mouse agreed to straighten himself out. Measure the length of each line on MM and write the lengths by the right letters. Don't forget the unit abbreviation.

A - _____ _____

B - _____ _____

C - _____ _____

D - _____ _____

E - _____ _____

F - _____ _____

G - _____ _____

H - _____ _____

I - _____ _____

J - _____ _____

K - _____ _____

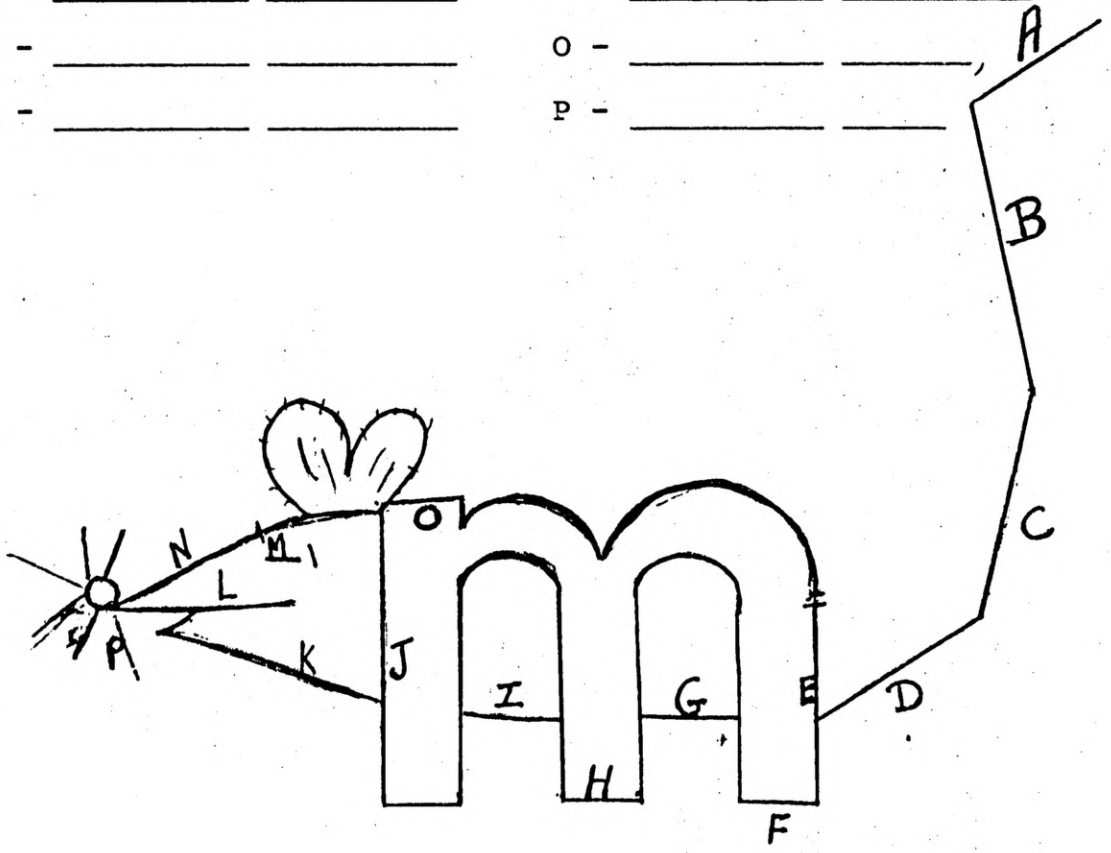
L - _____ _____

M - _____ _____

N - _____ _____

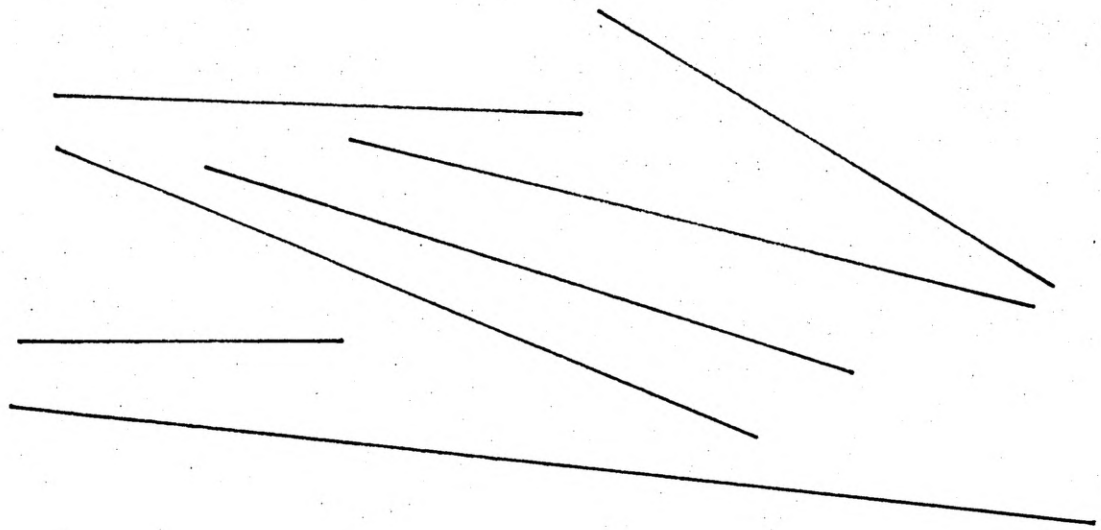
O - _____ _____

P - _____ _____



METRIC MOUSE THREE

Did you notice how the abbreviation for meter was made? It is just the _____letter of the word. How was cm made? _____It seems awkward to keep 'straw' for a unit of measure. I suppose we would call_____ _____a strawmeter, but someone before today decided, that since 'deci' means ten, we should call_____ a decimeter. What do you guess the abbreviation is?_____ If you supposed DM you are doing great. Draw a Metric Mouse on the line segments longer than a dm.

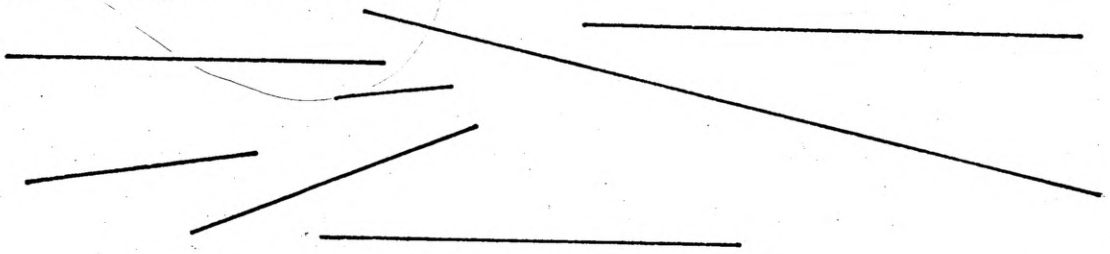


Place an X on the items that are:

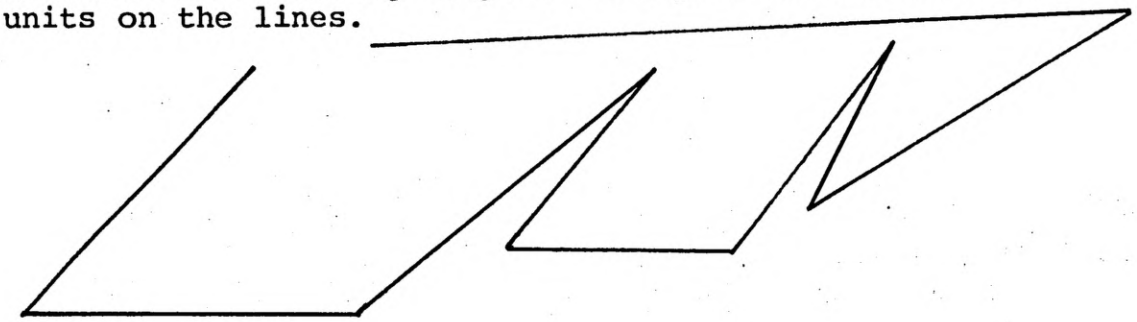
Longer than one meter	Longer than one CM	Longer than one CM
1) Finger	1) Dime	1) Football
2) Teacher	2) Cup	2) Finger
3) Room	3) A dot	3) Car
4) Book	4) Ant	4) Ant
5) Car	5) Bee	5) Grass
6) Bike	6) Car	6) Baseball
7) Football	7) Rat	7) Doorway
8) Man	8) House	8) Lion
9) Bird	9) Brick	9) Man
10) Brick	10) Vitamin pill	10) Bird

METRIC MOUSE FOUR

Measure the following lines and put your answer on the line. Don't forget the units.



Measure the following shapes. Put your measurements and units on the lines.

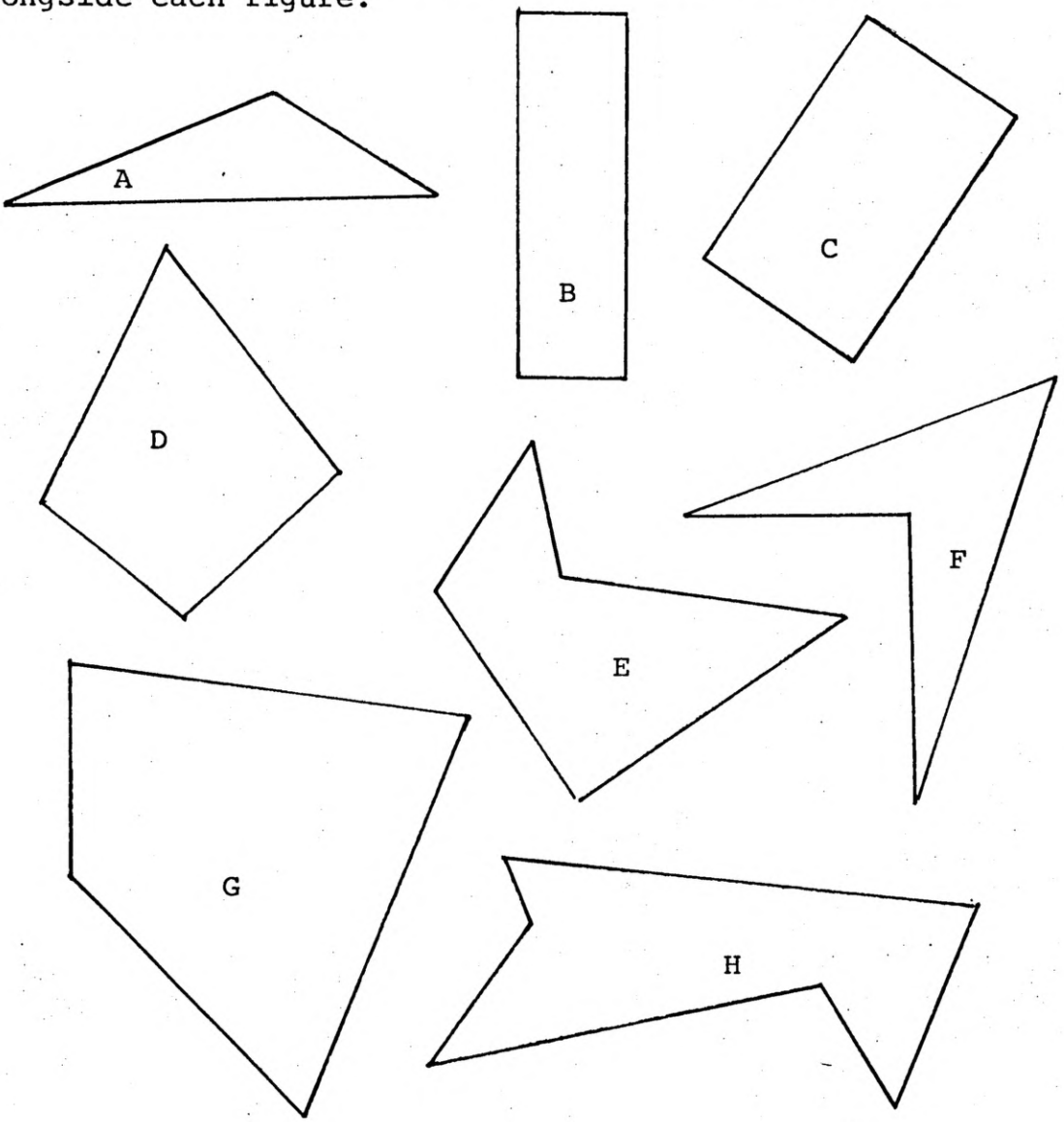


Metric Mouse does lots of running around shapes, houses, and parks. Show how many cm he ran today as he went around the shapes above. Do your work in the right hand margin.

Draw your own path for MM below and label the distance for each line segment.

METRIC MOUSE FIVE

Metric Mouse really thinks it is neat to keep a record of the distance he travels around shapes. This is called finding perimeters. (Oh-Oh, there is that meter word again with another prefix of (_____). MM is one of the only mice in the world who can do this, but it is still hard for him. Please give him a hand today and write in the lengths of the sides and then write the perimeter alongside each figure.



METRIC MOUSE LINES

Rules:

2-4 players

1. Each player needs a game sheet and a metric ruler.

2. To begin play, each player draws a cube at random and the greatest length indicates player one. Play rotates clockwise. Return cubes after each play.

3. A play consists of drawing a cube and constructing in centimeters a segment equal to the length indicated on the cube. The first segment must start from the end of MM's nose, going in any direction. Successive segments must start at the end point of the last segment constructed, going in any direction. If a 10 or 0 is thrown player estimates the distance he needs to go to the next mouse hole and then draws the estimated segment.

4. The object of the game is to end a segment within hole 1, then continuing the segments, go on to hole 2, 3, and 4. The first player to end a segment within hole 4 wins the game.

5. A segment may not pass completely through any hole during the game. Segments may intersect.

4

2

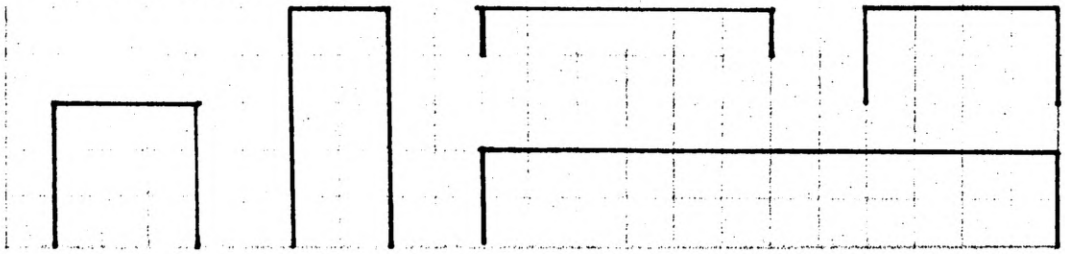
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METRIC MOUSE LINES

3

METRIC MOUSE SIX

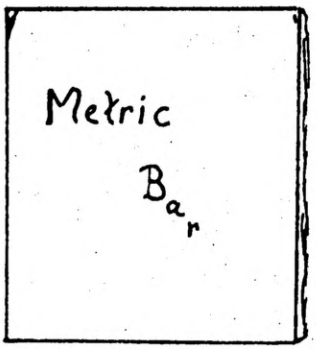
Metric Mouse is going on vacation and needs to board up his mouse holes to keep everyone out while he is gone. It is very difficult for him to know how much wood to buy because he has to stand on his hind feet so long to measure the holes that his tail gets a permanent bend in it. So he drew the holes on squared paper and then counted the number of CM in each hole. He forgot to put the values on the lines telling how many square centimeters were in each hole so would you write them in for him.

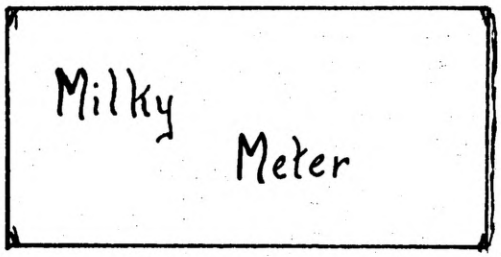


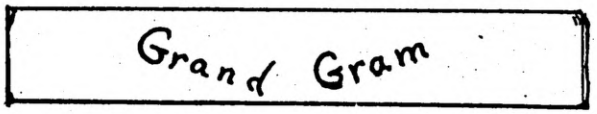
Draw three rectangles on the grid like MM's holes above, and find their areas. That is, count the number of square centimeters in each rectangle.



Mark the areas of the following candy bars. Which would you rather have to eat?_____







On this piece of grid paper would you carefully trace your bare foot. Now to find the area:

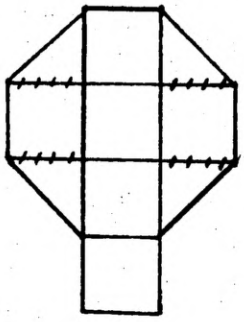
Count all the whole squares 1)_____

Count all the part squares and divide by two.

Put this value on the line 2)_____

Now add 1) and 2) to get the area _____

What is the area of the cross. Cut out this cross and fold on the lines, and then cut on the dotted lines with your scissors. Put glue on the flaps and make a box. Leave the lid open. Seal the edges with extra glue. Let dry for tomorrow's lesson.



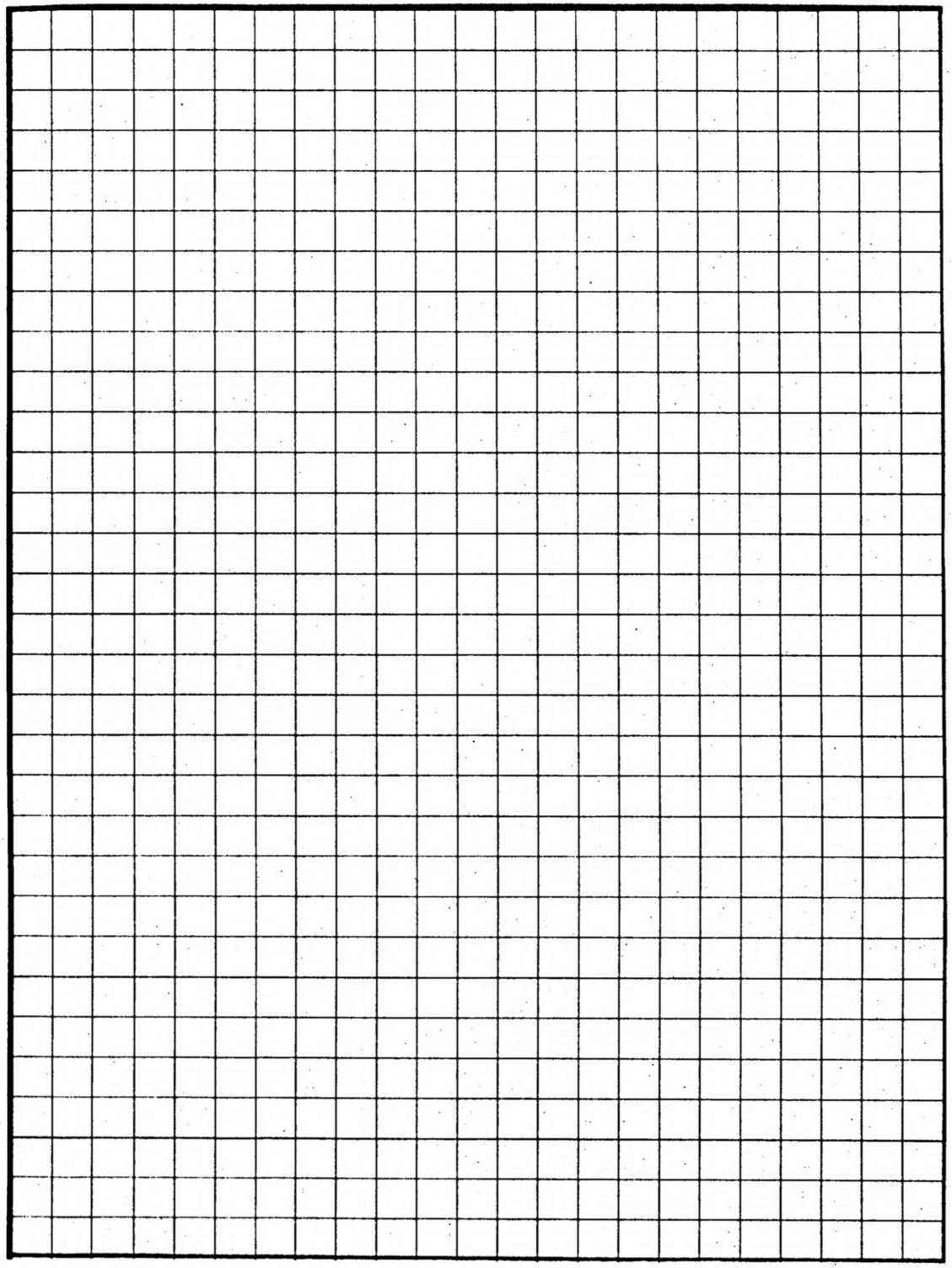
On this piece of grid paper would you carefully trace your hand. Now to find the area:

Count all the whole squares 1)_____

Count all the part squares and divide by two.

Put this value on the line 2)_____

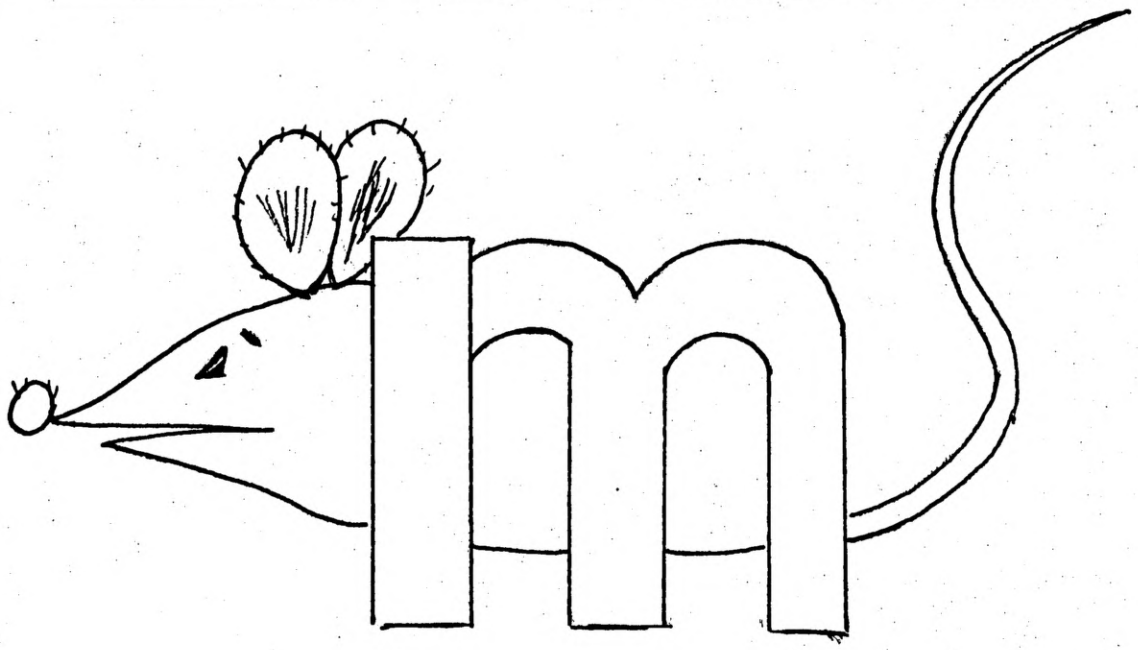
Now add 1) and 2) to get the area _____



METRIC MOUSE SEVEN

Metric Mouse is very thin and weights very little. In the Metric system weight is measured in grams. What is your guess for the abbreviation of gram?_____ A g is the weight of one cubic cm of water. Take the cm cube you made in your last lesson, fill it quickly with water, then pour the water into one of the pans on your balance. Now take and compare the weights of 10 items from the grab box with your gram of water. List the object and tell whether it is more, less than, or equal to a gram.

OBJECT	More-Less-Equal to	OBJECT	More-Less-Equal to
1)	_____	6)	_____
2)	_____	7)	_____
3)	_____	8)	_____
4)	_____	9)	_____
5)	_____	10)	_____



Cut out Metric Mouse.
Lay him over the grid you drew your foot on and lightly trace around him. Can you find his area?_____
Now weigh Metric Mouse on your balance. Does he weigh a gram? If not, how many Metric Mice do weigh a gram?_____

A nickel (5 cents) weighs about 5 grams. Pour out the water in the balance pan and put a nickel in the pan. Now do the problems below.

1) How many paper clips weigh 5 grams?_____
2) How many buttons weigh 5 grams?_____
3) How many macaroni weigh 5 grams?_____
4) How many pencils weigh 5 grams?_____
5) How many rubber bands weigh 5 grams?_____
6) If you wanted to see if 1 rubber band weighed 1 gram, how would you do it?_____
7) If you wanted to see how much a quarter weighed, how would you do it?_____
8) Make a clay mass to balance 5 nickels. Mark the mass 25 g. Now make a clay mass of 100 g, 200 g, and 400 g. Be sure to mark the size on each one. What is the heaviest mass you can now weigh without the nickels?
9) Make a metric mouse of clay weighing 250 grams.
10) Bring to school the labels from the cans of food or dry labels on a sheet of paper and make a collage for the bulletin board. Circle the metric weight on each label so it can easily be seen.

Complete the following chart by guessing:

Masses less than 5 grams-Masses about 5 g-Masses more than 5 g

METRIC MOUSE EIGHT

A thermometer is used to measure temperature and in the metric system this measuring is done in Celsius degrees. (Guess what the abbreviation is_____). To easier understand how a thermometer is made follow the given directions:

You will need one glass tube, one tongue depressor and 2 elastic bands. Fasten the tube to the wood as tightly as possible. Now submerge the bulb of your thermometer into the ice water. When the red line stops put a mark on the wood at this point. Label this zero degrees. (0°)

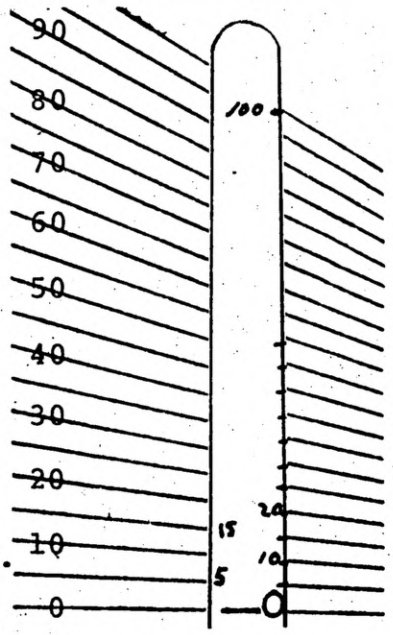
Now place bulb of thermometer in the boiling water until the red line stops. Quickly put a mark on the wood at this point. Label this 100 degrees. (100°)

These two steps should be done at least twice to make certain your marks are correct.

Have your teacher scratch or mark the tube to match your zero degrees, then carefully take the tube and the elastics off the tongue depressor and put them somewhere safe.

On the next sheet is an aid to help you make the necessary marks on your stick so you can read temperatures between 0 and 100.

Place the stick on the lines so that the 0 on your stick is even with the zero on the chart. Slide the stick right or left until the right end of the 100° line on the stick just touches the 100° line. With a lead pencil, place a small dot on the right side of the stick next to each slanted line. Now with your ruler draw straight lines across your stick for each dot you have on the right side. Label the 5°, 15°, 25°, etc. on the left of the stick and the 0°, 10°, 20°, on the right, just like the example.



After you have labeled the lines glue your tube to the center of the tongue depressor. Be sure the zero mark and the zero scratch match.

Let the thermometer set to dry.

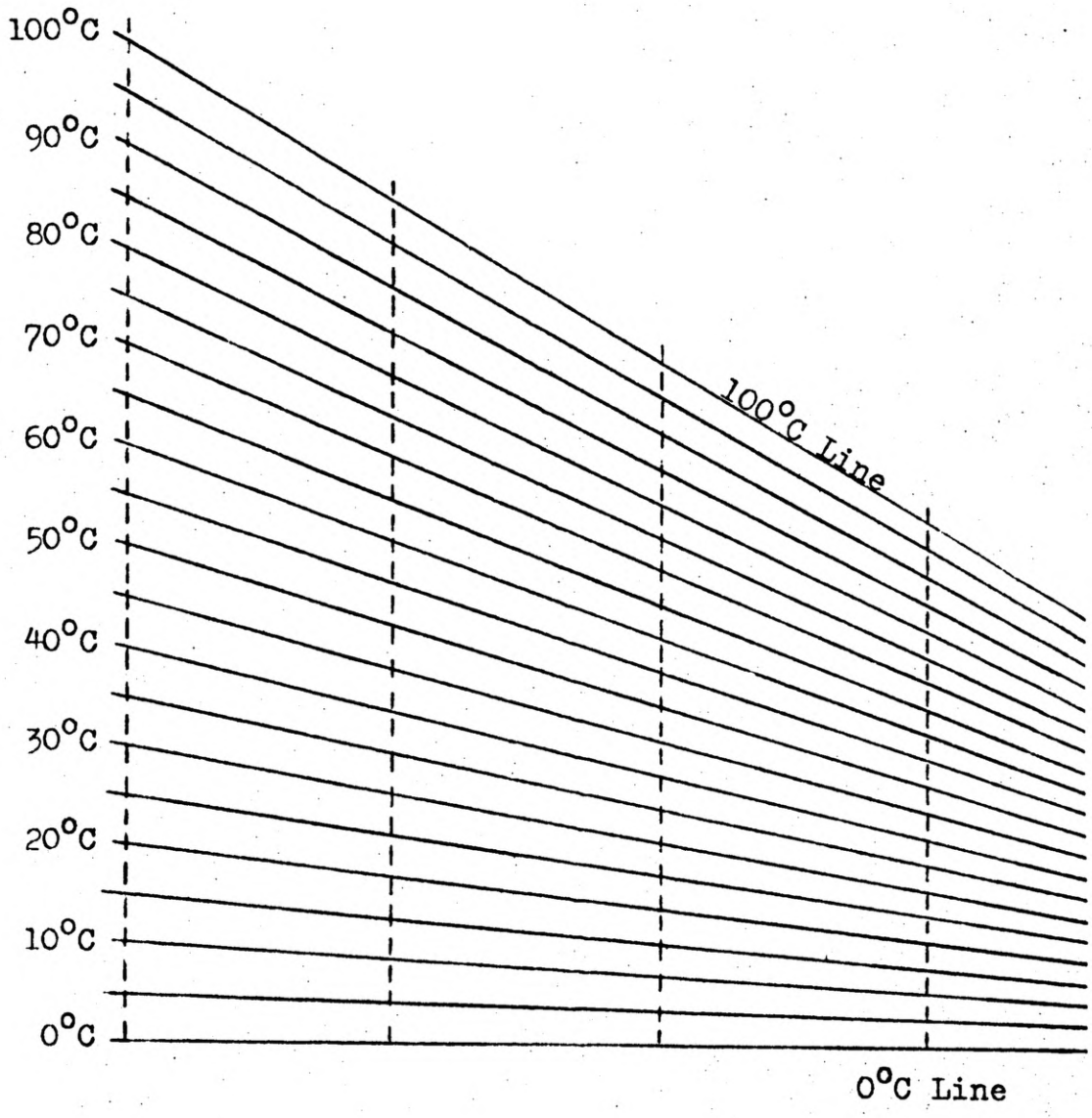
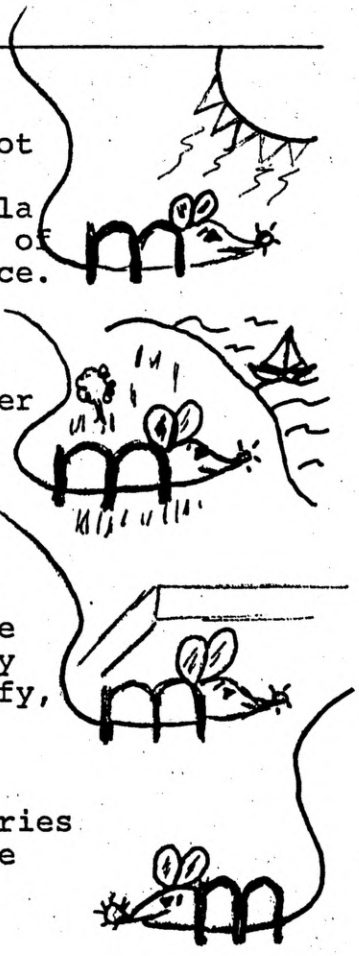


Figure 5. Thermometer

METRIC MOUSE MEMORY AIDS

You will probably have trouble remembering the values for common temperatures in Celsius measurement. Here are some memory aids, along with some drawing and coloring work. Read the aid and color the thermometer to read that value. Then fix up Metric Mouse so he will be more comfortable.

100	Boiling
40	
Fiery-Forty	Metric Mouse is really hot this fiery-forty summer day. Draw him an umbrella for shade and draw beads of sweat coming down his face.
30	
Thirsty, thirty	Metric Mouse is spending some thirsty thirty summer days by the lake. Draw him a glass of lemonade with a straw.
20	
Twentys plenty	Metric Mouse is watching TV at home this day where the temperature of twenty is plenty to be very comfy, Draw Metric Mouse a TV.
10	
Tingly ten	Metric Mouse really scurries fast when the temperature is a tingly ten. Put a sweater on MM.
0	Freezing
-40	
Frigid forty	Metric Mouse is not to be seen when the temperature is -40. Draw no Metric Mouse.



These questions were left here by MM to see if his memory aids helped you to think metric. See if you can get 100% without looking back.

1) A tingling day in May_____C

2) Can't find MM anywhere_____C

3) Beautiful day for soda pop and a boat ride_____C

4) Too hot to even move, just sitting in the shade_____C

5) Icicles are forming on the houses_____C

6) MM is fixing hot chocolate with water of what temperature_____C

7) It's a Christmas Day and MM is unwrapping packages. What temperature is it outside?_____Inside_____

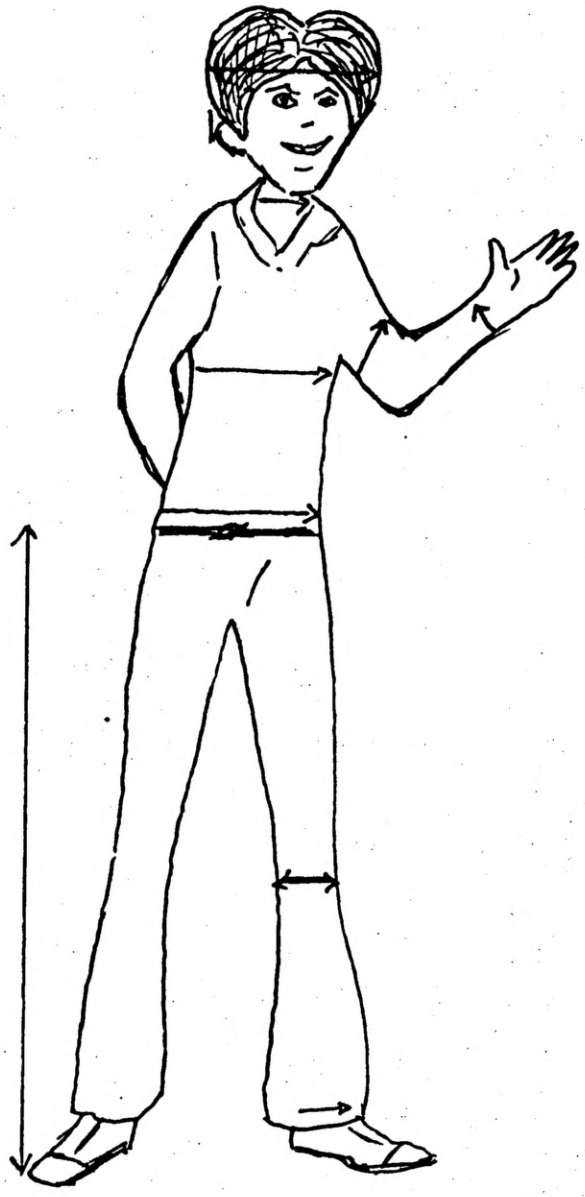
8) Just drinking lemonade while in the stands watching a baseball game_____C

9) Squirrels are really scurrying around putting nuts away for winter._____

10) Get your thermometer you just made. What temperature is your room?_____

11) Put your thermometer under your armpit for 2 minutes. What temperature is your body?_____

METRIC ME 9



head size

neck size

muscle size

chest size

waist size

wrist size

length of leg

knee size

Weight?

ankle size

METRIC MOUSE 10

Who Am I?

USING YOUR METER RULER

How many decimeters are in a meter_____
(Remember the straws?)

Now check how many centimeters in a decimeter_____

Notice 10 cm make 1 dm 10 dm make 1 m

This makes it possible to write a meter as 100 cm or as 10 dm

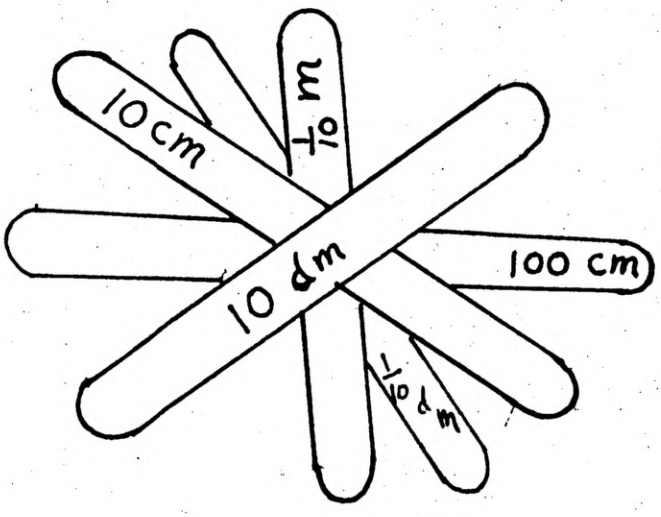
A dm is what part of a meter?_____

That's because there are 10 decimeters (straws) in a meter

One decimeter is _____part out of the 10 that make a meter.

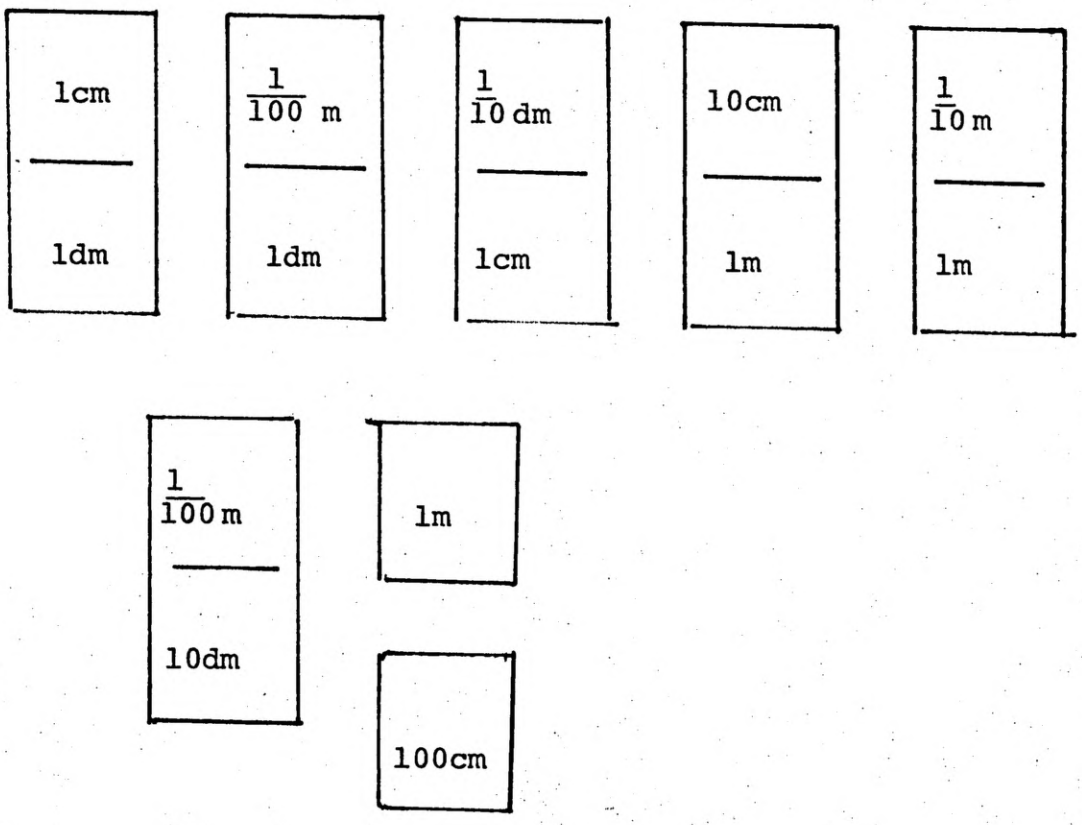
Therefore, 1 dm can be written as $\frac{1}{10}$ of a meter.

SEE IF YOU CAN COLOR THE METER LENGTHS RED
CM LENGTHS BLUE
DM LENGTHS YELLOW



CAREFUL, This is tricky

Cut out the following dominoes. Match the equal measurement names. They should form the letter.



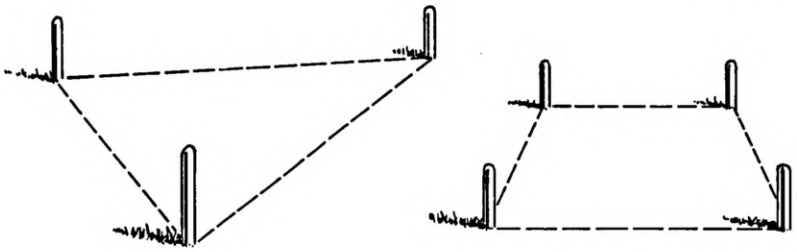
EXPERIMENT NO. 24 **Apparatus: None**

1) It takes 10 centimeters (cm) to make one (1) decimeter (dm). How many square centimeter (cm^2) in 1 square decimeter (dm^2)?
2) How many square centimeters (cm^2) in 1 square meter (m^2)?
3) How many square decimeters (dm^2) in 1 square meter (m^2)?

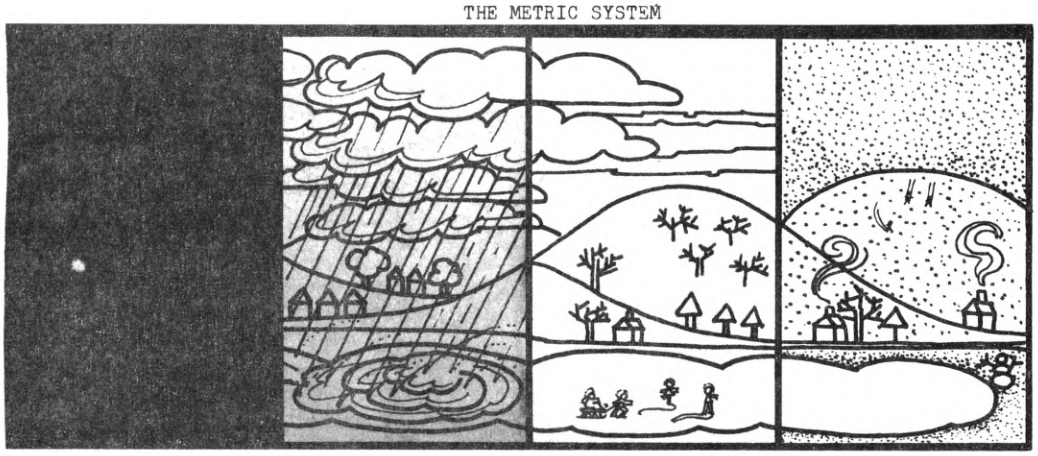
EXPERIMENT NO. 25 **Apparatus: Meter Stick and a Brick**

1) Find a brick wall in your school and measure the area of one brick.
2) How high is the wall. Find the total area of the wall using the area of one brick.
3) What unit of measurement would you use: (a) square centimeters (cm^2), (b) square decimeters (dm^2), (c) square meters (m^2), or (d) square Kilometers (Km^2)? Why?

EXPERIMENT NO. 26 **Apparatus: Meter Stick, Stakes, Hammer**



1) Using three stakes to stake out, by eye, a triangular piece of ground with 3 sides of equal lengths of 10 meters.
2) Check your results by using the meter stick. Comment on your accuracy.
3) Using four stakes, stake out, by eye, a square with 5 meters on each side.
4) Check your results by using the meter stick.
5) What is the area of the triangle and square above?



A Temperature Standard

Your simple thermometer might have been better than measuring temperature with your finger, but is it as good as a modern store-bought thermometer? *no*

Explain why.

A modern thermometer is closed at the top and has a number scale.

ric system. They decided to use things as standards that everyone could get. For a temperature standard they decided to use water. It was a good choice because water has two temperature points that are easy to see.

What happens to water when it gets very cold?

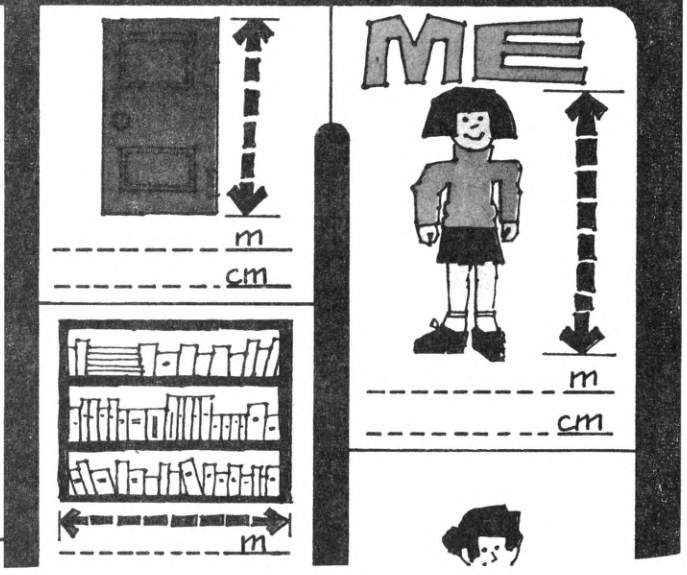
It freezes.

What happens to water when it gets very hot?

It boils.

Meters or Centimeters

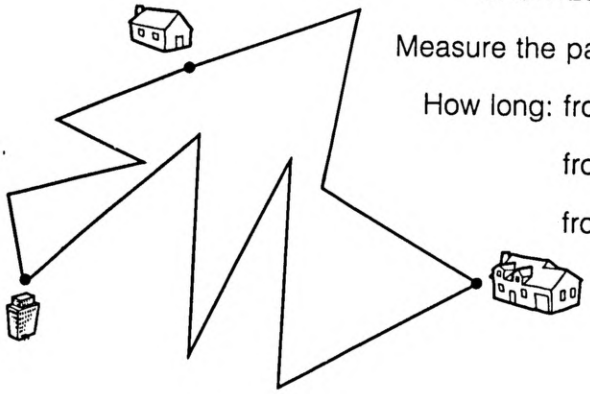
The decimeter is not commonly used in measurement of length. When talking about money, something costing $2.98 is not said to cost 2 dollars, 9 dimes, and 8 cents. Instead we say 2 dollars and 98 cents. Similarly we would not say a racetrack is 2 meters, 9 decimeters, and 8 centimeters long. There are 2 common ways of expressing this measurement — either 2.98 m or 298 cm. Measure the lengths of the objects shown on this page. Record these measurements both in m and in cm.



The International Metric System (SI) prefers that all measurements be expressed in decimal values of the meter.

For convenience, though, centimeters are used just as often in most metric countries.

SHORTEST PATHS



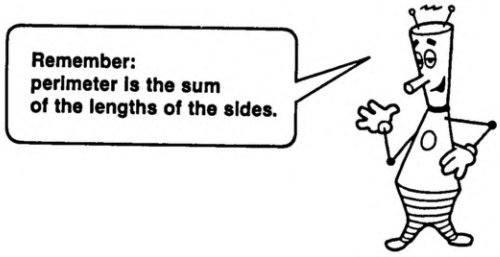
Measure the paths.

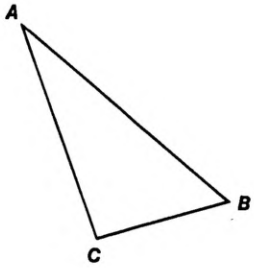
How long: from  to  ? _____ cm

from  to  ? _____ cm

from  to  ? _____ cm

PERIMETERS OF OTHER FIGURES





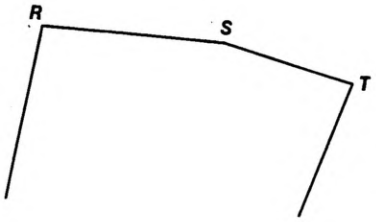
This is a triangle.

How many line segments are there? 3

To find the perimeter
measure each line segment, then add.

The perimeter of ABC is 6 cm + 3 cm + 5 cm.

The perimeter of ABC is 14 cm.



A five-sided figure is a pentagon.

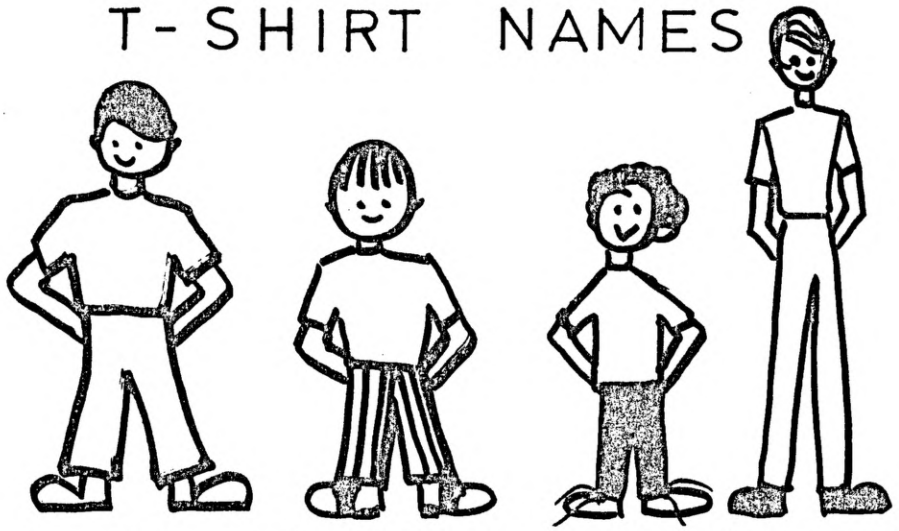
Are the sides of this pentagon
the same length? No

IS IT TALLER THAN ONE METER?

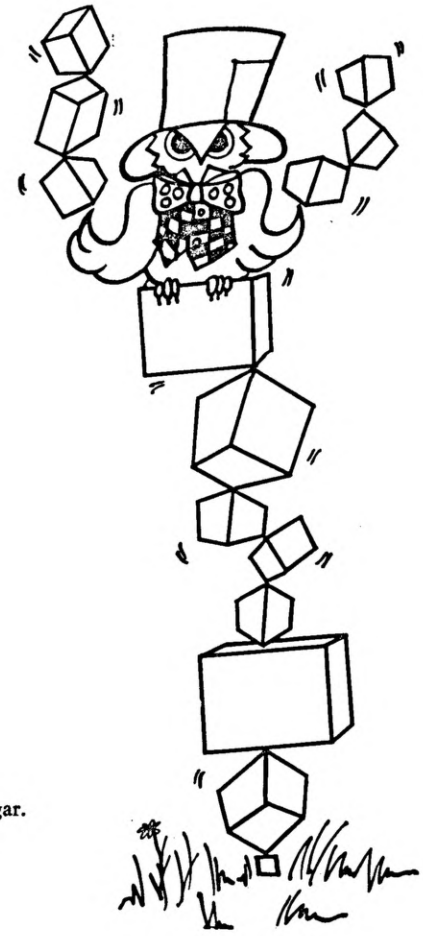
Color the correct answer box.

	YES	NO
1. Your desk?		
2. Your best friend?		
3. Your chair seat?		
4. The teacher?		
5. The back of your chair?		
6. The teacher's desk?		

T-SHIRT NAMES



Joe is 1 meter 25 centimeters tall.
Ken is 140 centimeters tall.
Bob is 1.32 meters tall.
Tom is shorter than Joe.
Print their names on their T-shirts.



MAD HATTER MARSHMALLOW CRISPIES

60 ml Margarine
720 ml Miniature Marshmallows
1.25 liter (1250 ml) Rice Krispies

1. Melt margarine over low heat.
2. Add marshmallows. Stir until melted and blended.
3. Remove from heat. Stir in Rice Krispies.
4. Press into greased pan. Cool.
5. Cut into squares.

SQUARES "MADDER THAN A HATTER"

150 ml Carob Powder
120 ml Whipping Cream
120 ml Honey
240 ml Powdered Milk
5 ml Vanilla
30 ml Soya Powder
240 ml Sunflower Seeds
Powdered Sugar

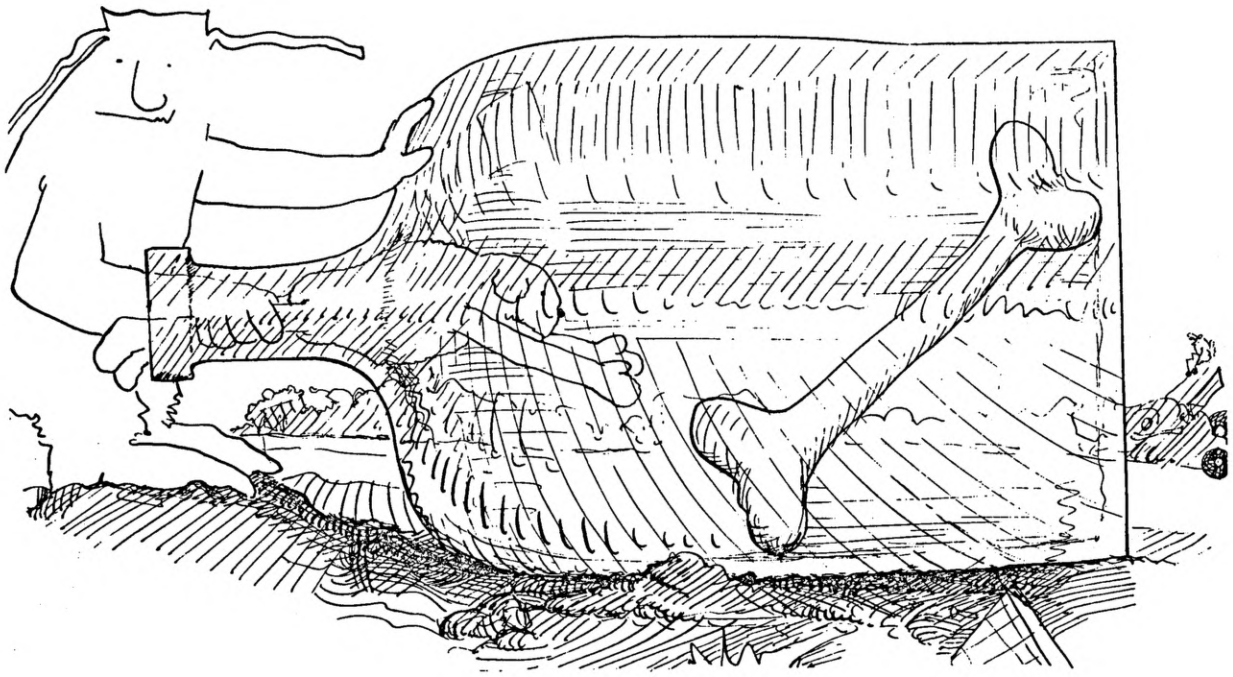
1. Mix all ingredients except sunflower seeds and powdered sugar. Add sunflower seeds.
2. Roll in powdered sugar. Chill 2 hours. Cut into squares.



GEORGIE PORGIE PUDDING

191 g Instant Pudding Mix, Chocolate Flavor
720 ml Cold Milk
5 ml Cool Whip and 1 Maraschino Cherry per serving

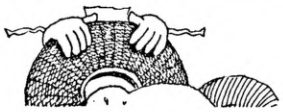
1. Measure the cold milk. Pour it into a mixing bowl.
2. Weigh the mix. Add it to the milk. Beat 2 minutes.
3. To serve 12, spoon 60 ml of pudding into each paper cup. For 24 pupils, spoon 30 ml of pudding for each serving.
4. Top each serving with 5 ml Cool Whip and a cherry.



1. The bottom of the bottle is ___ centimeters in length.

2. The bottom of the bottle is ___ decimeters and ___ centimeters in length.

3. Therefore, ___ centimeters are equivalent to ___ decimeters and ___ centimeters.



THE METRIC SYSTEM OF MEASUREMENT

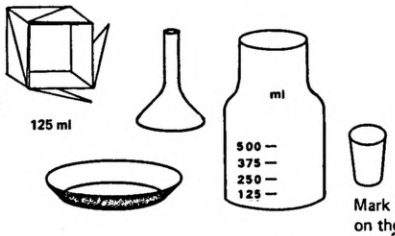


TEMPERATURE: Use the Fahrenheit F Scale and the Celsius C Scale.

1. Your popsicle is placed in a refrigerator at 32°C. Will it keep? _____
2. Your bath water measures 45°C. Will you shiver? _____
3. Your teakettle has just started to boil. Is it now just 212°C? _____
4. Ice has begun to form on a puddle, the thermometer reads 0°C. Right? _____
5. There is more heat needed to raise the Fahrenheit thermometer 10°F than the Centigrade thermometer 10°C. Right? _____
6. It's 50°C, do you need a fan? _____
7. There are 100° on Celsius from water freezing to water boiling. Right? _____
8. The Doctor uses a thermometer and says you have a 35°C temperature. Are you above normal? _____
9. C temperatures in the seventies are comfortable for a schoolroom. Right? _____
10. Temperature readings can go below zero on F scale but not on the C scale. Right? _____

TO MEASURE A LITER

Use your 125 ml measure and water.



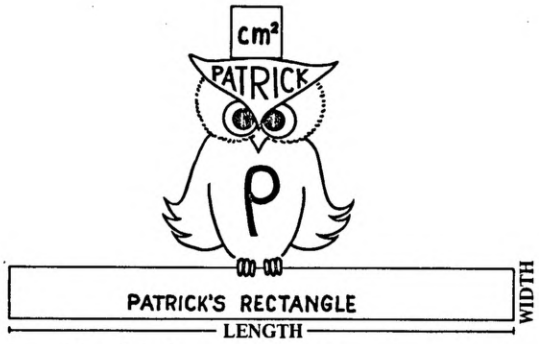
Have several large jars and pans . . . tall and narrow, low and flat, short and wide
(They should hold more than a quart.)

Pour eight of your 125 ml measures of water into one of the jars. Pour eight more into each of the others.

Mark water level on the glass jar.

Does a liter of water look like the same amount in each

What's Area?



Patrick wants to know.
He *needs* your help.

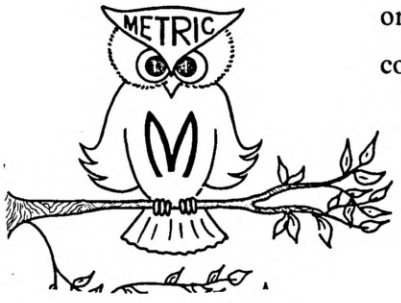
Patrick knows that the length of his rectangle is_____cm and the width is_____cm. He wants to find the area of his rectangle. Let's help Patrick.

First, look at the square on top of his head.

Each side of the square measures_____cm. The area of the square is one square centimeter.

Cut out the square. Use it to find how many square centimeters will cover the inside of his rectangle_____ sq. cm.

Comparing Leaves



Collect six different leaves. Outline them on cm grid paper. Count the squares covered by each leaf.

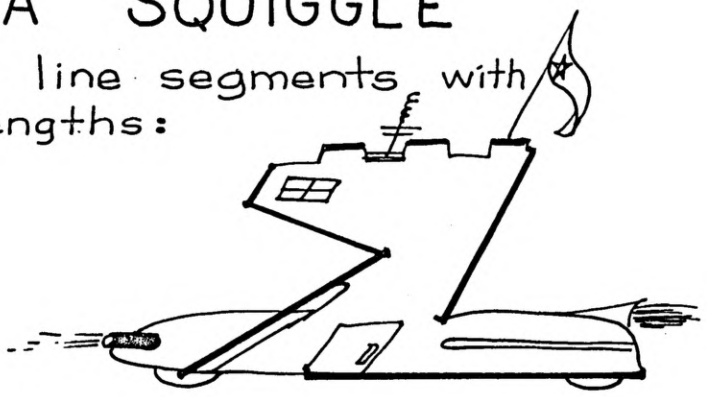
What was the greatest number of squares covered by a leaf?

What was the smallest number of squares covered by a leaf?

A SQUIGGLE

Draw 5 line segments with these lengths:

1 cm
3 cm
4 cm
5 cm
7 cm

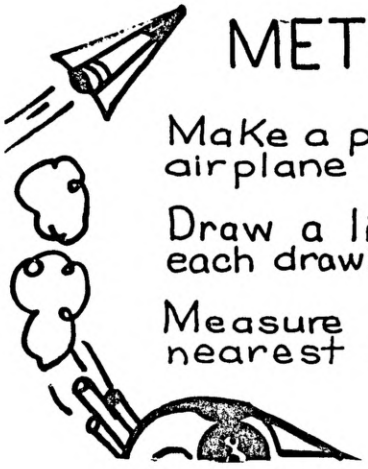


METRIC MOTORS

Make a page of motorcycle, airplane or car drawings.

Draw a line segment next to each drawing to show its size.

Measure each one to the nearest centimeter.





MAKE·A·GAME

Help Millie Meter and her friends get to Kilo Camp.



