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ABSTRACT

A description is provided of the scope of the metrication process, the curricular changes it will bring, and the role of instructional television in metric education. The cognitive and affective impacts of metrication upon adults and children are analyzed, along with the opportunity which it provides to re-examine the role of measurement in the curriculum. The metric system is described as one system of measurement, and anticipated curriculum changes are cited. Suggestions for teaching metrics are provided; attention is given to teacher as well as student needs. The report concludes with a consideration of the role of instructional television in metrication and measurement education. Factors associated with television which make it a desirable change agent are outlined; the value of a consortium approach is explored. Specific suggestions are provided for using television to implement metrication, including strategies for development, a time schedule, a program utilization plan, guidelines, and a topical outline of programs. (Author/PB)

agency for instructional television

PRELIMINARY REPORT

Metric Education

Prepared by
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April 1974

This Preliminary Report is provided for your reaction. Comments from you and other readers will help in the preparation of a prospectus of a major school television program project.

This report had its origin in September 1973 when the Agency for Instructional Television asked all American and Canadian chief school officers for help in the identification of needed program projects. In the following month persons from twenty-nine states and seven provinces came together at four regional meetings conducted by AIT. Participants recommended that AIT explore cooperative projects in essential learning skills, metric education and life coping skills.

The Agency for Instructional Television seeks to strengthen education in the United States and Canada through television and other technologies. Its basic function is the development of significant and effective school television programming, primarily through the pooling of state and provincial resources.

Metric Education

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Two sets of reaction forms are attached to the inside back cover. Please return one completed set to Agency for Instructional Television, Box A, Bloomington, Indiana 47401.

ABSTRACT

This preliminary report describes the scope of the metrication process, the changes it will bring about in the curriculum, and how instructional television can play a vital role through a consortium approach.

Metrication means an affective change as well as the development of cognitive knowledge and skills. A readjustment in thinking will be necessary for most adults, but learning to "think metric" may not be as difficult as some fear, if effective approaches are used. For children, the metrication process will differ initially with each level. The change provides an opportunity to re-examine the role of measurement in the curriculum, and to restructure the measurement component so that concepts can be developed meaningfully through activities.

Following a review of how the metric system developed, this report discusses the meaning of measurement and presents the metric system as one system of measurement. The units, the prefixes, and the relationships are noted. Also cited are changes in the metrication curriculum that

can be anticipated as the nation goes metric as well as the impact on other aspects of the curriculum.

The report describes how measurement has been taught and offers guidelines and specific scope-and-sequence suggestions for teaching the metric system. In teaching it as the primary system, the focus of instruction would be on measurement and providing measurement experiences. While the report emphasizes student needs, it also gives attention to the professional preparation of teachers.

The report concludes with a consideration of the role of instructional television in meeting the challenge of metrication and improved measurement education. It outlines factors associated with television that make it a desirable vehicle for implementing the change to the metric system. The value of a consortium approach to the use of television is explored. This is judged to be an efficient and effective way to assemble, organize, develop, and disseminate resources. The report gives some specific suggestions for using television to implement metrication, with strategies for development, a time schedule, a program utilization plan, guidelines, and a topical outline of programs.

METRIC EDUCATION

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I. INTRODUCTION: THE MEANING OF METRICATION

New York - 100 km

The driver saw the sign, glanced at his speedometer, which indicated 80 km/h, and thought, "About an hour and a quarter more and I should be there."

Cotton - $1.98 a meter

The clerk put the cloth on the counter, measured it with the meter stick, and said, "Two meters -- that'll be $3.96 plus tax."

Temperature - 34° C

"Boy, it's going to be a scorcher today!"

The metric system in use: what will it mean?

Primarily, it will mean a readjustment in thinking -- a change from what, for most Americans, is an automatic response to a system that, initially, will require conscious thought. Although it is only a change in measurement units, its impact will be vast. Change is a difficult process for many persons; some will feel as if the ground under their feet were shifting. Standard units such as the inch, foot, and pound are so ingrained, it is easy to assume they were decreed from above. After all, everyone knows what a mile is, or a pound, or a peck. On second thought, there are some obsolete and near-obsolete measures. Perhaps most of us do not really know how long a mile is (aside from the rote information that it's 5,280 feet). Still, we manage to communicate with one another.

Certainly we do, but we are having an increasingly difficult time communicating with people in other parts of the world (and getting them to buy our products). Most travelers and businessmen have long-since learned that they must be "bilingual" in terms of measures. About 95 per cent of the countries of the world use the metric system. The United States is one of only thirteen countries not using it, and it is the only industrial nation that has not changed (or is not in process of changing) to the metric system.

The change to the metric system will affect everyone, and no one denies that some problems will accompany the change. But learning to think metric need not be as difficult as many people suppose. The amount of new knowledge required is actually very small: a few bases and a few prefixes are all that are needed for everyday use. The units are stated in terms of powers of ten, making conversions from one unit to another quite simple. And while common measures are interrelated, no measure is used for two purposes (as, for instance, the ounce is used for both liquid and dry measures). Adults undoubtedly will find the metrication process more difficult than will children, simply because adults have used the current system longer. For most adults, there will be a period of converting: they will read a measurement in metric units, convert the metric units to units in our current system (because it has more meaning for them), then convert back to metric units if necessary. As the metric measures become more familiar to them, this process will gradually become unnecessary. Eventually, they will "think metric."

For children, the metrication process will differ initially with the age level. Secondary school students probably will go through much the same converting process that adults will, because they also are accustomed to thinking with our current system. They too will feel the need for a familiar reference. Younger children will find it easier to think metric. In the intermediate grades, the metric system can be taught independently of our current system. In the primary grades, the focus should be on the development of measurement concepts that underlie the use of any system of measurement.

To some, this means _if_ and when the legislation is enacted into law to establish the fact that we are going metric. In current proposals before Congress, a ten-year transition period usually is included; this means that during a ten-year period, we will gradually be shifting from our current system of measurement to predominant, though not exclusive, use of the metric system. A more realistic view is that the United States is going metric, with or without legislation. We are in the process now. The momentum for metrication is substantial. The question is not "whether," but "when" and "how." The government can only confirm the metric system as the sole official measurement system of the United States.

Metric units of measurement have been in use in this country for some purposes for many years. They are used for measuring electricity and time, vitamins and pharmaceuticals, film and tires. In some instances, the two systems of measurement are used together, as on labels on canned goods. (Check, for instance, a can of Campbell's soup.) In other cases, only metric measures are being used, as on certain car production lines. In the "Project Brief" on metrication developed for AIT by Joseph R. Caravella, some current metrication activities are summarized; See Appendix for his listing. Each month, the list grows.

Obviously there is still much to be done -- establishing new production standards and codes, retooling industries, recalibrating measurement devices. The costs will be great, but the U.S. Metric Study did not find them prohibitive. Most adults, however, are faced not with technical, industrial-production uses, but with the everyday use of a new system: with determining how far it is to a given place, how much butter to buy, how much carpeting will cover the living-room floor. They will need to realize (or be taught to understand) that the metric system is viable not merely because it will help some Americans in international trade relations, but because, as it is a simpler system than the one we currently use, it will help all Americans.

The motivational task is a large one. People must appreciate the need for change if they are to accept it. This requires a general affective change that will not come automatically. That is the task of education, which also must provide the requisite cognitive knowledge and skill.

For educators, the switch to the metric system offers an opportunity to reexamine the role of measurement in the curriculum. For many years it has not been considered a vital component; at some levels, it is taught if there is time to include it. But measurement is too necessary to everyday living to be slighted in the curriculum. Change to the metric system offers an opportunity to restructure the teaching of measurement so that its concepts can be developed more meaningfully through activities, so that the metric system is not merely memorized and applied without understanding.

This is a challenge to educators, and it is one in which instructional television can play a major role. How television might contribute will be discussed extensively later in this report. Meanwhile, this much can be said: television is an appealing medium that can reach large numbers of people quickly, efficiently, economically, and effectively, with meaningful metric information.

II. THE HISTORY OF METRICATION

The current American system of measurement (henceforth called the customary system) was inherited largely from England, though we made some alterations and additions. The origins of the system date from the time of mankind's earliest need to measure. And, just as the body provided the fingers and toes that could be used for counting and resulted in the evolvement of a numeration system based on ten, the body provided the basic units for the system of measurement. Thus, in the customary system, the basic units of length are derived from various dimensions of the human body. An inch is about the length of the end joint of the human adult's thumb; a foot is approximately the length of a human adult's foot; a yard is about the distance from the tip of the fingers of an outstretched arm to the tip of the nose; a mile is about the distance traveled by a Roman soldier in a thousand two-paced strides.

Measures for weight and volume developed independently of measures for length, resulting in an unwieldy system of haphazard units. The need to change from one measure to another requires the use of a large number of conversion units and formulas. People learn the ones they use most often, like inches to feet and feet to yards, and forget the ones they rarely use, like square feet to an acre, or pecks to a bushel, or firkins to a hogshead.

Against this tangle of haphazard units, the metric system seems elegantly simple in its consistency. Most of the units it employs are related by powers of ten. A consistent system of prefixes designates multiples and subdivisions of the basic units. The measures are interrelated.

The idea of a system of measurement based on units of ten is by no means a new one. Various proposals have been made during the centuries since man adopted the decimal system of numeration. When the United States was being formed, for instance, Thomas Jefferson devised and proposed a decimal system of measurement, realizing that communication between and among the states could be facilitated by wiping out the profusion of measures then in use. But Americans rejected the system: it seemed "unnatural." A logically developed system could not compete with one that had evolved from the wellsprings of history. Besides, some people were (and are) negative simply because the system was developed in foreign countries. The United States continued to reject a decimalized metric system -- until it became clear (with the metrication of Great Britain beginning in 1965) that it would soon be the only industrial nation in the world using a non-metric system. The hope that other nations would adopt our system has faded, and we can no longer afford to cling to it.

The path to worldwide acceptance of a metric system has not been smooth, but there has been a pattern of continuous progress toward the development and use of an efficient system. The chart that follows traces this pattern and the counterpoint of actions in the United States.

HISTORICAL STEPS TOWARD METRICATION

1670 Gabriel Mouton (a Lyons vicar generally regarded as the founder of the metric system) proposed a decimal system of weights and measures, defining its basic unit of length as a fraction of the length of a great circle of the earth.

1740 Preliminary calculations were made with a provisional form of a meter.*

1790 A metric system of measurement was developed by the French Academy. *The need for a uniform system of weights and measures was noted and discussed in the U.S. Congress, but no action was taken.*

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*The spelling of "meter" and "liter" has not been officially decided. Many people advocate the use of "metre" and "litre," in accordance with international standards. The "-er" form is used in this report since it is the form most commonly used in this country.

1795 France officially adopted a decimal system of measurement.

1798 A meeting was held in Paris to disseminate information about the metric system.

1799 The provisional meter and kilogram were replaced by newly established standards.

1821 *A document was issued by John Quincy Adams exhaustively listing the advantages and disadvantages of both the English and the metric systems; Adams concluded that "the time was not right."*

1840 France made use of the metric system compulsory.

1866 *Legislation made it "lawful throughout the U.S. to employ the weights and measures of the metric system." The system was not made mandatory, although this was anticipated.*

1875 The "Treaty of the Meter," setting up well-defined metric standards for length and mass, was signed in Paris by seventeen nations, *including the U.S.* The International Bureau of Weights and Measures was established.

1880 Most of Europe and South America had gone metric.

1890 *The U.S. received prototype meters and kilograms.*

1893 *The metric prototypes were declared by the Superintendent of Weights and Measures to be the "fundamental standards" for the U.S.: other measures were defined in terms of the standard meter and kilogram. (Thus, the yard is legally defined as a fractional part of a kilogram.)*

1918-29 *Approximately forty bills on metrication were introduced in Congress -- but no action was taken.*

1959 *Customary units were officially defined in terms of metric units.*

1960 The meter was redefined in terms of a wavelength of light. The modernized metric system, the International System of Units (Systeme International d'Unites), referred to as SI, was established.

1965 Great Britain announced its intention to convert to the metric system.

1968 *The U.S. Congress directed the Secretary of Commerce to undertake the three-year U.S. Metric Study, to evaluate the impact of the metric trend, and to consider alternatives for national policy.*

1971 *As a result of the Metric Study, it was recommended that the U.S. change to predominant use of the metric system through a coordinated national program.*

1972 *The Metric Conversion Act was passed by the Senate, but no action was taken by the House. (This means that new action will be required by Congress.)*

III. THE SYSTEM ITSELF AND ITS CURRICULAR IMPACT

A. What is measurement?

The idea of congruence is basic to measurement. We must match the object to be measured with the units of the measuring instrument. Measurement is a process of associating with some feature from the natural world a number that describes this feature in terms of some unit. The process of measurement assigns a number to some physical attribute of an object, such as length, volume, mass, time. Measurements are quantified descriptions. The description includes a number and a unit of measurement. The word "measurement" refers both to the process (the way measurements are performed) and to the product (the result of measuring). The process consists of choosing a unit and comparing with that unit. By determining how many of these units are "contained" in the object or quantity to be measured, we arrive at the approximate measure of the object. Measurements provide descriptions that are approximate, as are the measurements we make everyday, or extremely precise, as in some industrial and scientific uses.

Measurement is a major strand in the elementary school mathematics program, and basic measurement concepts are included in mathematics and other content areas at all levels of the curriculum. The importance of measurement is obvious also in everyday life. (It has been estimated that the average person uses about fifty-five measurement terms each day.)

We express measurement in units to which we ascribe some arbitrary name, such as meter or gram. Each of us could measure using any unit and giving it any name, but if one person is to communicate with another, both must know exactly what unit we are using. Thus, standard units, agreed upon by various groups of people, have been developed and these mean exactly the same thing to everyone who uses them. We select a standard unit because it facilitates communication. (With our customary system, a yard of material is the same length whether the person is in New York or Denver or San Francisco; with the metric system, a meter means exactly the same thing to a person in Kansas City as it does to a person in Berlin or Calcutta.) Yet we still use some non-standard units -- six blocks from the office, a pinch of salt. And we also compare without using any units: "Is the string long enough to go around the package?" or "I'll take the heavier piece."

The arbitrary nature of units of measurement does not mean that one can choose any kind of unit one wishes. Measures are specific to the objects being measured; the unit of measurement must exemplify the same characteristics as the object being measured. We use a meter stick to measure a line segment, but we use a liter container to measure a liquid.

For convenience, we also establish units to measure quantities that vary widely, such as the width of a room and the distance between two cities. We do not (usually) measure a room in inches or miles, or the distance between cities in feet. Therefore, we often have several units for each type of measure, and change from one of these units to another as the need arises. In the customary system, this can be an involved process; in the metric system, the change from one unit to another is simple.

All measures that are the result of a physical act of measurement are approximate, because of human error, the use of imperfect measuring instruments, and the actual nature of the thing being measured. Measurements are thus "correct to some unit." The smaller the unit of measurement, the greater is the precision. We can make measurements to almost any required degree of precision by the use of sufficiently small units.

We know from research that concepts of length are generally learned more readily by young children than are concepts of volume or of weight (or mass), and that concepts of area develop more slowly. We know that certain ideas, such as that of the conservation of matter (changing the shape of an object does not change the mass) are essential to developing measurement ideas. These research findings (as well as others related to curriculum development) must be considered as the measurement strand of the curriculum is developed.

B. What is the metric system?

The metric system is merely a system of measurement. It adheres to three basic principles.

1. The standard unit of length is based on some unchanging, absolute standard found in the physical universe. (As first defined, the meter was based on a fraction of a great circle of the earth; now the meter is defined in terms of a more accurate and reproducible standard, a wavelength of the orange-red line of the spectrum of krypton-86.)

2. The basic units of length, volume, and mass are directly related to each other.

3. The specified multiples and subdivisions of the standard units are decimally related.

Charts that outline the units of the metric system are being seen increasingly. Actually, their proliferation has obscured the basic simplicity of the metric system. One gets the impression that one must memorize all those tables (with all those zeroes!). These are the facts that should be emphasized: (1) you need to become familiar with only a few basic words, meter, gram, liter, and a few prefixes, milli, centi, kilo; (2) you need to know that meters are used to measure length; grams, mass (or weight); liters, volume (of liquids); degrees Celsius, temperature; and (3) you will actually use (and therefore need to remember) only a few of the common measures for everyday life -- grams, kilograms, millileters, liters, centimeters, meters, kilometers. Few of us have looked recently at a fully delineated table of our customary system of weights and measures. When we do, we realize how few of the measures we actually use, or even remember. Just possibly we memorized the whole table once, to pass some test, but we have forgotten even the existence of most of it. Emphasis must be placed on how simple the metric system is, but the use of all these charts and tables does not help to make this point.

Elementary school children should not be presented with a completed table and then be told/led/cajoled/drilled to memorize it. Their understanding of the measures on the table must be developed gradually, over a period of time. Through many experiences in using the measures, the students will learn the relationships, which they may then record as a table. For junior and senior high school students, the development of tables (which they have seen in current text materials) may not be necessary, but the experiences in using the metric units are essential. For adults, the charts should emphasize the measures they will use, with appropriate pictures to indicate the approximate sizes of these measures. Teachers themselves may know the information on the tables, and may, in pre-service and in-service courses, even be presented with them, but this does not mean that they in turn should present them to their children. Nor does it mean, because tables are included in documents such as this one, that they are to be memorized. Tables are useful to indicate the content, to indicate the interrelationships, to indicate the system at a quick glance. But we can learn to use metric measures best by simply using them.

The International System of Units (SI) is a complete system of measurement. Many of these units are used only by those in specialized (usually engineering and scientific) professions. The seven basic SI units are the meter, kilogram, second, ampere (for electrical current), kelvin (or ° Celsius), mole (for amount of substance), and candela (for luminous intensity). It has been suggested that we use SI as our everyday language of measurement (as, for instance, South Africa is doing), but the specificity of SI does not seem warranted for most everyday use.

The types of metric measures that will be commonly used are:

Quantity to be measured	Name of Unit	Symbol
length	meter	m
mass (weight)	kilogram	kg
volume	liter cubic meter	l m^3
temperature	° Celsius	° C
time	second	s

Relationships exist among the units of length, mass, and volume. Thus, 1 milliliter = 1 gram = 1 cubic centimeter (a cube that is 1/100 of a meter on each side); 1 liter = 1 cubic decimeter (a cube that is 1/10 of a meter on each side).

Prefixes are attached to the name of the basic unit to indicate the relationship of that unit to the base unit. The same prefixes are used with multiples of different units. The prefix "kilo" always indicates one thousand of the unit; "centi" always means one-hundredth of the unit (just as "cent" always means one-hundredth of a dollar). In some instructional materials currently available, too much emphasis is given to "deka" and "hecto"; rarely are these prefixes used, except in "hectare" (for large area measurement). Little emphasis should be placed on learning them (though they may be discussed in comparing the metric system with our numeration system).

The measures of length, mass (weight), and volume that it will probably be necessary to learn are indicated on the following chart, along with the symbols and equivalents. It should be noted that remembering the equivalent measures will be no problem if the meaning of the prefixes is understood.

Quantity to be Measured	Unit of Measure	Symbol	Equivalent Measures
length	millimeter	mm	10 mm = 1 centimeter
	centimeter	cm	100 cm = 1 meter
	meter	m	1000 m = 1 kilometer
	kilometer	km	
mass	gram	g	1000 g = 1 kilogram
	kilogram	kg	1000 kg = 1 metric ton (tonne)
	metric ton	t	
volume	milliliter	ml	1000 ml = 1 liter
	deciliter	dl	10 dl = 1 liter (l)
	liter	l	
	cubic centimeter	cm^3	1000 cm^3 = 1 cubic decimeter = 1 liter
	cubic decimeter	dm^3	1000 dm^3 = 1 cubic meter
	cubic meter	m^3	

C. <u>What other changes can be anticipated in the mathematics curriculum as we "go metric?"</u>

The impact of using the metric system on the teaching of two aspects of the mathematics curriculum is frequently discussed. One of these is the teaching of place value and the numeration system. The other is the teaching of fractions.

<u>Place value and numeration</u>. Obviously, both our numeration system and the metric system have a decimal base. It would seem that experience and practice with one should transfer to some achievement in the other, though research evidence of this is difficult to find. Teachers will need to be aware of the relationship, however, and be prepared to exploit it. The two topics will need to be coordinated at many points; for instance, when pupils are learning about the thousands place in the numeration system, the meaning of the prefix "kilo" in the metric system should be developed.

Certainly continued attention will have to be given to exponential notation (10^3 and 10^{-1}, for instance) and to scientific notation. And operations with decimals will need to be given more emphasis, possibly at lower levels than in the curriculum sequence at present.

Fractions. Purists insist that fractions not be used with metric units. By definition the metric system seems to negate the need. But pragmatists find that terms such as "1/2 liter" or "half liter" persist in metric countries, possibly because it is easier for people to picture a "half liter" (that is, a liter measure that is half-filled) than it is to picture "500 ml." With experience in thinking metric, there is perhaps no need, but visual images persist.

To think that use of the metric system means that we no longer will need to teach common fractions is nonsense. We might note the argument that rational numbers exist as a component of mathematics. But put the abstraction aside and consider the practical: what do you use to describe one of the parts that results when you cut an apple into two equal parts? Both mathematics and real life demand understanding of fractions; they must continue to be considered a part of the mathematics curriculum. The amount of time devoted to computation (that is, addition, subtraction, multiplication, and division) with fractions probably will decrease, however, and more attention probably will be given to computation with decimals.

D. What will be the impact on other aspects of the curriculum as we "go metric?"

Certain subjects are more measurement-related than others. Home economics courses, for example, frequently involve practical use of measures of length, weight, or volume. Making clothes from patterns, following recipes, decorating rooms -- all of these imply measurement. The entire consumer education aspect of the curriculum will have to be adjusted to the use of metric measures. Cookbooks are now being prepared in metric editions, and patterns and measuring cups and tape measures are available in metric sizes, but this will help only so much. Students will still have to use both metric and customary measures and be able to make conversions. Does this mean that students must learn tables in both systems, plus conversion factors or equation factors or equations? Not necessarily. For students, as well as for adults, equivalency tables and measuring tools on which both measures are named should be available.

For industrial arts/vocational education courses also, the shift to the metric system creates problems. Skill in using metric measures must be stressed, but familiarity with the customary measures must be maintained for years to come, since materials will continue to be available in customary units, and repairs on items made with customary units will need to be made. Building and repairing trades will continue for some time to use both systems, but with continuous progression toward use of the metric system only. Equivalency tables and dual-system measuring instruments will be needed (in addition to strictly metric measures). Knowing approximate conversions will help.

In business education courses, the use of metric measures for a wide variety of business applications will need to be developed. The needs of local industries and businesses will need to be explored. Teachers can help industrial and business concerns with their re-education problem. Certainly the schools can provide the foundation of metric knowledge and skill that will be needed by students who will be going to work in those industries and businesses. To that foundation, each industrial and business concern can add the additional, more specific metric knowledge that is required.

In science classes, students have been accustomed both to using metric measures and to converting. The shift to metric only can come quite swiftly in these classes.

The mathematics teacher at the elementary school level will face the change to metric not only in mathematics lessons but also in other subject areas where measurement is used. Mathematics textbooks probably will make the needed changes first. Social studies, language arts (including reading), and other textbooks probably will be somewhat slower in reflecting the change. The teacher will need to be watchful for such phrases as "twenty-five miles to Philadelphia" or "three cups of flour," and must help the child estimate the distance or amount in metric measures.

Mathematics teachers and teachers of other curricular areas at the secondary school and college levels should come together to develop cooperative procedures. How can the mathematics teacher help? For what experiences should each teacher be responsible? What should the mathematics teacher introduce that other teachers will reinforce through use? What practical applications can be drawn into the mathematics curriculum? Usefulness of the metric system across curricular areas will have to be made apparent to students. Adults certainly will see the interdisciplinary effect in many aspects of daily living.

Mathematics (and science) teachers probably will be given the task of providing in-service help to other teachers. In this role they should stress not only what the metric system is, but also what it means to each subject area, its impact on life in the future, and how all teachers can help in developing and reinforcing metric ideas.

IV. TEACHING THE METRIC SYSTEM

A. How has measurement been taught?

Teaching the use of the varied measures of the customary system has always been a strand of the elementary-school mathematics program. Emphasis has been placed on learning equivalent measures (the number of inches in a foot, feet in a rod, ounces in a quart, and so on). There are fifty-three denominate units in the customary system, with no consistent pattern in the relationship of the units. Linear measures generally have received the most attention; for older students, determining square and cubic measurements has been stressed. In the junior high years, review has been the pattern, and, frequently, it has been during these years that the metric system was first introduced.

The need to develop understanding through experiences in measurement has been recognized for years. Many curriculum guides and textbooks suggest informal activities using non-standard measures that, in turn, lead students to see the need for development of a standard system of measurement. Yet frequently in practice, little time is given to such experiences prior to the introduction of the standard system. Sometimes measurement ideas are introduced and reinforced with experiences; too often the method has been one of "tell and show," followed by exercises.

It is difficult to present a scope-and-sequence chart that accurately depicts what has been taught about measurement at each level. Textbook and curriculum practices vary widely. Yet the scope and the sequence are generally somewhat similar to that indicated on the following chart. (The topic of "money" has generally been considered a measurement topic, but is excluded from the chart.)

MEASUREMENT TOPICS IN CURRENT CURRICULA

Level 1 (ages 5-7)

Develop "measure consciousness" through experiences: develop familiarity with capacity of the pint and quart; weight of the pound; time by the hour; calendar by the week, day, month, year; amount by the dozen, cup.

Make comparisons such as far/near, high/low, small/large, fast/slow, hot/cold, tomorrow/yesterday, heavy/light, full/empty.

Measure to the nearest inch, half-inch, quarter-inch.

Recognize relationships among cup, pint, quart; measure in gallons and half-gallons; recognize dozen.

Measure to the pound.

Tell time to the half-hour, quarter-hour, and five-minute intervals; read a calendar.

Read a thermometer; identify freezing point on Fahrenheit thermometer.

Level 2 (ages 8-9)

Recognize relationships among inches, feet, yard; find perimeter of polygons; find area of rectangular regions; measure to the nearest 1/8 inch, developing concept of precision; add, subtract and multiply with measurements; measure angles informally.

Recognize relationships among cups, pints, quarts, gallons; use equivalent measurements.

Develop relationships between ounces and pound; use equivalent measurements.

Develop relationships between minutes and hour; read minutes past hour; tell time in one-minute intervals; recognize equivalent time measures; use seconds.

Level 2 (ages 8-9) continued

Compare degrees of temperature.

Recognize standard abbreviations.

Estimate measurements.

Level 3 (ages 10-11)

Use formulas for finding perimeter, area, circumference, volume.

Work with land measure: rod, square rod, acre, square mile.

Read simple scale drawings.

Find locations on map using latitude and longitude; identify time zones.

Divide with measurements.

Use a protractor to measure angles.

Recognize the derivation of common standard units.

Recognize "greatest possible error."

Organize tables of length, liquid measures, dry measures, time, weight, etc.

Level 4 (ages 12-13)

Review perimeter, area, angle, volume measures, etc.

Discuss metric units of length, weight, and capacity.

Practice conversions with metric units.

B. How has the metric system been presented in current programs?

Emphasis has been given to the metric system at the upper age levels, and sometimes not until the junior high years. In some recent programs and textbooks, metric measures are introduced earlier, beginning at ages eight or nine with units of length. The general pattern has been:

1. Tables of metric measures are given.
2. Conversion factors are given.
3. Most problems or exercises in which metric units are involved are conversions from the metric system to the customary system of measurement, or vice versa. (These are really just multiplication and division exercises.)
4. Metric rulers and meter sticks generally have customary units as well; few other metric measuring instruments are used (except in the science classroom).

C. How should the metric system be taught?

A set of guidelines and some scope-and-sequence suggestions follow. Neither list is exhaustive: both are intended to call attention to some of the more important factors to keep in mind when planning a program.

GUIDELINES FOR TEACHING MEASUREMENT WITH THE METRIC SYSTEM

1. Focus the instruction on measurement, with the metric system evolving (that is, taking its role) as the standard system of measurement.

2. Keep in mind that before children can understand the metric system or any other system of measurement, they must have experiences in measuring. They must understand the concept of what measurement is. Some prerequisite skills and understandings are essential before <u>any</u> standard measures are used.

3. After the students have attained the prerequisite knowledge and skills, use non-standard measures to develop the concept of why a standard system of measurement is needed as well as to extend concepts of what measuring means and that things can be measured in various ways. (Only when the child understands how arbitrary the choice of a unit actually is will he realize the importance of standardization in measurement and appreciate that the history of measurement is essentially a struggle for standardization.)

4. Then develop the logic of using a measurement system based on ten, to correspond with our numeration system, and introduce the metric system.

5. Begin with linear measures, because the metric units of length are the basic units from which the units of mass and volume are derived. For children in the intermediate grades, begin with the meter as the basic unit; for smaller children who may have difficulty handling the meter stick (and who do not yet know the numbers to 100 sufficiently), begin with the centimeter as the basic unit.

6. In the elementary school, teach the metric system as <u>the</u> system of measurement; later, the customary system may be discussed as one of the other systems of measurement. Schools may have to teach some of the customary measures along with the metric system for a while, since the country as a whole will be using both for years to come. Teach the metric and customary systems as dual/alternative systems: the customary system happens to be the one their parents use.

7. Avoid conversion exercises, concentrating on use of the metric system. The individual needs to learn metric measurement by itself and thus learn to think in that language of measurement. Children who have not learned any system of measurement will have little difficulty learning and accepting the metric system.

8. Limit conversions within the metric system to commonly used units adjacent in size. Present-day metric materials often ask students to perform extensive conversions, such as changing km to dm. Just as useless are exercises requiring addition of unlike units; rarely will this be needed in actual metric situations. Instead of stating 4 decimeters 3 centimeters, the measure will be given as 43 centimeters; instead of 5 meters 16 centimeters, we will say 516 centimeters or 5.16 meters. Children will need to understand the relationship between measures, but should be encouraged to use the standard form.

9. Use actual units and measuring instruments. Avoid completely the use of the scaled-down versions sometimes found in current text materials.

10. Develop understanding that the appropriate instrument should be used for different measurement purposes: the meter stick for length, the balance for weight (mass), the container for volume, the clock for time, the thermometer for temperature.

11. Introduce the units at the point at which they are to be used. Concentrate on those units necessary from a utilitarian standpoint at all age levels, including adult. Do not teach the tables per se.

12. Emphasize estimations, such as, "About how many matchbook covers long is the desk?" or "About how many grams of sugar do you put in a cup of coffee?" Verify estimates with non-standard and later metric measures. Develop the meaning of and a feeling for the size of units through experiences that center around estimating and checking the estimates.

13. Stress the idea that measurement is approximate. Schools have given children many illustrations of "exact" measures; measurement is not as precise as we have made it seem. Precision is partially dependent on the unit of measurement we use.

14. With pupils who already know the customary system, as well as with adults, approximate conversions may be needed. Relate metric measures to common objects and to body measures.

    The meter is a little longer than a yard.
    The liter is a little larger than a quart.
    The gram is about the weight of an ordinary paper clip.
    The kilogram is a little heavier than two pounds.
    Body temperature is about 37° C.

15. Use metric units at every opportunity, including those arising in subject matter fields other than mathematics.

16. Introduce prefixes as they are needed. Association and presentation of the complete set of prefixes should be done late in the development, and then merely to serve the function of noting the orderliness of the system and its relationship to our numeration system. The prefixes kilo, deci, centi, and milli are the only ones that will need to be stressed in the elementary school.

17. Teach only the commonly used multiples and subdivisions and their corresponding prefixes and symbols; for instance:

m, cm	100 cm = 1 m
mm	10 mm = 1 cm
km	1000 m = 1 km
g, kg	1000 g = 1 kg
l, ml	1000 ml = 1 l

18. Stress the importance of correct symbol usage, which is the same in all languages.

19. Give special emphasis to symbols for area and volume units that contain superscripts. More emphasis on exponential notation and on scientific notation will be needed in the elementary school.

20. Discourage the use of common fractions with metric units except when needed to develop specific quantitative concepts. When a fractional term is used, write it in decimal form (that is, "one-half" as ".5" or "0.5").

SCOPE-AND-SEQUENCE SUGGESTIONS

Primary level*

A. Develop the basic prerequisite skills and understanding about measurement by having the student:

1. Match, sort, and compare objects -- long/short, heavy/light, large/small, etc.

2. Make direct comparisons of two objects by placing them next to each other, to determine which is longer or shorter, heavier or lighter, larger or smaller, etc.

3. Compare three objects, developing the idea of transitivity (that is, if A is shorter than B and B is shorter than C, then A is shorter than C).

4. Place several objects in order, from longest to shortest, heaviest to lightest, etc.

5. Make direct comparisons by using a third, larger unit to describe the comparisons. For instance, give the child three sticks. Have him tell the length of the first and second sticks in terms of the length of the third stick.

6. Combine lengths, masses, and volumes, using physical objects. For instance, put the water from four glasses into one container; put two desks together, etc.

7. Transform objects for comparison, applying the idea of conservation (that no length, etc., is lost in the process). For instance, pour sand that is in two similar containers into two differently shaped containers.

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*Many of the suggestions in the first two primary-level items are discussed by Higgins (1974).

8. Compare by iteration, placing objects end-to-end a number of times, pouring over and over, etc. This relates measurement to a process of counting.

9. Make metric measures available for use in "play" activities. Use metric measures and terms in everyday experiences, even if the metric system itself is not under discussion. Use them, for instance, when recording temperatures on a daily calendar, marking heights of pupils on a wall hanging, etc.

B. Extend the concept of measurement by using non-standard (arbitrary) units.

1. Use varying units. For instance, give each student a different length of string; have the student measure an object and report his measures in terms of that length. Develop the reason for using a common measure, communication with others.

2. Have the class choose an appropriate (common) unit and use it to make indirect comparisons. Measure a variety of objects. For instance, use John's foot as the unit; each child would make a copy (model) of the length of John's foot and use it to measure the room, desks, etc. It will probably happen that, even when a common unit is used, the measures will not all agree. Discuss the approximateness of the measurements.

3. Measure between limits, reporting the measurements as "between two and three units," for instance.

4. Use multiples of the basic unit as the need arises for a larger unit; subdivide the basic unit when smaller units will facilitate more accurate measurement. (Since we have a decimal system of numeration based on powers of ten, it follows that for ease of calculation, the subdivision of the units should also be based on ten. Measurement with the metric system thus can be integrated with other topics in the curriculum.)

5. Develop the idea that for communication with others (outside the one classroom), a common standard unit is needed.

C. Having established the background for developing a decimal standard system of measurement, gradually introduce the various standard units of the metric system and the instruments used to measure in these units. (This listing is general; many specifics must be added.)

1. The meter and centimeter probably should be introduced first. The child should have practice in measuring to the nearest centimeter with the ruler and meter stick. He needs to be taught how to hold the ruler to make careful measurements, and how to draw lines that reflect careful measurement. (He needs similar instruction on how to use other measuring instruments.)

2. After the student has had some practice in measuring, teach him to estimate metric lengths. Begin with gross comparisons ("Is a meter about the length of the school building or about the length of the bookcase?"), then develop finer ones ("About how many meters long is the room?").

3. Discuss the need to use appropriate measurement units -- centimeters to measure the width of a book, meters to measure the length of a room, kilometers to measure the distance between two cities.

4. Begin to develop the relationship with the numeration system. For instance, explore counting on a metric ruler and on the meter stick; note the 1-10-100 correspondence.

5. Provide activities in weighing with a balance, first using the kilogram, since it is easier to handle than is the gram weight. (Weight is a more difficult concept, according to research, and is more difficult to estimate.)

6. Introduce the liter as a unit for measuring volume.

7. Develop time concepts related to the hour and minute.

8. Use the Celsius thermometer in everyday situations, having the child read and record temperatures.

Intermediate level

A. Develop the relationships between the prefixes, stressing the relationship to the decimal numeration system. Use decimal notation. (The most frequently used prefixes are milli, centi, deci, kilo.)

B. Introduce the symbols for the metric units as the unit is introduced: m, dm, cm, mm, km, g, kg, l, ml.

C. Teach the relationships among measures. For instance, for length, develop such relationships as:

10 mm = 1 cm	(emphasis should be placed on these four)
100 mm = 1 dm	
1000 mm = 1 m	
10 cm = 1 dm	
100 cm = 1 m	
1000 m = 1 km	

Later teach such relationships as:

1 mm = 0.1 cm = 0.001 m
1 cm = 0.01 m
1 m = 0.001 km

D. Measure to the nearest millimeter; to the nearest milliliter; to the nearest gram.

(In the elementary school, the distinction between mass and weight can be noted, but the term "weight" probably will be used. Mass is sometimes thought of as the amount of material in an object. Weight is the measure of gravitational force on a mass and varies with the location of the mass (object). The weight of an astronaut on the moon is less than his weight on the earth because the force of gravity is less on the moon; he may be weightless in a space station. His mass, however, is the same in all three places. We have been so accustomed to using the term "weight" incorrectly that it will probably still be used in cases where the correct term is "mass.")

E. Develop understanding of rectangular solids: 1 liter = 1 cubic decimeter (dm^3) = 1000 cubic centimeters (cm^3).

F. Convert from one metric measure to another, stressing the relationship to the numeration system (10-100-1000). Develop the ability to convert mentally.

G. Introduce addition and subtraction with common measure. Compare with regrouping in addition and subtraction algorithms. Later use multiplication and division with measures.

H. Develop angle measures (which are the same in both metric and customary systems).

I. Work with metric units in problems on perimeter, area, circumference and area of circles, volume, time, temperature, etc.

J. Develop understanding of the relationships among units for length, volume, and mass.

K. Develop the idea of accuracy and precision of measurements and of significant digits.

L. Extend time concepts and temperature ideas.

M. Discuss the history of measurement, presenting selected aspects to indicate how varied systems of measurement developed.

<u>Secondary level (and adult level)</u>

A. Units for such quantities as force, pressure, work, power, and electricity should be presented in science and vocational education courses as the need arises.

B. Generally, the problems at the junior and senior high school levels will not be much different from those at the adult level. The very things that will be taught to the elementary-school children also will have to be presented to the older students and to the adults. Obviously, for specific purposes -- for example, in science -- more extensive development of the metric system will be needed than in other classes. Metric

Secondary level (and adult level) continued

units can be presented with limited reference to or comparison with a few customary units. The emphasis should be on making actual measurements with metric instruments. No problems should be presented that involve conversions from the customary to metric units or vice versa. The decimal nature of the systems should be stressed in realistic problem-settings; comparisons to the monetary system may be particularly helpful. The workshop approach in which the student actually makes all types of measurements with metric instruments is highly feasible and desirable.

The scope-and-sequence chart on the following pages has been added to provide an example of how one nation (South Africa) projects the measurement program.

SCOPE-AND-SEQUENCE CHART

	Length	Mass	Area	Volume	Time
Level 1	Experiences. Vocabulary: length, long, short	Experiences. Vocabulary: mass weight, heavy, light		Experiences. Vocabulary: volume, capacity, cup, bottle, spoon	Experiences. Vocabulary: days of the week
Level 2	Experiences. Vocabulary: meter, centimeter	Experiences. Vocabulary: kilogram		Experiences. Vocabulary: liter	Experiences. Vocabulary: days, time, hour, month, year
Level 3	Practical introduction to meter and centimeter. Symbols and relationship, 1 m = 100 cm. Measure in full cm and in full, 1/2, and 1/4 m.	Practical introduction to kilogram. Symbol. Measure in full, 1/2, 1/4 kg.		Practical introduction to liter. Symbol. Measure in full, 1/2,1/4 l.	Relationship between hour, day, week, month, year. Practical knowledge of hour, 1/2 hour, 1/4 hour.
Level 4	Introduction to kilometer, millimeter. Symbols and relationship. Notation for lengths exceeding 1 m (1 m 55 cm or 1.55 m). Correct notation for 1/2 and 1/4 m as 500 and 250 mm. Operations with one unit.	Introduction to metric ton and gram. Symbols and relationship. Correct notation for 1/2 and 1/4 kg as 500 and 250 g. Notation for mass exceeding 1 kg. Calculations with one unit.		Introduction to kiloliter and millileter. Symbols and relationships. Correct notation for 1/2 and 1/4 liter as 500 and 250 ml. Notation for volume exceeding 1 liter. Calculations with one unit.	Reading time on clock to nearest minute.

Level 5	Consistent use of short notation (1.500 m). Operations with two consecutive units (km, m) or (m, mm)	Consistent use of short notation. Calculations with two consecutive units (t, kg) or (kg, g)		Consistent use of short notation. Calculations with two consecutive units (l, l) or (l, ml)	Relationships. Practical introduction to second. Symbol.
Level 6	Explanation of short notation as decimal notation.	Explanation of short notation. Comparison between masses of different substances with the same volume.	Concept of area. Units, m^2, cm^2, mm^2. Relationships. Practical knowledge of units. Measure using squared paper; calculations after dimensions have been determined by measurement.	Explanation of short notation. Estimation of the capacity of containers.	
Level 7	Discussion of relationships from kilo- to milli-. Consolidation.	Discussion, consolidation.	Hectare and square kilometer introduced. Relationship with m^2. Simple scale drawings.	Discussion, consolidation. Introduction of concept of volume. Use of m^3, cm^3, mm^3. Symbols and relationships. Practical use of units.	

Adapted from The Use of the SI in Primary Education, South African Bureau of Standards, October 1971.

D. What teaching aids will be needed?

It is important that many materials be used in the measurement program, but some measuring instruments are essential. Not all will have to be purchased: some can be made from materials such as heavy cardboard, by teachers, students, or parents. At the very least, one set of metric measuring instruments for length, weight (mass), and volume must be purchased for each school. These could then be considered the standard set, and copies made to conform with the standard.

At the next level of expense, some measuring instruments might be shared by several groups or classes. Some equipment might be available from science classes. Varied types of measurement instruments should be used for some measuring activities (e.g., balance scales, bathroom scales, nurse's scales, etc., for weighing), and many of these can be shared by classrooms.

In or readily available to each classroom, whether materials are purchased or handmade, there should be, as appropriate:

1. several meter sticks
2. a plastic tape measure (possibly 150cm)
3. a 20- or 30-cm ruler for each student, graduated only in metric units (these might, for instance, have 20 cm on one side and 200 mm on the other side)
4. pan balances with gram weights
5. containers graduated in milliliter and liter units
6. models of square decimeters, square meters, cubic decimeters, cubic meters, etc.
7. blocks (many sets of colored rods have unit blocks that are cubic centimeters, and rods that are graduated by centimeters)
8. Celsius thermometer (must be purchased)
9. clock

A kit of materials with activity cards and worksheets, is most useful, but items can be collected by teachers. Many of the materials now on the market are of dubious quality for the money: only careful evaluation will assure that the materials are accurate and are consistent with guidelines for teaching measurement and the metric system.

V. PUBLIC ACCEPTANCE AND THE ROLE OF THE TEACHER

A. Who can help or hinder the metrication process?

The affective reaction of people -- fear and apprehension leading to resistance -- can be the biggest hindrance to metrication. Children can be expected to have few negative affective reactions; adults will be more likely to fear the unknown, to resist change, to be aware of being at the mercy of shopkeepers. Inaction can promote these feelings of apprehension. The transition period will be long; during it, everyone will be having some of the same problems. There is a need to develop awareness of meeting a challenge while keeping one's sense of humor. Over and over, we need to emphasize how little must be learned; we need to be sure no one feels that conversion formulas must be memorized. We need to note how much we already use metric measures. We need to develop -- not all at once but over a period of time -- an intuitive feeling for metric measures.

Educators and especially mathematic educators have a crucial role in the metrication process. The school must take responsibility for making parents aware of what metrication means and of how the school's curriculum is being adapted, as well as for helping parents themselves learn the metric system. Newsletters provide one vehicle; workshops in which parents actually use the metric system are another particularly effective method. According to the United States Metric Survey, people would welcome having television used for helping to teach them about the metric system.

The amount of interest in learning more about the metric system will vary, partially depending on the amount of industry in an area and on the educational role assumed by other agencies. Teachers will need to approach the task with particular care. There is no need to develop apprehension where none exists; metrication may be slightly confusing, but it is also a relatively simple learning task if it is approached with a positive attitude. Education and information must be provided at the time adults first need it. Parents have to know why Susie is bringing home those assignments and worksheets; they have to be prepared to learn along with their children. It may need to be stressed, to teachers as well as to parents, that this is not the "new mathematics" revolution all over again, that this is a permanent national change and not one "dreamed up" or "foisted on them" by mathematics educators.

The plans of the school district must be coordinated internally, as well as externally. The curriculum supervisor or the principal, superintendent, or other administrator must ascertain that every teacher and all phases of the curriculum are prepared for the change. Plans must be made for the initial stage, as well as for each following year in the transition phase, until there is full metrication. The state departments of education have a particularly important part to play in establishing guidelines.

The forces of the community must be involved in the adult education process -- the chamber of commerce, the Jaycees, and similar groups, as well as industrial and business concerns. They can provide a communications channel for educational information. The most difficult groups to reach are those who do not have children in school.

Developing awareness and educating for change is a task that must be shared by the media. Spot announcements, inclusion of metric measures in regular programs or columns and in weather reports, a feature about the change and what it means -- all must be planned. Television and newspapers should use care not to "sensationalize" the problem; they may need to be sensitized to this danger. The schools can provide the media with many suggestions on how to develop understanding both of the need to change and of the metric system. Consumer groups need to take special responsibility to see that unfair practices do not result from the use of unfamiliar measures.

From other countries we can learn which procedures have worked well and which have not. On the one hand, we have examples of an effective media awareness approach. On the other hand, we know the kinds of problems that can accompany gradual conversion. For instance, in weather reports in Great Britain temperatures were given in both Fahrenheit and Celsius. Listeners paid attention to the Fahrenheit readings and ignored the Celsius. Not until only the Celsius was used did they learn Celsius. In South Africa and other countries, the change was announced for several months, then went into effect overnight. People learned when they were forced to learn.

Metrication has been comparatively smooth in British schools, and we have learned much from their activity approach. As our own mathematics teachers plan specific curricular and instructional details, British materials can provide some useful models.

B. Who will teach teachers about metrication?

In many states across the country, state departments of education and local educational agencies are already involved in the metrication process. Canada, which reached the decision to convert in 1970, is similarly in various stages of metrication. Position papers have been generated; task forces have been working; supplementary curriculum guides have been produced. Publishers and other producers of materials have been spinning out products. Several states and provinces (including Florida, Mississippi, Ontario, and Manitoba) have developed plans for or are producing television programs. Workshops of many kinds are being held or planned. And in a few classrooms the students have already "gone metric."

The initial problem being tackled by most groups is not the matter of materials and activities, but that of staff development -- specifically, educating teachers. (In Britain, incidentally, this was found to be the concern of first priority.) Ohio provides one example of such planning. The following item is taken from the January 1974 issue of Report, the monthly newsletter of the Ohio State Department of Education.

> *The State Board of Education called for the development, dissemination, and implementation of appropriate instructional materials for the in-service preparation of teachers on teaching the metric system as the standard unit of measurement in Ohio schools. Inservice programs will begin this summer with a set of workshops to be held throughout the state for representative teachers from Ohio's 620 school districts. These teachers will then lead workshops in their own districts. Ultimately, teachers will serve the community by conducting instruction to reeducate the public at large.*

Planning is going on in California, Hawaii, Maryland, Florida, Wisconsin, New Jersey, and the list grows.

A key factor in the in-service education of teachers is: get them involved in using the metric system in the in-service program. Put them in a metric world and they will learn to use the system far better than if they are only taught about it. Have the teachers develop activities and try out activities. After the activity phase, stress the methods that will work best with students. Discuss the entire measurement component: how will children actually learn measurement best? Then make sure the teachers know the facts about the metric system -- the units, the prefixes, the symbols, the interrelationships, what to stress and what not to stress.

We must not ignore the pre-service teacher. It has happened frequently that the pre-service teacher was not acquainted with imminent curricular changes; then, when the pre-service teacher became a teacher, in-service education had to be sought immediately. Pre-service instruction must parallel in-service instruction.

Not only do teachers need to know the metric system, but they also need to know why we are going metric. They need to know salient points in the history of the metric system and to understand the purposes and results of the United States Metric Study. They need to have a firm grasp of the advantages (and the disadvantages) of the metric system, and they need to realize the curricular implications for other aspects of the mathematics curriculum and other curricular areas. Text materials and workbooks will have to be checked to see that they contain correct usage, symbols, and practices.

If educators do a good job with children, and the children go home happily using the new skills and knowledge of the metric system, then parents and others will accept the change more readily.

VI. THE ROLE OF INSTRUCTIONAL TELEVISION

A. What is the scope of the metrication need?

Consider again the scope of the educational task of metrication:

- Both children and adults -- the entire population in both the United States and Canada -- need to learn the components of the metric system.
- Both children and adults need to learn how to apply the metric system to the measurement activities that arise every day; they need to learn to "think metrically."
- Both children and adults need to accept, not only cognitively but also affectively, a change necessary for coping with the world about them.

Each of us must attain a metric perspective toward measurement as it affects our daily lives. And we need to attain that perspective, with its accompanying competency in knowledge and skills, relatively soon.

Instructional television is particularly suited to the task confronting educators as they seek to teach millions of children and adults to cope with a metric world. Television is the medium that can reach the huge audience both efficiently and effectively. Television can present a model for effecting a change to meet societal needs, and it can take a leadership role in curriculum change. Television can equalize the learning opportunity; it can aid in the development or redevelopment of fundamental skills that will be used throughout each person's life.

B. Why can instructional television facilitate the metrication process?

Most of us probably turn on the television set every day. We may have become so accustomed to television, in fact, that we do not even think about the factors that make it an effective instructional tool. What are some of these factors that are intrinsic to television, or that can be employed if television is used as a vehicle for implementing the change to metrication?

1. To attack a problem of such scope as metrication, television:

- is an accepted medium that is part of the child's as well as the adult's world.
- can facilitate the change to metrication quickly.
- can provide mass availability, reaching all age levels conveniently and economically.
- can reach home-bound learners, whether adults or children, and can facilitate student-parent interaction.
- can provide a bridge between school and community, allowing exchange of information and serving as a public forum for educational discussion.

.has authority that commands participation and/or follow-up activity.

.can provide a minimum resource to all schools.

2. To aid the teacher in coping with metrication, television:

.can present desirable alternative teaching strategies, techniques, and content, while maintaining control over what is taught and how it is taught.

.can take some of the initial pressure from the teacher, providing adequate instruction when a teacher is uncertain of metric knowledge and skills and how to teach them.

.can provide controlled structure, sequence, and pacing.

.can complement existing activities or initiate activities.

3. To facilitate learning by each individual, television:

.can use presentational techniques not readily available in the classroom -- split-screen visualization, multiple images, and superimpositions, as well as animation, dramatization, and motion.

.can provide experiences that are vicarious or real, contrived or situational, common or rare.

.can broaden the base of experience by touching on all phases of life.

.can show relationships, perspective, and dimensions; can match, compare, order and change order, transform, and transfer.

.can provide poorer readers with an equal chance to learn.

C. Why is a consortium approach to the use of television for metrication logical?

With a large, short-term effort, instructional television can help education to meet the specific societal need as we change to the metric system. The immediacy of the need urges the development of a coordinated effort.

The consortium approach provides management for solving problems and developing materials, as well as for distributing them and for serving as a clearinghouse so that the experiences of one member or group are available to others. A consortium is a group of people making decisions, with a systematic design for development that avoids duplication of effort. A consortium is a way of

.assembling resources,

.organizing resources,

.developing resources, and

.disseminating resources.

There is a redundancy of effort and costs if every state individually goes through the same conceptualization and development process. Even more redundancy occurs if every community or local educational agency duplicates the process. A cooperative effort to plan and develop materials seems inherently logical. Furthermore, the consortium approach --

the amassing of resources on a large scale -- makes achievable a quality of programming far out of reach of any single agency or small group of agencies.

The coordination of activities is as vital as the cooperative nature of the project. Sharing in the conceptualization is an efficient, effective procedure; it is akin to having an extended staff. Together, the members of a consortium can devise an array of instructional alternatives and still maintain consistency of goals and concepts. The collaborative efforts of the consortium approach have been found to be extremely effective in previous AIT projects.

D. <u>What are the components of the consortium project?</u>

The consortium project includes the following:

.<u>Curriculum Design/Development</u>

--meetings for conceptualizing and planning the development of both television and non-television materials

--services of consultants and specialists in curriculum development

--services of specialists in planning for instructional television

.Production of Materials

--television lessons, comprehensive and articulated, but recognizing that television instruction must be supplemented with other types of instruction

--other non-print materials, including film and cassette versions of television programs

--print materials, including resource handbooks for teachers

.Dissemination/Implementation

--plans for staff development with provisions for in-service preparation

--plans for scheduling and other facets of implementation

.Research

--formative evaluation and revision

--summative evaluation

E. How can instructional television be used to implement the metrication process?

In presenting a series of programs on measurement and the metric system, instructional television can broaden the scope of learning and serve in a capacity that is often filled only by textbooks and other printed materails: it can provide a model and guidelines for the type of teaching and the type of program that should be taught. The development of a uniform set of guidelines for the introduction of metric concepts is vital. In the curriculum design phase, the consortium -- incorporating the cooperative efforts of state and provincial departments of education, as well as of members of the National Council of Teachers of Mathematics* -- will need to agree on guidelines for the television series. The television lessons must be consistent with state goals for metrication and for the teaching of measurement.

Television can be extraordinarily effective in providing a model for methods and procedures that could be used by educators as we go down the road to metrication. Changing methodology is one of the most difficult problems of teacher education. Modeling has been found to be a highly effective way of producing change.

Television has another advantage over the textbook: it can show children and adults in action. It can show what to do and how to do it, as a model for students. It can present actual measurement of such things as a bridge or a building -- or an ant or a micro-organism. It can depict

* Guidelines proposed by the Metric Implementation Committee of the National Council of Teachers of Mathematics have been incorporated into this document.

a realistic environment that is metrically oriented. It can focus on how children are learning and what problems they face -- or on adults and how they are coping. It can involve the learner by directing and asking for responses.

The programs must be based on solid instructional foundations -- from the viewpoints of mathematics, the curriculum (in mathematics and in other subject areas), and the methods of instruction. The focus of the television component should be on (1) using the metric system in real-life instances and (2) involving the learner in measurement activities with the metric system, as well as (3) presenting information about the metric system. The television component must be placed in perspective as one component in the total learning program; the function television is to perform must be clear. It serves to introduce, to extend; to motivate, to involve; to present situations similar and dissimilar to those the learner finds about him. The television component cannot, should not, must not stand alone; children need actual experiences of measuring to develop a measurement concept.

It is unrealistic to consider a set of instructional television programs that do not make provision for staff development and specifically for teacher education. There is a tendency to think of teacher preparation as separate; the programs for child and teacher must be integrated. Materials for both should be produced by the same persons; the total concept must be outlined, and the excitement of the children's materials maintained in the teacher's materials. The focus for teachers as well as for children should be on using metric measures in actual situations.

The teacher-education materials might include some non-print as well as printed materials. Through television, cassettes, or films, factors such as apprehension about the metric system, how to facilitate the change, implications of teaching measurement through activities, how to involve students in the program, and the specific knowledges and skills necessary for teaching measurement with the metric system can be depicted and discussed. Such materials should be planned so that they could be used in various situations, ranging from independent use by one teacher to use by many as part of a workshop.

The teacher's resource handbook is an essential component of the project. It will serve as a reference for information, as well as a pre- and post-program planning guide. It should include such items as:

- .major mathematical ideas or focal points for each program
- .specific suggestions for activities to precede and follow the television lessons
- .questions that might be asked
- .some pages that could be copied for student use
- .sources of additional materials
- .explication of the reasons for teaching non-standard as well as standard measurement activities, historical aspects of the metric system, and other background information
- .pictures of children doing measurement activities
- .suggestions for teacher-education patterns

The design for in-service education and the materials produced for in-service education are an important part of the consortium effort. Unless teachers are prepared, and unless they know how to use the television lessons to teach measurement with the metric system effectively, the consortium has not succeeded in its total task.

F. <u>What strategies for development seem feasible?</u>

The metric system of measurement replaces another system of measurement already being taught. Thus, we face the task of teaching some children who know nothing about <u>any</u> system of measurement, some who have been taught something about the customary system, some who have been taught metric measurement as a second system with conversions as the connective to the customary system, and some who have used the customary system to the point where it is automatic. In addition, we will face a transition period in which we move progressively closer to metrication, until finally the metric system becomes our primary system of measurement.

As we develop a set of television lessons, we need to consider the problems that arise because of the varied levels of previous learning. What a twelve-year-old needs to be taught this year, an eleven-year-old might be taught next year. In time, giving information about the system itself will become relatively less important, for children will have received prior instruction at earlier levels and the system will have begun to be used in everyday life. Measurement and the role of the metric system will fall into perspective.

The life of a television series should be quite long, since the permanent focus of instruction will be measurement rather than the metric system. This reflects an educational decision that the metric system of measurement should be presented in the perspective of developing measurement concepts.

With committed effort and careful planning, it will be possible to have a total curriculum package completed by September 1976 -- a date that seems appropriate and realistic when both the needs of the schools and the demands of production are considered. A proposed time schedule for the consortium effort follows.

1974	Summer	Completion of prospectus
1974	Fall	Begin instructional design
1975	Winter	Begin pilot production
1975	Spring	Begin production, evaluation, and revision of materials
1976	Fall	All materials available
1977	--	Summative evaluation

There needs to be a carefully articulated development of materials. The pattern of use of the television programs in the first year may differ from the pattern of use in the second and following years. Consider the intermediate-level child who has worked with the customary system but has no experience with the metric system. He needs some orientation. The first lesson at the intermediate level might build a basis for understanding why the metric system is to be used, and also include ideas about measurement *per se* that are developed in earlier programs (but which he has not seen). Other programs focus on extending concepts about a topic at successively more advanced developmental levels. As the following chart indicates, some schools may want to use television more extensively during the first year, to make sure that older children have the opportunity to learn what is also introduced to younger children.

POSSIBLE PHASES OF TELEVISION PROGRAM USE

	Grade Level	Year 1	Year 2	Year 3	...*
Primary (P) (20 programs)	1 2 3	(P)1- 5 (P)1-10 (P)1-20	(P)1- 5 (P)1-10 (P)6-20	(P) 1- 5 (P) 6-10 (P)11-20	
Intermediate (I) (30 programs)	4 5 6	(I)1-10 (I)1-20 (I)1-30	(I) 1-10 (I) 1-20 (I)11-30	(I) 1-10 (I)11-20 (I)21-30	
Secondary (S) (10 programs	7 through 12	(S)1-10	(S) 1-10	**	
Adult		***	***	**	
Teacher (T) (1 to 5 programs)		(T)1- 5	(T) 1-5	**	

* Program use in subsequent years the same as year 3.

** Program use probably discontinued as knowledge of metric system can be assumed

*** Five programs selected from the ten developed for Secondary use

As the planning for the television materials proceeds, it seems clear that these guidelines must be kept in mind:

1. Program series must be organized in such a way that the school and the teacher have flexibility to develop different patterns of use. They may be used once a week, possibly twice a week -- or at two-week intervals. Better learning will occur if the programs are adequately spaced, for involvement in activities between television lessons is essential.

2. The rate of use may be dependent on the levels of the children and the development of the measurement concepts. The programs must be developed with the continuum of developmental states in mind.

3. The television lessons should not be thought of as "metric injection," but as an integral component for teaching one aspect of the mathematics curriculum.

4. Just watching the television lesson is not enough to develop measurement concepts; students must work with materials. It is essential that schools provide these materials. Measurement involves doing. It is not passive, not a "spectator-sport." The television component must not be passive.

The following are some specific suggestions to be considered in the development of the programs.

1. Present metric measures in context with real examples and experiences: develop situations in which metric measures are actually shown in use. Involve a variety of activities, for varied age levels. The television lessons must not be static.

2. Show students in problem-solving situations; involve the viewers and have them measure with or respond to the television.

3. Present open-ended challenging problems that viewers must resolve after the television is turned off.

4. Make it essential that students have actual experiences with measures before and after each television lesson. Provide directions for students for reinforcement of the concepts presented in the television lesson.

5. Incorporate a news-and-weather segment with the series so that the metric system is experienced in another realistic setting.

6. Convey a positive attitude; problems and difficulties must be accepted but not overstated, and realistic ways of dealing with them must be proposed.

7. Include the kinds of situations that cannot be duplicated in the classroom -- measuring a tall building or recording temperature changes around the world, for instance.

8. Include some activities that can be replicated in the classroom.

9. Give the viewer a frame of reference whenever showing metric instruments -- for example, show a child with a meter stick rather than an animated figure with a meter stick.

10. Include interdisciplinary segments; for instance, provide situations such as a social studies application in which an exchange student discusses clothing sizes or maps with metric specifications.

11. Use with care a format with short, appealing segments.

12. Direct students to many relevant experiences with metric measure outside the classroom.

Topical outline of programs

The outline that follows is included as an aid in visualizing what topical focus might be included in each of the proposed television programs. This is only one of many possible ways of indicating the essential topics. At the curriculum design stage of the consortium effort, the actual outline for the set of programs will be developed, with delineation of specific knowledges and skills, consideration for interrelationships and spiraling strands, and creative presentation strategies interwoven. The sequence must be devised in terms of specific knowledge and skills to be taught at each developmental level, may be stated in terms of behaviors, should incorporate review and other reinforcement strategies, and must carefully consider the affective impact.

PRIMARY

First level (5 programs)

1. Experiences with matching, sorting, and comparing
2. Experiences with matching, sorting, and comparing
3. Experiences with matching, sorting, and comparing
4. Using non-standard measures
5. What is measurement?

Second level (5 programs)

1. How are measurements used?
2. Using non-standard measures
3. Developing a standard measure
4. A decimal measurement system
5. Measuring time and temperature

Third level (10 programs)

1. Developing concepts of measurement in various situations
2. Measuring length: meters and centimeters
3. Measuring weight: kilograms
4. Measuring volume: liters
5. Estimating measurements
6. Relationship of metric and numeration systems
7. Relationship of metric and numeration systems
8. Measuring time and temperature
9. Measuring perimeters
10. Exploring measurement uses

INTERMEDIATE

Fourth level (10 programs)

1. What is the metric system?
2. Extending length measurement concepts
3. Extending length measurement concepts
4. Extending volume measurement concepts
5. Extending volume measurement concepts
6. Extending weight measurement concepts
7. Relationships among measures
8. Extending understanding of square measures
9. Extending understanding of cubic measures
10. Estimating measurements

INTERMEDIATE (continued)

Fifth level (10 programs)

1. Extending length measurement concepts
2. Extending volume measurement concepts
3. Extending weight measurement concepts
4. Changing units within the metric system
5. Changing units within the metric system
6. Decimal notation
7. Decimal notation
8. Finding the area
9. Finding the area
10. Measurement of circles

Sixth level (10 programs)

1. Extending length, volume, weight measurement concepts
2. Extending length, volume, weight measurement concepts
3. Measuring angles
4. Measuring area
5. Measuring circles
6. Precision in measurement
7. Decimal notation and relationships
8. Measuring to scale
9. History of measurement
10. History of measurement

Upper (10 programs)

1. The metric system: what and why?
2. Measuring length
3. Measuring volume
4. Measuring weight
5. Developing relationships
6. Using other measures
7. Specific measurement applications
8. Specific measurement applications
9. Extending measurement concepts
10. Extending measurement concepts

ADULT

(Five selected Upper programs)

TEACHER

(One to five programs)

Two sets of reaction forms are attached to the inside back cover. Please return one completed set to Agency for Instructional Television, Box A, Bloomington, Indiana 47401

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APPENDIX

CURRENT METRICATION ACTIVITIES

Joseph R. Caravella
Director of Professional Services
National Council of Teachers of Mathematics

According to many sources, including the Wall Street Journal, United States companies are not waiting for legislation to convert to the metric system. Anticipation of metric legislation, international trade economics, and the simplicity of working with the metric system are three reasons for producing the increased number of metric converts in our country. These companies have also found conversion costs to be nominal with a planned program sequenced over several years.

Because the automobile industry would like to convert at its own rate instead of following a national timetable, its metrication program has already begun. As a result of General Motors, Ford, and other major metal-working industries converting to the metric system, machine-tool sales have increased. The importance of this decision to convert is obvious when the number of subcontractors that will be affected is considered.

Examples of specific metrication programs include the following:

General Motors will be switching all new products to metric measurements, including the Wankel rotary engine, and phasing-out the old equipment as it wears out.

Ford is introducing an all-metric engine line that will be produced in the United States.

International Harvester plans to use metric measurements exclusively, for new products at its Libertyville, Illinois, construction equipment plant.

The Caterpillar Tractor Company has a program for new designs to be in metric units.

Cooper Industries and the Thorsen Tool Company are increasing their production of metric tools to meet the demand created by imported products. The prediction has been made that within five years every mechanic in the United States will have both metric and English-unit standard tools.

IBM began a ten-year phasing-in program in 1972 with new product development using metric units.

The Timken Company began to prepare for conversion ten years ago. Today they can produce bearings and other products to metric specifications as required.

In May 1973, the Sun Oil Company decided to convert, since delaying conversion was jeopardizing its export trade. They urged the rest of the petroleum industry to follow. In August 1973, a state agency, the California Division of Oil and Gas, also switched to the metric system (SI).

The International Road Federation has converted to the metric system of measurement. The Ohio Department of Transportation (ODT) has installed some road signs on its interstate highways showing distances in kilometers as well as in miles. On two of its current projects, the ODT is using metric units completely. These programs have been implemented at the governor's request in anticipation of favorable legislation by the Congress. Highway departments in Arizona, Michigan, and Minnesota have also begun metrication programs.

Winemakers are considering metric fills. The California Wine Institute has proposed that domestic winemakers change to the metric system.

The U.S. Department of Health, Education and Welfare, Food and Drug Administration has announced that new nutrition information printed on food labels will be in metric units. Also, the U.S. Geological Survey has reported that standard topographical maps for Alaska will be in metric units.

In July of 1972, the National Conference on Weights and Measures of the National Bureau of Standards, by resolution, urged educators "to begin a program of instruction in the metric system as a regular part of the curriculum at all levels of the educational system."

A selected list of other companies using the metric system include the following:

- General Electric
- Xerox
- Litton Industries
- Honeywell
- Northrop Corporation's Aircraft Division
- North American Rockwell
- Lawrence Livermore Laboratory (atomic laboratories)
- Gerber (baby foods)
- McCormick (spices)
- Nabisco (cookies and crackers)

Instructional aids for metrication are another focus of the current activities.

The National Microfilm Association has available a set of six (43 x 56 cm) "Think Metric" wall posters as a part of its metrication effort.

The National Aeronautics and Space Administration, Marshall Space Flight Center's Metrication Task Group, in cooperation with the Metric Association has recently published the fifth edition of Information on the Metric System and Related Fields. This extensive bibliography of metric publications and articles, information resources, materials, and instructional aids is available from the Metric Association.

The Metric Association (MA) has been promoting metrication for over fifty years. Its newsletter, annual meetings, and an increasing number of regional meetings have brought together approximately two thousand individuals and an impressive list of corporate members. The current interest in metrication has overburdened the volunteer officers of the MA to the extent that arrangements were made with Ideal School Supply Company to market the MA metric training aids, with the exception of the MA publications.

Two new all-metric periodicals have just been introduced. Starting in September 1973, the American Metric Journal and Metric News, bimonthly publications, will provide articles and current information concerning metrication in the U.S. and around the world.

An American National Metric Council has been established under the auspices of the American National Standards Institute (ANSI) to serve as a coordinating, planning, and information center for all organized elements of U.S. society involved with conversion to the international metric system. ANSI, recognizing the rapidly accelerating trend toward increased metric usage in the U.S., has just published a bibliography of metric standards in addition to its other metric pamphlets and posters. The Council is a good example of non-government-initiated metrication coordination.

The toy industry has suggested that special toys and games could assist metric education.

The Metric Information Office at the National Bureau of Standards continues to be the primary source of metrication information for the U.S. Their instructional aids are a must for educators.

Currently, thirteen metrication bills have been introduced in the House of Representatives and one in the Senate. The bills generally call for a ten-year conversion period. The change would be voluntary and gradual but planned by a National Metric Conversion Board. Hearings were held in March 1973 and again in May 1973 by the House Committee on Science and Astronautics. The thirteen House bills are sponsored by 55 of its 435 members. This is one indication of Congressional support for metric legislation.

If you still do not feel that metrication is upon us, consider --

-- the recent Sears, Roebuck and Co.'s tool sale, which featured both English-unit and metric products

-- the statutory standard for automobile emissions, which was defined in metric units

-- the space-flight data

-- the swimming and track events at the Olympics and the metric dimensions at Cincinnati's baseball stadium

-- that the calorie, which most of us try to avoid, is the metric unit for heat

-- the dual-labeling of food products and dress patterns

-- the metric unit on medical prescriptions

REACTION FORM

METRIC EDUCATION

Please respond to these questions as comprehensively as possible, using additional sheets as required. Your reactions will be considered in a subsequent revision of this report, a prospectus for a major cooperative television project, expected in June, 1974. Two sets of reaction forms have been provided. Please return one completed set to: Agency for Instructional Television, Box A, Bloomington, Indiana 47401.

Name: ______________________ Title: ______________

Agency: ______________________

Address: ______________________

Is the initiation of metric education currently a major concern of your agency? At the policy level? At the operational level? At what educational level(s)?

Do you feel that the proposed curriculum is educationally desirable?

This report proposes the simultaneous initiation of metric instruction at all educational levels. *Do you agree with this approach?*

How do you feel about using instructional television as a major part of your conversion effort?

(continued)

Do you feel that the project would serve the short-term educational needs of metric conversion? Would it also serve to strengthen regular instruction in measurement? Should both goals be incorporated into this project?

This report describes a specific curriculum for metric education. *Is it compatible with planned or existing curricula in your state, provincial or local educational agency?*

The report calls for making the complete metric educat n project available at the beginning of the 1976-77 school year. *Is this chedule satisfactory?*

Does the plan for phasing in the television programs over three years appear sensible?

(continued)

We would value any additional comments on or reactions to this preliminary report and the metric education project. Please take into account such things as: the timeliness of the project, its feasibility, its scope and other considerations that might lead to its acceptance and use. *In short, how do you really feel about the project?*

If you would like to receive additional copies of this report for your own use, please indicate the number desired.

Number of copies ______

We would like to send this preliminary report to people you think ought to receive copies. Please list their names and addresses.

Please accept our thanks.

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